e-ISSN: 2458-8377

SELCUK UNIVERSITY PRESS

SJAFS

SELCUK JOURNAL OF AGRİCULTURE AND FOOD SCİENCES

VOL 37 NO 2 2023 AUGUST

https://dergipark.org.tr/tr/pub/selcukjafsci

Selcuk Journal of Agriculture and Food Sciences

Selcuk Journal of Agriculture and Food Sciences

Product Information

Publisher	Selçuk University, Faculty of Agriculture
Owner (On Behalf of SUAF)	Prof. Dr. Sait Gezgin Dean
Editor in Chief	Prof. Dr. Ercan Ceyhan, Selçuk University, Türkiye
Printing House	Selçuk University Press
Date of Publication	30.08.2023
Language	English
Frequency	Published three times a year
Type of Publication	Double-blind peer-reviewed, widely distributed periodical
Indexed and Abstracted	TR DİZİN GOOGLE SCHOLAR SCIENTIFIC INDEXING SERVICES (SIS) ARAŞTIRMAX CAB ABSTRACTS / GLOBAL HEALTH CROSSREF CAB DİRECT MIAR SCILIT ESJİ Dimensions OAJI ERIH PLUS ACARINDEX Cosmos
Aims and Scope	Selcuk Journal of Agriculture and Food Sciences is unique journal covering mostly theoretical and applied all disciplines of agriculture, food and energy sciences such as agronomy, crop sciences, animal and feed sciences, poultry sciences, field crops, horticulture, agricultural microbiology, soil science, plant nutrition, agricultural engineering and technology, irrigation, land scape, agricultural economics, plant pathology, entomology, herbology, energy, biofuels and biomass, food chemistry, aroma, microbiology, food science and technology, biotechnology, food biotechnology, agricultural production, nutrition and related subjects.
Web Address	http://sjafs.selcuk.edu.tr/
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Selcuk Journal of Agriculture and Food Sciences

CONTENTS

Research Article

Selcuk Journal of Agriculture and Food Sciences

Selcuk Journal of Agriculture and Food Sciences

Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 210-222 DOI:10.15316/SJAFS.2023.021 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Ampelographic Characteristics of Grape Varieties Cultivated in Aksaray Province

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HIGHLIGHTS

- The ampelographic identification of local cvs. Aşeri and Emir was made for the first time and protected as a genetic resource.
- Cv. Parmak Üzümü was identified as an ecotype distinct from its previously identified counterparts.

Abstract

In this study, eight cultivars, all of which are *Vitis vinifera* L., are grown in Aksaray province were determined. Identification material was selected approximately 20 years old, own roots vines in the producer vineyards. Ampelographic characteristics are defined by 123 descriptive characters in the OIV (The International Organization of Vine and Wine) list of grape and grapevine rootstock varieties identification criteria. With the numerical codes of the OIV identification criteria, similarity analysis was made in the IBM SPSS Statistics software (SPSS) package program, and the similarity relationships of the cultivars were visualized with a dendrogram. Aşeri and Mor Üzüm varieties defined in Aksaray province are not registered in the European Catalogue, but all varieties are Vitis vinifera L. Subsp. vinifera is registered as Turkey varieties. All the cultivar excluding Aşeri, and Emir names defined here are included in the Turkey grapevine genetic resources list, and several cultivars containing the same name or synonyms have been defined in different studies. The ampelographic descriptions of Aşeri and Emir grape varieties were made for the first time. The ampelographic definitions of Ak Dimrit, Çavuş, Kalecik Karası, Mor Üzüm, Parmak Üzümü and Sergi Karası cvs were confirmed with previous descriptions made in different provinces. The similarities and differences of the varieties we identified were reflected in the similarity dendrogram. Six of the eight grape varieties are hermaphrodite, and two of them (Çavuş and Sergi Karası) are functional female flowers. In the international variety catalogue records, the most common Aksaray variety on a global scale is Çavuş variety originating from Turkey. The cv. Parmak Üzümü was a separate ecotype due to its differences from previous identification records. It would be appropriate to protect the Aşeri, Emir, and Parmak Üzümü varieties, which we described for the first time, in the grapevine genetic resources of Turkey.

Keywords: Aksaray, Grape, Vitis Vinifera Linné Subsp. Vinifera, Identification, Similarity Analysis

1. Introduction

Turkey's vineyard area is 400998 ha and grape production is 4208908 tons (FAOSTAT 2022). Viticulture is one of the most important sociocultural sectors. Although the exact records about the grape varieties in our vineyards area have not been reached, the diversity of the field studies is remarkable. Although studies on the

Citation: Kara Z, Yazar K, Doğan O, Ünlü D (2023). Ampelographic Characteristics of Grape Varieties Cultivated in Aksaray Province. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 210-222. https://doi.org/10. 15316/SJAFS.2023.021

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Received date: 20/11/2022

Accepted date: 04/03/2023

identification and protection of our grapevine genetic potential started before the republican period, the most active conservation and identification work is carried out under the leadership of Tekirdağ Viticulture Research Institute. With the introduction of the identifiers (OIV 1983) created by method standardization studies, created under the leadership of the method union OIV (The International Organization of Vine and Wine) in the identification of grape varieties, they were accepted and used by all researchers and these descriptors were constantly renewed in the process.

Ampelographic and molecular descriptions of grape varieties in different viticulture regions (Sabir et al 2009; Ates et al 2011; Kılıç et al 2011; Kara et al 2016; Çelik et al 2018; Esmek et al 2018; Kara et al 2018; Akram et al 2019; Bahar et al 2019; Kupe 2020; Koç et al 2021; Ünal & Cuma 2022) and in different countries (Mandić et al 2018; Popescu & Crespan 2018; Volynkin et al 2018; Biniari & Stavrakaki 2019; Bounab & Laiadi 2019; El Oualkadi & Hajjaj 2019; Maraš 2019; Margaryan et al 2019; Milovanov et al 2019; Mirela et al 2019; Novikova & Naumova 2019; Petcov et al 2019; Rustioni et al 2019; Bibi et al 2020; Crespan et al 2020; Dallakyan et al 2020; Grigoriou et al 2020; Hameed et al 2020; Iliescu et al 2020; Jiménez-Cantizano et al 2020; Maistrenko et al 2020; Papapetrou et al 2020; Pastore et al 2020; Simeonov 2020; Stavrakaki et al 2020; Theuma 2020; Crespan et al 2021; Fedosov et al 2021; Fanelli et al 2021; Fatehi et al 2021; Gutiérrez-Gamboa et al 2021; Hmimsa et al 2021; Ilnitskaya et al 2021; Margaryan et al 2021; Milišić et al 2021; Zombardo et al 2021; Bardales et al 2022; Chehade et al 2022; Cıchı et al 2022; Dumitru et al 2022; Gago et al 2022; Gisbert et al 2022; Gonçalves & Martins 2022; Mouniane et al 2022; Pszczólkowski et al 2022; Roychev & Keranova 2022) were studied.

Ampelographic and molecular descriptions of grape varieties were made in different vineyard regions and in different countries. OIV (2009) was used as the ampelographic descriptor in the studies. Various molecular descriptors have been used for molecular characterization. Similarity analyses of cultivars were performed according to ampelographic descriptions and/or molecular identifiers.

In previous studies, synonyms of grape varieties were determined, similarities were examined by comparing them with national and international variety catalogues, and the records of those not included in these catalogues were completed. National and international cultivar records were created for the cultivars identified for the first time in local identification studies. Conservation measures were taken for the cultivars or genotypes that were not in the conservation collections. In this study, grape varieties still grown in Aksaray province were defined.

2. Materials and Methods

In the province of Aksaray, 10100 tons of grapes were produced in the vineyard area of 16280 da in 2021 (TÜİK 2022). This study was carried out in the 2019 and 2020 vegetation periods in the producer vineyards of the Kara Ören village of the center of Aksaray province and the villages that are actively engaged in viticulture with other vineyards.

The cultivars studied were healthy, about 20-year-old vines at yielding age and on their own roots. The plant material was Ak Dimrit, Aşeri, Çavuş, Emir, Kalecik Karası, Mor Üzüm (Bulut Üzümü), Parmak Üzümü and Sergi Karası grape varieties. A total of 123 traits included in the OIV grape and vine rootstock varieties identification criteria list (OIV 2009) were used in the identification of grape varieties. Similarity analysis was performed in the IBM SPSS Statistics software 23 (SPSS) with the numerical codes of the OIV strains, and the similarity relationships of the eight cultivars were visualized with a dendrogram. The identified characteristics of the cultivars and similarity analysis results were compared with the previous identification records, and similarities and differences were evaluated.

3. Results

3.1. Ampelographic definitions

The shoot tip type of the young shoot showed the characteristics of Vitis vinifera cultivars in all varieties and was closed. Differences were determined in terms of the distribution of anthocyanin coloration on the prostrate hairs at the shoot tip, the intensity of anthocyanin coloration on the prostrate hairs at the shoot tip, the density of the prostrate hairs at the shoot tip, and the density of erect hairs at the shoot tip (Table 1).

Significant differences were noted between cultivars in terms of shoot definitions, except that since all cultivars were Vitis vinifera cultivars, successive tendrils coded OIV 016 were intermittent.

In terms of young leaf definitions, cultivars generally differentiate between 4-6. young leaf upper surface colour (OIV 051-2) detected in leaves was similar in all cultivars. On the other hand, only the Çavuş cultivar differed from the others in terms of hair types and densities coded OIV 053, OIV 054, OIV 055 and OIV 056, which were detected on the 4th leaf from the shoot tip.

One of the definitions of mature leaves coded, OIV 070 (Anthocyanin coloration area on the main veins on the upper surface of the mature leaf blade), OIV 070-1 (Anthocyanin coloration on the main veins on the upper surface of the mature leaf blade), OIV 071 (Mature leaf blade, anthocyanin coloration area on the main veins on the lower surface of the mature leaf blade), OIV 077 (Tooth size associated with mature leaf blade size), OIV 081-1 (Presence of teeth in mature petiole sinus), OIV 081-2 (Mature petiole sinus is limited by veins), OIV 082 (Mature leaf upper side sinus degree of openness / overlap), OIV 083-1 (Base shape of mature leaf upper sinus), OIV 083-2 (Mature leaf teeth in upper side sinus), and OIV 084 (Density of erect hairs between the main veins of mature leaves on the lower surface of the blade), all cultivars were in the same group.

In terms of lignified shoot definitions, the differences were very limited according to the cultivars. The ten identification characters examined were included in the same identification codes for all cultivars.

In our study, inflorescences were identified with 4 features, of which only 8 cultivars with the code OIV 153 were included in the same group in terms of the number of clusters per shoot.

Grape clusters were identified with 8 features, the varieties identified differed in terms of OIV 202 coded Cluster Length (excluding stem), OIV 203 coded Cluster width and OIV 204 coded Cluster density.

17 characteristic features of the berry were determined, Aksaray cultivars differed in terms of only 3 features (OIV 220 code berry length, OIV 225 code berry skin colour, and OIV 231 code the intensity of anthocyanin coloration in berry pulp).

The 4 features related to seeds (OIV 241 coded the formation of seed in berry, OIV 242 coded the length of seed, the OIV 243 coded weight of seed, and OIV 244 coded transverse protrusions on the dorsal side of seed) were similar in the 8 cultivars identified.

Phenological features were determined with 6 characters, of which only OIV 306 coded autumn colour of leaves was similar in 8 cultivars examined.

Fruit set and berry quality characteristics were defined with three characters, of which OIV 501 coded Fruit setting rate differed according to the varieties, while OIV 505 coded the sugar content of must, and OIV 508 coded the pH of fruit juice were in the same group in all cultivars.

Mature leaf ampelometric measures were identified by sixteen characters, the traits with which the cultivars most differentiated. Among these characteristics, OIV 601 coded Mature leaf N1 vein length, OIV 602 coded Mature leaf N2 vein length, and OIV 603 coded Mature leaf N3 vein length was similar while cultivars differed in other characters.

Table 1. Ampelographic descriptors and definitions

OIV Code	Descriptive	Emir	Dimrit	Çavuş	Kalecik K.	Sergi K	Aşeri	Mor	Parmak
OIV 001	Young shoot: Shoot tip type	1	1	1	1	1	1	1	1
OIV 002	Young shoot: Distribution of anthocyanin coloration on the prostrate hairs at the shoot tip	2	3	3	2	3	1	1	1
OIV 003	Young shoot: Intensity of anthocyanin coloration on the prostrate hairs at the shoot tip	7	7	7	3	9	1	3	3
OIV 004	Young shoot: Density of erect hairs at the shoot tip	3	3	9	3	9	1	3	7
OIV 005	Young shoot: Density of erect hairs at the shoot tip	5	5	9	5	9	1	1	7
OIV 006	Shoot: Habitus (before tying)	3	3	7	5	5	3	5	3
OIV 007	Shoot: Colour of the dorsal side of the internodes	1	1	2	1	3	2	2	2
OIV 008	Shoot: Colour of the ventral side of the internodes	1	2	1	1	2	2	2	1
OIV 009	Shoot: Colour of the dorsal side of the nodes	1	2	2	1	3	2	2	2
OIV 010	Shoot: Colour of the ventral side of the nodes	1	2	2	2	2	2	2	2
OIV 011	Shoot: Erect hair density on nodes	1	1	5	5	5	1	1	1
OIV 012	Shoot: Erect hair density between nodes	1	1	1	3	3	1	1	3
OIV 013	Shoot: Prostrate hair density on the nodes	1	1	5	5	3	1	1	1
OIV 014	Shoot: Prostrate hair density between the nodes	1	1	5	3	3	1	1	1
OIV 015-1	Shoot: Distribution of anthocyanin coloration on winter buds	1	9	9	5	9	5	1	9
OIV 015-2	Shoot: Intensity of anthocyanin coloration on winter buds	1	5	3	5	5	5	1	5
OIV 016	Shoot: Number of consecutive tendrils	1	1	1	1	1	1	1	1
OIV 017	Shoot: Length of tendrils	5	3	7	7	7	7	7	5
OIV 051	Young leaf: The colour of the upper surface of the blade (4th leaf)	1	1	5	1	1	1	1	1
OIV 051-2	Young leaf: Upper surface colour (4-6th leaves)	1	1	1	1	1	1	1	1
OIV 053	Young leaf: Density of prostrate hairs between the main veins on the lower surface of the leaf (4th leaf)	3	3	9	3	3	3	3	3
OIV 054	Young leaf: Density of erect hairs between the main veins on the lower surface of the leaf (4th leaf)	3	3	9	3	3	3	3	3
OIV 055	Young leaf: Density of prostrate hairs between the main veins on the lower surface of the leaf (4th leaf)	3	3	9	3	3	3	3	3
OIV 056	Young leaf: Density of erect hairs on the main veins on the lower surface of the leaf (4th leaf)	3	3	7	3	3	3	3	3
OIV 065	Mature leaf: The size of the blade	7	5	7	5	5	7	5	5
OIV 067	Mature leaf: Shape of the blade	2	4	5	5	5	4	4	1
OIV 068	Mature leaf: Number of lobs	3	3	3	4	5	4	3	3
OIV 069	Mature leaf: Upper surface colour to blade	6	6	7	6	7	6	6	6
OIV 070	Mature leaf: Anthocyanin coloration area on the main veins on the upper surface of the blade	1	1	1	1	1	1	1	1
OIV 070-1	Mature leaf: Anthocyanin coloration on the main veins on the upper surface of the blade	1	1	1	1	1	1	1	1
OIV 071	Mature leaf: Anthocyanin coloration area on the main veins on the under surface of the blade	4	4	4	4	4	4	4	4
OIV 072	Mature leaf: Shrinkage on the blade	1	1	1	1	5	5	5	1
OIV 073	Mature leaf: Undulation between main and lateral veins on blade	1	1	1	9	9	9	1	9
OIV 074	Mature leaf: Profile of the cross section of the blade	4	1	2	2	4	4	3	2
OIV 075	Mature leaf: Blistering on the upper surface of the blade	7	1	5	1	1	1	1	1
OIV 076	Mature leaf: The shape of the tooth	7	1	5	1	1	1	1	1
OIV 077	Mature leaf: Tooth size associated with blade size	5	5	5	5	5	5	5	5
OIV 078	Mature leaf: Ratio of tooth length to width	5	5	5	7	5	5	3	5
OIV 079	Mature leaf: Opening/overlap condition of petiole sinus	5	5	5	7	5	5	3	5
OIV 080	Mature leaf: Shape of petiole sinus	7	2	2	5	5	5	2	2
OIV 081-1	Mature leaf: Tooth in the petiole sinus	2	2	2	2	2	2	2	2
OIV 081-2	Mature leaf: Bordering by veins in the petiole sinus	1	1	1	1	1	1	2	1
OIV 082	Mature leaf: Degree of openness/overlap of upper side sinus	1	1	1	1	1	1	1	1
OIV 083-1	Mature leaf: Base shape of upper sinus	3	3	3	3	3	3	3	3
OIV 083-2	Mature leaf: Teeth in upper side sinus	9	9	9	9	9	9	9	9
OIV 084	Mature leaf: Density of prostrate hairs between the main veins (on the lower surface of the blade)	1	1	1	1	1	1	1	1
OIV 085	Mature leaf: Density of erect hairs between the main veins on the lower surface of the blade	3	3	9	3	3	3	3	3
OIV 086	Mature leaf: Density of prostrate hairs on the main veins on the under surface of the blade	3	3	9	3	3	3	3	3
OIV 087	Mature leaf: Density of erect hairs on the main veins (on the lower surface of the blade)	3	3	9	3	3	3	3	3
OIV 088	Mature leaf: Prostrate hairs on the main veins on the upper surface of the blade	3	3	9	3	3	3	3	3
OIV 089	Mature leaf: Erect hairs on the main veins on the upper surface of the blade	1	1	9	1	1	1	1	1
OIV 090	Mature leaf: Density of prostrate hairs on petiole	1	1	9	1	1	1	1	1
OIV 091	Mature leaf: Density of erect hairs on petiole	1	1	5	1	1	1	1	1
OIV 093	Mature leaf: Ratio of stem length to main vein length	3	1	1	3	3	3	5	3
OIV 094	Mature leaf: Depth of upper side sinus	5	3	3	7	7	7	7	7
OIV 101	Woody shoot: Cross section	2	2	2	2	2	2	2	2
OIV 102	Woody shoot: Structure of the surface	1	1	1	1	1	1	1	1
OIV 103	Woody shoot: Main colour	2	2	2	2	2	2	2	2
OIV 104	Woody shoot: Lenticels	1	1	1	1	1	1	1	1

Table 1 (continued).Ampelographic descriptors and definitions

OIV 105	Woody shoot: Erect hairs on the nodes	1	1	1	1	1	1	1	1
OIV 106	Woody shoot: Erect hairs between the nodes	1	1	1	1	1	1	1	1
OIV 351	Woody shoot: Shoot vigour	5	5	5	5	5	5	5	5
OIV 352	Woody shoot: Growth of lateral shoots	5	5	5	5	5	5	5	5
OIV 353	Woody shoot: Length of internodes	5	5	5	5	5	5	5	5
OIV 354	Woody shoot: Thickness of internodes	3	3	3	3	3	3	3	3
OIV 151	Flower: Sex organs	3	3	4	3	4	3	3	3
OIV 152	Inflorescence: The node from which the 1st inflorescence comes	2	2	1	2	2	2	2	2
OIV 153	Inflorescences: Number of clusters per shoot	2	2	2	2	2	3	2	2
OIV 155	Inflorescence shoot: Fertility of lower buds (1st-3rd buds)	5	1	1	5	5	5	9	5
OIV 202	Cluster: Length (Excluding stem)	5	5	7	5	5	5	7	5
OIV 203	Cluster: Width	3	3	3	3	3	3	3	5
OIV 204	Cluster: Density	5	7	5	7	7	5	7	5
OIV 206	Cluster: The stem length of the bunch on the main shoot	1	1	1	1	1	1	1	1
OIV 207	Cluster: Lignification of the stem	1	1	1	1	1	1	1	1
OIV 208	Cluster: Shape	1	2	2	2	2	2	3	2
OIV 209	Cluster: Number of wings of the first bunch	2	2	2	2	2	2	2	2
OIV 502	Cluster: Single cluster weight	5	5	5	5	5	5	5	5
OIV 220	Berry: Length	5	3	3	5	5	5	5	5
OIV 221	Berry: Width	5	3	5	5	5	5	5	5
OIV 222	Berry: Uniformity of size	1	1	1	1	1	1	1	1
OIV 223	Berry: Shape	8	8	8	8	8	8	8	8
OIV 225	Berry: Skin colour	1	1	1	3	1	1	5	1
OIV 226	Berry: Uniformity of skin colour	1	1	1	1	1	1	1	1
OIV 227	Berry: Wax layer	1	1	1	1	1	1	1	1
OIV 228	Berry: Skin thickness	7	5	5	5	5	5	5	5
OIV 229	Berry: Hilum	1	1	1	1	1	1	1	1
OIV 231	Berry: Intensity of anthocyanin colouring in berry flesh	1	1	1	1	1	1	5	1
OIV 232	Berry: Juiciness of berry flesh	2	2	2	2	2	2	2	2
OIV 233	Berry: Must yield	5	5	5	5	5	5	5	5
OIV 235	Berry: Flesh firmness	2	2	2	2	2	2	2	2
OIV 236	Berry: Special aroma	1	1	1	1	1	1	1	1
OIV 238	Berry: Stalk length	3	3	3	3	3	3	3	3
OIV 240	Berry: Stalk break resistance	3	3	3	3	3	3	3	3
OIV 503	Berry: Single berry weight	3	3	3	3	3	3	3	3
OIV 241	Berry: Formation of seeds	3	3	3	3	3	3	3	3
OIV 242	Berry: Length of seeds	5	5	5	5	5	5	5	5
OIV 243	Berry: Weight of seeds	1	1	1	1	1	1	1	1
OIV 244	Berry: Transverse projections on the dorsal side of the seeds	2	2	2	2	2	2	2	2
OIV 301	Phenology: Time of bud burst	5	5	3	5	3	3	5	5
OIV 302	Phenology: Time to full bloom	7	5	5	7	1	3	9	9
OIV 303	Phenology: The time when the berries start to mature (veraison)	5	5	5	8	1	3	5	7
OIV 304	Phenology: Time of full physiological maturation of berries	7	7	5	7	1	3	7	7
OIV 305	Phenology: The time when shoots begin to lignify	7	7	5	7	1	3	7	7
OIV 306	Phenology: Autumn colour of leaves	2	2	2	2	2	2	2	2
OIV 501	Berry setting and berry quality: Fruit setting rate	3	3	3	5	3	3	5	3
OIV 505	Berry setting and berry quality: Sugar content of must	7	7	7	7	7	7	7	7
OIV 508	Berry setting and berry quality: pH in juice	7	7	7	7	7	7	7	7
OIV 601	Mature leaf: N1 vein length (cm)	7	7	7	7	7	7	7	7
OIV 602	Mature leaf: N2 vein length (cm)	7	5	7	5	5	5	5	5
OIV 603	Mature leaf: N3 vein length (cm)	7	7	7	7	7	7	7	7
OIV 604	Mature leaf: N4 vein length (cm)	7	7	9	3	9	9	9	9
OIV 605	Mature leaf: Distance from petiole sinus to upper side sinus (cm)	5	3	1	3	5	1	5	1
OIV 606	Mature leaf: Distance from petiole sinus to lower side sinus (cm)	4	8	3	8	6	5	5	7
OIV 607	Mature leaf: Measure of angle between N1 and N2 veins, measurement from first branching point	3	1	5	3	1	1	3	1
OIV 608	Mature leaf: Measure of angle between N2 and N3 veins, measurement from first branching point	7	1	3	5	3	5	7	3
OIV 609	Mature leaf: Measure of angle between N3 and N4 veins, measurement from first branching point	1	1	3	1	1	1	1	1
OIV 610	Mature leaf: Measure of the tangential angle to the tooth at the stem attachment point with N3 and the tip of N5	5	5	3	5	5	3	3	1
OIV 612	Mature leaf: Tooth length of N2 (cm)	3	3	5	7	1	9	3	1
OIV 613	Mature leaf: Tooth width of N2 (cm)	7	3	3	3	5	5	5	5
OIV 614	Mature leaf: Tooth length of N4 (cm)	7	9	1	7	5	3	1	7
OIV 615	Mature leaf: Tooth width of N4 (cm)	9	7	9	7	7	7	5	5
OIV 616	Mature leaf: Between the tooth at the tip of N2 and the tooth at the tip of the first branch off from N2 Number of teeth, including those at the margins	3	5	7	5	3	7	5	3
OIV 617	Mature leaf: Distance between the tooth at the tip of N2 and the tooth at the tip of the first branch leaving N2 (cm)	5	9	7	7	5	5	5	5

3.2. Similarity analysis

In the similarity analysis, 8 grape varieties defined in Aksaray province formed a double cluster. On one side of this structure, there was a single Çavuş grape variety, while the other 7 varieties were divided into two branches on the other side (Figure 1). In one of these branches, Mor Üzüm and Emir varieties took place together. The other branch was again divided into two sub-branches, one double and the other triple. While Aşeri and Sergi Karası were in the double arm, Kalecik Karası, Parmak Üzümü and Dimrit took place in the triple arm.

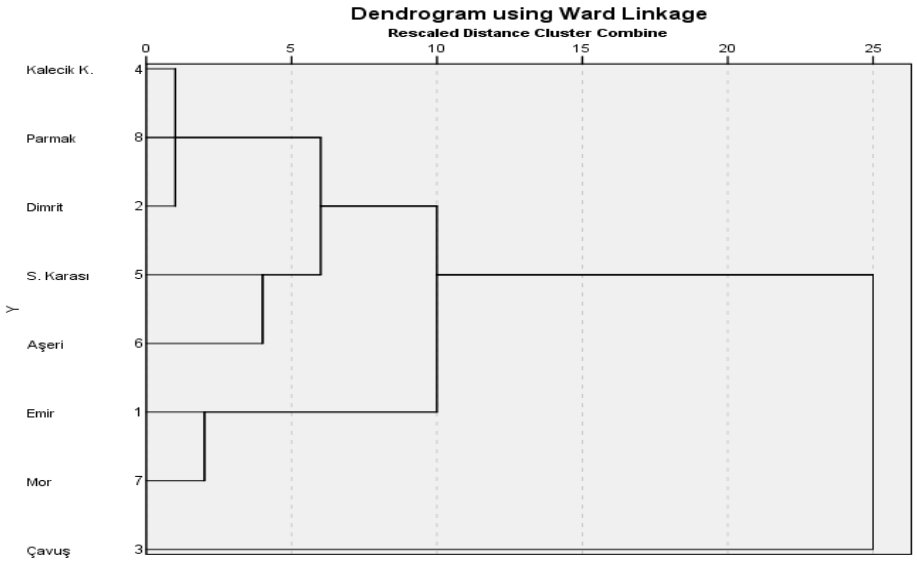

Figure 1. Clustering dendrogram of grape varieties according to 123 ampelographic identification OIV (2009)

Ak Dimrit, in the Turkey grapevine genetic resources list (Boz et al 2012), in the European Catalogue, in the International variety catalogue Vitis vinifera Linné Subsp. vinifera Variety number VIVC 673 and 3573, there are two records as a white Turkey variety. In these records, it is seeded, its usage area is for table and drying and it is flower type hermaphrodite. Synonyms registered in the international variety catalogue are Ak Üzüm, Beyaz Dimrit, Dimrit Ak Üzüm, Irızgı Kaleburcu, Irızkı. The owner of the variety is the Aegean Region Agricultural Research Institute with the code TUR001, the Çukurova University Faculty of Agriculture with the code TUR020 and the Manisa Viticulture Research Institute with the code TUR041. In previous studies, ampelographic and genetic characterization of this cultivar was performed by Vouillamoz et al (2006) and Sabir et al (2009).

Aşeri, is not registered in the Turkish grapevine genetic resources list (Boz et al. 2012) and in the European Catalogue. In the international variety catalogue, Vitis vinifera Linné Subsp. vinifera was recorded as Variety number VIVC 5319 and white coloured Turkey variety. In these records, it is seeded, its usage area is for table and drying and it is flower type hermaphrodite. The synonyms registered in the international variety catalogue are Ahmetbey, Hasandede, Hasandede Beyazı, Hasandede Gelber and Sungurlu. The owner of the variety is the Aegean Region Agricultural Research Institute with the code TUR001 and the Tekirdağ Viticulture Research Institute with the code TUR035. In previous studies, the genetic characterization of this variety was defined by Selli et al (2007).

Çavuş, Turkey grape vine genetic resources list (Boz et al 2012), the European Catalogue and the International variety catalogue Vitis vinifera Linné Subsp. vinifera Variety number VIVC 10196 is registered as a white Turkey variety. According to these records, the variety is seeded, the usage area is table, and the flower type is female. 82 synonyms are given in the international variety catalogue. Some of the synonyms are Ak Çavuş, Çavuşoğlu Ak Çavuş, Çavuşoğlu, Chouch Blanc, Rosaki, Çoban, Rosaki D'Anatolie. The beneficiary

of the variety is Çukurova University Faculty of Agriculture with the code TUR020, Directorate of Atatürk Horticultural Research Institute with the code TUR028, Tekirdağ Viticulture Research Institute Directorate with the code TUR035 and Manisa Viticulture Research Institute with the code TUR041. In addition, 32 institutions from different countries were registered as variety owners. In previous studies, ampelographic description of this variety, Kara (1990), genetic characterization, Adam-Blondon et al (2001), Ghaffari et al (2014), Laucou et al (2018) and genetic association mapping was done by Snoussi et al (2004).

Emir, Turkey grapevine genetic resources list (Boz et al 2012), Vitis vinifera Linné Susp. vinifera Variety number VIVC 13621 is registered as a white Turkey variety. In these records, it is seeded, its usage area is for wine, its flower type is hermaphrodite, and its synonym is White Grape. The owner of the variety is the Tekirdağ Viticulture Research Institute with the code TUR035. In previous studies, the genetic characterization of this variety was performed by Vouillamoz et al (2006) and Arroyo-García et al (2006).

Kalecik Karası, Turkey grapevine genetic resources list (Boz et al 2012), Vitis vinifera Linné Subsp. vinifera Variety number VIVC 5936 is registered as a black coloured Turkey variety. In these records, it is seeded, the usage area is wine, and the flower type is hermaphrodite. Synonyms are given as Ada Karası, Çal Karası, Hasandede, Horozkarası, Kara Kalecik and Papazkarası. The beneficiary of the variety is Çukurova University Faculty of Agriculture with the code TUR020, Tekirdağ Viticulture Research Institute with the code TUR035, and Manisa Viticulture Research Institute with the code TUR041. In a previous study, Sabir et al (2009) made the ampelographic and molecular description of this variety in Adana.

Mor Üzüm, is registered as Mor Büzgülü in the Turkey grape vine genetic resources list (Boz et al. 2012), but not in the European Catalogue. This variety is included in the encyclopaedic dictionary of grape varieties and synonyms (Galet & Grisard 2015). In the international variety catalogue, Vitis vinifera Linné Subsp. vinifera Variety number VIVC 1812 is registered as a crimson-pink, purple coloured Turkey variety. The usage area of this seeded variety is for wine and table, and the flower type is hermaphrodite. Synonyms are given as Bulut Üzümü, Buludi and Mor Üzüm. The beneficiary of the variety is the Aegean Region Agricultural Research Institute with the code TUR001, the Tekirdağ Viticulture Research Institute with the code TUR035 and the Manisa Viticulture Research Institute with the code TUR041. In a previous study, Kara (1990) made the ampelographic description of this variety in Tokat.

Parmak Üzümü, Turkey grape vine genetic resources list (Boz et al 2012), in the European Catalogue and the International variety catalogue Vitis vinifera Linné Subsp. vinifera Variety number VIVC 1286 is registered as a white Turkey variety. The use of this seeded variety is for table and drying and the flower type is hermaphrodite. Synonyms are Adıyaman Üzümü, Ağ Besni, Agbesni, Bandırma, Beyaz Bamba, Besni, Besni Beyazı, Peygamber and Zeyni. The beneficiary of the variety is the Aegean Region Agricultural Research Institute with the code TUR001, the Çukurova University Faculty of Agriculture with the code TUR020, the Atatürk Horticultural Research Institute with the code TUR028, the Tekirdağ Viticulture Research Institute with the code TUR035, and the Manisa Viticulture Research Institute with the code TUR041. In a previous study, Kara (1990) gave the ampelographic description of this variety, and its genetic characterization was done by Karatas et al (2019). The variety we describe is considered as table grape in the region.

Sergi Karası, Turkey grapevine genetic resources list (Boz et al 2012), the European Catalogue and the International variety catalogue Vitis vinifera Linné Subsp. vinifera Variety number VIVC 11508 is registered as a white colour Turkey variety. The use of this seeded variety is wine grapes, table grapes and dried grapes, and the flower type is female. 17 synonyms have been reported in the international variety catalogue and some of them are Antep Karası, İri Kara, Kara Sergi, Lanlan Karası, Mikeri, Mikeri Siyahı, Oğlak Karası, Orak Karası, Sergi Kara, Sergi Karası, Siyah Karnur and Tahannebi Siyahı. The beneficiary of the variety is Çukurova University Faculty of Agriculture with the code TUR020, Tekirdağ Viticulture Research Institute Directorate with the code TUR035 and Manisa Viticulture Research Institute with the code TUR041. In previous studies,

ampelographic and genetic characterization of this variety was performed by Sabir et al (2009) and Karatas et al (2019)

4. Discussion

Of the grape varieties produced in Aksaray, Aşeri and Mor Üzüm are not registered in the European Catalogue, but all varieties are listed in the international variety catalogue as Vitis vinifera Linné Subsp. vinifera are registered as Turkey varieties with different numbers. These grape varieties are included in the Turkey National Collection Vineyard variety list. The ampelographic and molecular descriptions of Ak Dimrit, Kalecik Karası and Sergi Karası cultivars were made by Sabir et al (2009) in Adana, and Kara (1990) ampelographic descriptions of Çavuş, Mor Üzüm and Parmak Üzümü varieties were made in Tokat.

Aşeri and Emir varieties were defined ampelographically for the first time. Although Ak Dimrit and Aşeri varieties are given synonymously in the international variety catalogue, significant differences were noted in our study. This difference is also reflected in the similarity dendrogram. The flower type of six of the eight grape varieties is hermaphrodite, and two of them (Çavuş and Sergi Karası) are functional females. According to the records of the international cultivar catalogue, the most common Aksaray cultivar on a global scale is Çavuş cultivar originating in Turkey, 70 synonyms of this cultivar and available in 36 institutions in 23 countries.

The flower types included in the previous records and descriptions of the cultivars we described were confirmed by field observations. In the Turkey Vine Genetic Resources list, many Parmak Üzümü genotypes (eg Gelin Parmağı, Kadın Paramağı, Hatun Parmağı) were mentioned. However, full ampelographic diagnoses of Parmak Üzümü types could not be reached. It was confirmed by field observations that the ecotype described in this study was grown around Aksaray, Nevşehir and Kayseri provinces.

It would be appropriate to protect the Aşeri, Emir and Parmak Üzümü varieties, which we described for the first time, in the grapevine genetic resources of Turkey.

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: : The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 223-231 DOI:10.15316/SJAFS.2023.022 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Comparison of Student – t, Welch's t, and Mann – Whitney U Tests in Terms of Type I Error Rate and Test Power

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HIGHLIGHTS

- Student – t, Welch's – t, and Mann – Whitney U tests were examined by various simulation combinations.
- It is indicated that Welch's t-test is robust for preserving the type I error rate when the distribution is normal.
- In real-life applications, using Welch t-test as an alternative to these two methods is recommended.

Abstract

In this study, we compared the Student's t-test, Welch's t-test, and Mann-Whitney U test, in terms of their type I error rate and statistical power when the assumptions of parametric tests are violated in different situations. Materials used in this study, consisted of random numbers generated using the Numpy library in the Python programming language. All random numbers were generated from a normal distribution with N (0, 1) parameters. Balanced and unbalanced experimental conditions were simulated 50 000 times for each combination. The study revealed that, in comparison to other tests, Welch's t - test was particularly more conservative in terms of type I error rate. It was discovered that the Student-t test had higher power values than the Mann-Whitney U test, mainly when only a small sample size of observations was used for the analysis. This simulation study indicated that Welch's t - test is robust for preserving type I error rate when the distribution is normal. Therefore, in practice, the use of Welch t-test is recommended based on the findings of this study. One of the recommendations of this study is that the tests in question should also be evaluated in cases where observations have different distributions.

Keywords: Type I error rate; Test power; Student – t test; Mann – Whitney U test; Welch's – t test; Simulation

1. Introduction

Depending on the situation, parametric or non–parametric statistical approaches are preferred in studies where the means or median values of two groups are compared. Parametric tests, as it is well–known, act by some parameters in the probability distribution to which the observation values belong. The Student – t-test, which compares the means of two independent groups, is also a parametric method that needs the normal distribution of observations and the homogeneity of group variances. Nonparametric methods, on the other

Citation: Ergin M, Koskan O (2023). Comparison of Student – t, Welch's t, and Mann – Whitney U Tests in Terms of Type I Error Rate and Test Power. *Selcuk Journal of Agriculture and Food Sciences*, 37(2),223-231. https://doi.org/10. 15316/SJAFS.2023.022
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Received date: 19/10/2022
Accepted date: 05/03/2023

hand, assume that the observation values are not obtained from a certain probability distribution. Therefore, it is represented in the literature as distribution – free. It is widely known that parametric tests are more robust than nonparametric tests when assumptions are provided, even with a small sample size. Furthermore, it has been reported that when the number of observations in both groups is equal (balanced design), the Student – t test is a powerful test even if the homogeneity of the variances, which is considered to be the most important assumption of the parametric tests, is violated. Moreover, it is reported that the heterogeneity of variances in experiments where the number of observations is not equal (unbalanced design) causes the probability of type I error determined at the beginning of the experiment to not be maintained at 5% (Zimmerman and Zumbo 1993).

In general, the options that researchers may use when the assumptions are not met can be summarized as (i) the Welch – t-test, which is one of the parametric alternative approaches, or (ii) the Mann – Whitney U test, which is one of the non–parametric approaches. The parametric alternative to the Student – t test is the Welch – t-test, which was developed by correcting the degrees of freedom of the independent two–group t–test in experiments where group variances were not homogeneous (Derrick et al. 2016). As a result of previous simulation studies, it has been reported that the Welch – t-test is more powerful when the assumption of homogeneity of group variances is not met (Oshima et al. 1991; Keselman et al. 1991). Welch–t-test has been reported to better preserve the type I error probability in unbalanced designs with unequal sample sizes (Zimmerman 2004). Keselman et al. (2004) have claimed that Welch – t-test is not affected by the heterogeneity of variances but is influenced by non–normality of the observations. In addition, Winter (2013) supported through a simulation study that applying the Welch–t-test on experiments with very small sample sizes is problematic.

In this simulation study, Student – t, Welch – t, and Mann – Whitney U tests which compare the mean or median values of two groups, were examined in terms of type I error rate and test power by designing various simulation combinations.

2. Materials and Methods

In the present study, random numbers generated from normal distribution by using the "random" function in the Numpy library of the Python programming language were used. Student – t, Welch – t, and Mann – Whitney U tests were compared in terms of both type I error rate and test power values by constituting various situations. Detailed information on the simulation design for type I error rate and test power is presented in Table 1. The simulation scenario used to calculate Type I error rates is as follows:

1. Define a variable as count = 0.
2. Generate two samples of data from normal (0,1) distribution using the "random" function to consider the null hypothesis.
3. Perform all tests at the predetermined significance level (α = 5%).
4. Compute and store all p – values in a list variable.
5. If p – value ≤ 0.05, increase count variable by one.
6. Perform these procedures 50 000 times.
7. Calculate the type I error rates as follow:

$$\frac{(\text{Number of Rejected } H_0 \text{ Hypothesis})}{(\text{Number of Total Simulations})}$$

The simulation scenario for calculating power values is as follows:

1. Define a variable as count = 0.

2. Generate two samples of data from normal (0,1) distribution using the "random" function to consider the null hypothesis.
3. Add constant value to the mean of the first group to create the desired standard deviation differences (Repeat this step for all standard deviation differences such as 0.75, 1, and 1.5).
4. Perform all tests at the predetermined significance level (α = 5%).
5. Compute and store all p – values in a list variable.
6. If p – value ≤ 0.05, increase count variable by one.
7. Perform these procedures 50 000 times.
8. Calculate the type I error rates as follow:

$$\frac{(\text{Number of Rejected } H_0 \text{ Hypothesis})}{(\text{Number of Total Simulations})}$$

Table 1. Simulation design.

Type I Error Rate		**Test Power**		
n	$\boldsymbol{\sigma^2:\sigma^2}$	**n**	$\boldsymbol{\sigma^2:\sigma^2}$	**Δ**
8,8 15,15 25,25 35,35 45,45 65,65	1:1 1:3 1:5 1:10	8,8 10,10 15,15 25,25 30,30 45,45	1:1	0.75 1 1.5
8,15 15,20 20,27 35,45 50,60	1:3 3:1 1:7 7:1			

Student – t-test

In general, population variance is unknown and therefore the variance estimated from the sample should be used. The t-test that is developed by William S. Gosset as the "Student" nickname, is suitable where the population variance is unknown. The difference between the two sample variances should be equal to the variances calculated from samples drawn from the same population, indicating that the variances are homogeneous. When considering whether the difference between the means of the samples is part of the distribution, there are two estimates of the population variance, as each sample variance is an estimate of the population variance for the calculated t-value. Therefore, the weighted average of these variance estimates, based on their degrees of freedom, will provide a more reliable estimate of the population variance. Student – t test value calculated by Equation (1) and Equation (2).

$$t = \frac{\overline{A} - \overline{B}}{S_D} \tag{1}$$

$$S_D = \sqrt{\frac{\sum d_A^2 + \sum d_B^2}{(n_A - 1) + (n_B - 1)} * \frac{(n_A + n_B)}{n_A * n_B}} \tag{2}$$

It shows the theoretical t distribution with $(n_A - 1) + (n_B - 1)$ degrees of freedom.

Welch – t-test

It has been reported that deterioration of variance homogeneity causes changes in the performance of the Student – t test, both in terms of type I error rate and test power (Delacre et al. 2017). For this reason, Welch 1947) developed an approach based on the separated variances and correction of degrees of freedom. When the assumptions of the Student's t-test are not met, the Welch t-test can be used as a parametric alternative. The t statistic in question may be calculated by Equation (2.3). Some statistical software calculates the Welch t-test value using a formula that differs from the generally accepted one. For instance, IBM SPSS software calculates degrees of freedom with Equation (2.4), while Minitab software calculates degrees of freedom according to Equation (2.5).

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \tag{3}$$

$$S.D. = \frac{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)^2}{\frac{\left(\frac{S_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{S_2^2}{n_2}\right)^2}{n_2 - 1}} \tag{4}$$

$$S.D. = \frac{(VAR_1 + VAR_2)^2}{\left(\frac{VAR_1{}^2}{n_1 - 1} + \frac{VAR_1{}^2}{n_2 - 1}\right)} \tag{5}$$

Mann – Whitney U test

In the comparison of two independent groups, in cases where the assumptions of the t-test, which is a parametric test, are not met, that is, the distribution is not normal or the distribution type of the feature in question is not known, the non-parametric Mann Whitney U test is used (Mendes 2012). The working principle of the Mann-Whitney U test is to test whether the two groups represent samples from the same population, according to the group medians.

Observations belonging to two groups, A and B, are brought combined into a single group (nA+ nB = N). After the observations are ranked with ordinal scores from 1 to N, U-test statistics are calculated through Equation (2.6) and Equation (2.7).

$$n_A > n_B : U = T_A - \frac{n_A(n_A + 1)}{2} \tag{6}$$

$$n_A < n_B : U = T_B - \frac{n_B(n_B + 1)}{2} \tag{7}$$

Since the U test statistic shows a uniform distribution, it provides the determination of the critical value necessary for testing the H_0 hypothesis. If the said U test statistic value is greater than the critical value, the H_0 hypothesis is rejected, meaning that these two groups do not represent the same population (McKnight and Najab 2009; Zar 1984).

To evaluate whether all tests are conservative to various simulation combinations, Bradley's criterion of robustness was considered. The results of Bradley's (1978) study indicate that when testing at the significance level of 5.00%, a robust test's actual Type I error rate should be between 4.50% and 5.50%. Furthermore, Murphy and Myors (2014) reported that a power level that reaches or exceeds 80% is typically considered to be adequate. Therefore, we will consider 80% is a standard for sufficiency in test power.

3. Results

Type I error rates in simulation scenarios where the number of observations in both groups is balanced ($n_1 = n_2$) 8, 15, 25, 35, 45, 65, and variance ratios are 1:1, 1:3, 1:5, 1:10, it is given in Table 2 as a percentage. When the variance ratios are equal in a 1:1 ratio, the type I error rate has consistently remained at 5% across all three tests in the simulation design with equal observations. It has been remarked due to the increase in the number of observations.

In the case of a 1:3 ratio where the variance ratio deviates from homogeneity, the type I error rates seemed robust according to Bradley's criterion of robustness. The Welch's t-test only satisfied Bradley's criterion for robustness in all sample sizes when the variance ratios were 1:1.5. When the variance ratio was 1:10, the type I error rates calculated after conducting the Student t-test and Mann-Whitney U test for all sample sizes exceeded the Bradley's criterion. However, the type I error rates seemed conservative after conducting Welch's t-test.

Table 2. The type I error rates at various variance ratios occur when the number of observations is equal.

n	$\sigma^2:\sigma^2$	S_t	W_t	MWU
(8,8)	1:1	5.0	4.9	5.0
	1:3	5.4	5.0	5.4
	1:5	5.8	5.2	6.1
	1:10	6.0	5.1	6.8
(15,15)	1:1	4.9	4.9	4.5
	1:3	5.2	4.7	5.3
	1:5	5.7	5.0	5.9
	1:10	6.1	5.1	6.6
(25,25)	1:1	5.0	5.0	4.7
	1:3	5.4	5.0	5.4
	1:5	5.6	4.9	5.8
	1:10	6.1	5.1	6.8
(35,35)	1:1	5.0	5.0	5.0
	1:3	5.5	5.1	5.5
	1:5	5.6	4.9	5.9
	1:10	6.2	5.2	6.8
(45,45)	1:1	4.9	4.9	4.9
	1:3	5.3	4.9	5.3
	1:5	5.7	5.0	5.8
	1:10	6.2	5.2	6.6
(65,65)	1:1	5.0	5.0	4.9
	1:3	5.5	5.1	5.5
	1:5	5.5	4.9	5.7
	1:10	6.2	5.2	6.6

S_t: Student – t-test, W_t: Welch – t-test, MWU: Mann – Whitney U test, n: Number of observations

The type I error rates in simulation designs where the number of observations per group is unbalanced ($n_1 \neq n_2$) and variance ratios are 1:3, 1:7, 3:1, and 7:1, it is given in Table 3 as a percentage. Across all the combinations of variance ratios and sample sizes we tested, Welch's t-test yielded results that satisfied the Bradley's criterion of robustness. Similar to Bindak's (2014) study, cases such as positive and negative associations were also tried. Based on the results of the large variances and large sample sizes simulations (positive association), Student – t test did not satisfy Bradley's criterion. Yet, Mann – Whitney U test seemed robust with increasing number of observations. In the case of the large variance in small sample sizes (negative association), the Student – t and Mann – Whitney U tests exceeded the Bradley's criterion and seemed non-robust. Welch's t-test produced conservative results for all sample size and associations of variances.

Table 3. The type I error rates at various variance ratios occur when the number of observations is not equal.

n	σ^2: σ^2	S_t	Wt	MWU
(8,15)		2.5	4.8	3.2
		1.7	5.0	3.3
		9.5	5.2	7.3
		13.3	5.3	9.4
(15,20)		3.7	4.9	4.1
		3.3	5.1	4.7
		6.9	5.0	6.1
		8.5	5.2	7.7
(20,27)	1:3	3.7	5.1	4.6
	1:7	3.1	5.0	4.8
	3:1	7.2	5.1	6.6
	7:1	8.5	4.9	7.9
(35,45)		3.8	5.1	4.8
		3.3	5.0	5.2
		6.5	4.9	6.3
		7.7	5.0	7.7
(50,60)		4.0	5.0	5.1
		3.7	5.0	5.7
		6.2	5.0	6.1
		6.8	5.0	7.6

S_t: Student – t-test, W_t: Welch – t-test, MWU: Mann – Whitney U test, n: Number of observations

Table 4 presents the rejection rates of the null hypothesis (i.e., the results related to the test power) as a percentage when there are certain differences between group means. Assuming homogeneous variances and a standard deviation difference of 0.75, the power values for all tests remained below 80% until the sample sizes of the groups reached 25. The test power exceeded the desired power of 80% except for the Mann – Whitney U test when the sample sizes are 30. Furthermore, the power values for all three tests exceed 90%, when the difference between population means in standard deviation 1 and sample size is 25. The test power values exceeded 90% in small sample sizes due to the increase in standard deviation difference. It is more pronounced when the standard deviation difference is 1.5. For instance, while the sample size is 10 in both groups, the test powers calculated after all three tests is exceeded the desired level of 80%. When the sample size is 45, the power values calculated could reach 100%.

Table 4. The test powers when the number of the observations in the groups is equal and variances are homogenous.

Δ	0.75			1			1.5		
n	S_t	W_t	MWU	S_t	W_t	MWU	S_t	W_t	MWU
(8,8)	28.59	27.89	27.2	46.19	45.29	43.95	79.87	79.14	77.22
(10,10)	35.51	34.93	31.53	55.92	55.41	50.94	88.41	88.10	84.96
(15,15)	50.6	50.3	46.98	75.51	75.32	71.63	97.71	97.69	96.71
(25,25)	73.7	73.64	70.63	93.38	93.36	91.74	99.93	99.93	99.88
(30,30)	81.44	81.41	79.04	96.91	96.90	95.94	99.99	99.99	99.99
(45,45)	94.11	94.11	92.93	99.72	99.72	99.58	100	100	100

S_t: Student – t-test, W_t: Welch – t-test, MWU: Mann – Whitney U test, n: Number of observations, Δ: Standard deviation differences

4. Discussion

In balanced simulation designs where the number of observations in the groups is equal and the variances are homogeneous, all methods met Bradley's criterion. However, when the assumed population variances of the groups deviated from the homogeneity, the Student t-test and Mann-Whitney U test increased the type I error rate and still seemed conservative. The Welch's t-test successfully maintained the type I error rate of 5% for all sample sizes and seemed conservative. In terms of these findings, our study's results are consistent with the studies of Derrick et al. (2016), Kasuya (2001), and Ruxton (2006).

In the unbalanced simulation designs where the number of observations in both groups was not equal, positive, and negative associations of variances were tested. For all combinations, Welch's t-test yielded results very close to the type I error rate determined at the beginning of the experiment 5% and may be definable as conservative. These findings are consistent with the studies of Ahad and Yahaya (2014), Bindak (2014), and Ruxton (2006).

When considering the power values, the Student t-test and Welch's t-test performed better than the Mann-Whitney U test, especially for small sample sizes. The reason for the Mann-Whitney U test having such a trend could be the assumption that the populations from which we took our groups were normally distributed. This result is similar to the study conducted by Bindak (2014). While the variances were homogeneous for the Student's t-test, a desired power value of 80% could be achieved with sample sizes of 30, 25, and 15 for all differences in standard deviations, respectively. Aslan et al. (2021) reported that to achieve a test power of 80-90% for the t-test with effect sizes of 0.75, 1, and 1.5, sample sizes of 33, 23, and 13 were required, respectively. In addition, Koskan et al. (2022) demonstrated that as the standard deviation differences between two treatments increase, the minimum sample sizes required to achieve a test power of 85-95% were decreased. These results are consistent with our findings.

In this study, the Student t-test, Welch's t-test, and Mann-Whitney U test were evaluated in terms of both Type I error rate and test power in two groups assumed to be normally distributed. Especially, it was noteworthy that Welch's t-test was more conservative in terms of type I error than the other tests. In terms of power values, it is seen that the Student t-test is more powerful than the Mann-Whitney U test, especially for small sample sizes. Therefore, the distributions of the populations from which the groups were assumed to be taken should be investigated by creating distributions with more skewed distributions.

5. Conclusions

In the present study, consistent with the literature, it was observed that the power values of all tests increased as expected when the number of observations in the groups and the differences in standard deviation between the group averages increased. All statistical tests produced similar results in terms of test power. Again, if the distribution is normal and the variances are homogeneous, it is seen in parallel with the literature that all tests preserve the type I error at the level of 5%. When the homogeneity of variances starts to be violated, it is observed that the type I error values of the Mann-Whitney U test are higher than 5%. In addition, Welch's t-test is better than other tests (Student – t, and Mann – Whitney U) in unbalanced designs for preserving the type I error rate at the level of 5%. The Student – t test is more powerful than Mann – Whitney U test, especially when studied with a small sample size. In conclusion, it should be investigated how this situation changes by constructing the distributions of the assumed populations from which the groups are taken to have more skewed distributions.

In real life, according to the literature, the most commonly used and reliable statistical method for comparing two groups is the Student t-test when the assumptions were met. Although the effectiveness of the t-test decreases relatively when the assumptions were not met, the Mann-Whitney U test is commonly used

in such cases. The Welch t-test, which is independent of the assumptions, has been shown to be an alternative to the other two methods in terms of both type I error rate and test power. It is observed to produce better results in some extreme cases. Therefore, in real-life applications, using Welch t-test as an alternative to these two methods is recommended.

Author Contributions: Conceptualization, M.E. and O.K.; methodology, M.E.; software, M.E.; validation, M.E., and O.K.; investigation, M.E.; writing—original draft preparation, M.E.; writing—review and editing, M.E. and O.K.; supervision, O.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 232-241 DOI:10.15316/SJAFS.2023.023 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Rhizobacteria Increases Growth and Development of Blackberry Saplings

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HIGHLIGHTS

- The results show that the applications have a positive effect on vegetative characteristics. SK-39, SK-50 and SY-43 bacterial strains increased the plant height and shoot length, SK-39 and SY-43 bacterial strains increased shoot diameter, SK-50 and SK-39 increased plant fresh weight, SK-50 increased plant dry weight. Treatments increased the root wet weight, SK-50 and SK-39 strains increased the root dry weight.
- Applications increased the leaf N, P, K, Ca, S, Zn, Cu and Na content while bacterial treatments reduced leaf Mn contents.
- Applications significantly increased the amount of leaf IAA, GA, cytokinin and zeatin content in the leaves, while decreased ABA content.

Abstract

In this study, the effects of rhizobacteria on vegetative growth of Chester Thornless blackberry cultivars saplings were investigated. In this context, plant height, shoot number, stem diameter, average shoot length, root length, plant fresh and dry weight, root fresh and dry weight, IAA, ABA, GA, cytokinin, zeatin hormones and N, P, K, Ca, Mg, S, Mn, Fe, Zn, Cu, Na nutrients were investigated. According to the evaluations, the highest plant fresh and dry weights and root fresh and dry weights were obtained from the SK50 bacteria strain. It was determined that plant height, stem diameter, average shoot length and root length maximum increased with SK-39 strain. Bacteria applications increased the IAA, GA, cytokinin and zeatin contents and decreased the ABA content in the leaves. With bacteria applications, leaf N, P, K, Ca, S, Zn, Cu and Na contents increased compared to control. According to the results of the research, it can be recommended to use *Herbaspirillum huttiense* SK-39, *Achromobacter xylosoxidans denitrificans* SK-50, *Pantoea agglomerans* GC subgroup SY-43 and *Microbacterium ester aromaticum* SY-48 bacteria strains in order to promote growth and development in the cultivation of blackberry cultivars.

Keywords: Blackberry; Rhizobacteria; Growth; Development

1. Introduction

Blackberry, which has a unique taste, color, and aroma like many berry fruits, is a member of the Rubus genus of the Rosaceae family. The fruits of the blackberry, which has a bushy feature, are juicy, soft, and edible.

Citation: Ameen ZAA, Pirlak L, Khalee AJK, Metin T, Dönmez MF (2023). Rhizobacteria Increases Growth and Development of Blackberry Saplings. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 232-241. https://doi.org/10. 15316/SJAFS.2023.023
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Received date: 15/10/2022
Accepted date: 10/03/2023

This type of fruit, which has a high economic value, is used in different ways such as jam, fruit juice, frozen fruit and cake production in the food industry (Ağaoğlu, 1986).

Pigments, phenols, flavones, flavonoids, vitamins, and fibers in blackberries, which contain high levels of antioxidants, are of great importance for human health. It has been determined in studies that these substances are higher than many fruit species such as banana, apple, and pear (Ravai, 1996; Kähkönen et al., 1999; Halvorsen et al., 2002).

In parallel with the increase in the world population, the need for food also increases and in order to meet this need, it is necessary to take measures to in-crease the yield in plants. It is known that chemical and synthetic substances applied to plants in agricultural areas adversely affect the natural balance, human and animal health and soil fertility by negatively affecting the environment. With the excessive and unconscious use of synthetic materials, the physical and chemical quality characteristics of agricultural soils deteriorate, soil and waters are polluted with toxic substances. Such problems can lead to the destruction of agricultural lands, which are important for the healthy and balanced nutrition of future generations, and to a decrease in the productivity of our lands. For this reason, organic fertilizers and various biological organisms are used for fertilization. Examples of these are farm manure, vermicompost, bat manure, bacteria, and mycorrhizae.

Bacteria can be applied to plants from roots or leaves, and it is seen among the promising applications especially in agricultural production. In agricultural areas, beneficial bacteria are used to increase the resistance of plants to biotic and abiotic stress factors, to accelerate plant growth and to increase yield.

Rhizobacteria, one of the most abundant microorganisms in the rhizosphere, have been reported as bacteria that are specific to the rhizosphere and colonize plant roots (Antoun and Kloepper, 2001). Approximately 2-5% of rhizobacteria have a beneficial effect on plant growth when reapplied to a soil containing competitive microflora and are therefore called plant growth-promoting rhizobacteria (Kloepper, 1978).

The use of rhizobacteria that promote plant growth is gaining worldwide importance and acceptance and looks promising for the future. Rhizobacteria, which promote plant growth, are also known to create resistance to various plant pathogens in crops such as cereals, legumes, ornamentals, vegetables, spices, and some perennial plants (Antoun and Prévost, 2005).

The use of biofertilizers consisting of beneficial microorganisms instead of synthetic chemicals in-creases plant growth, prevents damage to the environment and protects soil fertility (O'Connell, 1992). It is reported that there are many bacterial species living in common with plants in the plant root zone, and some of them increase yield and quality in plants. These bacteria, which belong to the genera Acinetobacter, Alcaligenes, Arthrobac-ter, Azospirillium, Azotobacter, Bacillus, Beijerinckia, Burkholdria, Enterobacter, Erwinia, Rhizobium and Serrotia, are named as 'Plant Growth Promoting Bacteria' (Rodriguez and Fraga, 1999, Nowak and Struz ve Struz, 2000; Sudhakar et al., 2000). Studies have shown that these bacteria increase plant growth and yield in many fruit species (Kloepper, 1989; De Silva et al., 2000; Sudhakar et al., 2000; Del Carmen Jaizme-Vega et al., 2004 Eşitken et al., 2006; Pırlak et al., 2007; Aslantaş et al., 2007; Pırlak and Köse, 2009; Eşitken et al. 2010; Arıkan and Pırlak, 2014; Ramos-Solano et al., 2014; García-Seco et al., 2015; Pırlak et al., 2020). Many bacterial species belonging to the genera Bacillus, Azotobacter, Azospirillum, Beijerinckia and Pseudomonas have nitrogen fixing properties (Reis et al., 1994). It was determined that the nitrogen fixing bacteria provided increases in plant growth and yield with foliar application in mulberry (Sudhakar et al., 2000), sweet cherry (Eşitken et al., 2006) and apple (Pırlak et al., 2007). It is also reported that bacteria promoting plant growth increase the synthesis of growth regulators in plants (Zahir et al., 2004).

This study was conducted to investigate the effects of some rhizobacterial strains that promote plant growth on growth and development of blackberry saplings.

2. Materials and Methods

2.1. Materials

The research was conducted in the Research and Application Greenhouses of the Department of Horticulture, Faculty of Agriculture, Selcuk University in 2021.

Chester Thornless blackberry saplings produced by tissue culture method were used as material.

Chester Thornless: A very vigorous, productive, large fruited, late maturing, moderately winter-hardy and thornless blackberry variety introduced in the USA in 1985. Chester Thornless is more productive than Hull Thornless and is similar in fruit size, col-our, firmness, quality, and seed size. On hot, sunny, and humid days, its fruit does not soften and lose its color as quickly as the fruits of other thornless semi-erect varieties (Galletta et al., 1998).

In the study, bacteria strains *Herbaspirillum huttiense* SK-4, *Herbaspirillum huttiense* SK-39, *Achromobacter xylosoxidans denitrificans* SK-50, *Pantoea agglomerans* GC subgroup SY-43 and *Microbacterium ester aromaticum* SY-48 were used. Bacteria were obtained from Iğdır University, Faculty of Agriculture, Department of Plant Protection. Determined characteristics of bacterial strains are given in Table 1.

Table 1. Determined characteristics of bacteria strains

Bacteria strains	N*	K*	Ca*	P*
SK-4	+	+	S^+	S^+
SK-39	S^+	+	+	S^+
SK-50	S^+	+	+	S^+
SY-43	S^+	+	W^+	S^+
SY-48	+	S^+	+	+

N: Nitrogen fixing, K: Potassium dissolving, Ca: Calcium using, P: Phosphorus dissolving, S+: Strong positive, W+: Weak positive, +: Positive

2.2. Methods

Bacteria used in the experiment were planted on Nutrient Agar in Iğdır University Faculty of Agriculture Department of Plant Protection laboratories and kept at 30°C for 24 hours. After the soaking process, a suspension was formed from the bacterial cultures in Nutrient Broth. The application of bacteria to plants was done at a density of 109 CFU ml-1 (Esitken et al., 2006).

Bacteria were first applied to the roots before planting, and then a total of 6 applications were made, 5 times with a one-month interval. After root pruning and cleaning of the seedlings in inoculation, the roots were kept in the bacterial suspension for 30 minutes. After bacterial inoculation, the saplings were planted in 12-liter pots containing soil: sand: fermented manure at a ratio of 2:1:1. The bacteria applications of the saplings planted in March were repeated in April, May, June, July, and August by pouring bacterial suspensions into the pots.

The following measurements and analyzes were made on the saplings removed at the end of the growing season.

The plant height of the saplings was measured with the help of a tape measure from the soil level. The number of bottom shoots of the saplings was deter-mined by counting. The shoot length of the seed-lings was measured with a tape measure. At the end of the experiment, wet weight measurements were taken by cutting the shoots determined before the experiment with the help of scissors and then kept in an oven at 72°C for 48 hours and their dry weights were weighed using precision balances. The diameters of the shoots were measured with the help of digital caliper. At the end of the experiment, the wet weight of the root parts of the

plants removed from the pots was taken and then, after 48 hours in an oven at 72°C, their dry weights were weighed using precision balances. At the end of the experiment, the root length of the plants removed from the pots was measured with a tape measure (Ipek et al., 2014).

After the leaf samples were taken for nutrient analysis, they were brought to the laboratory, washed, and then dried at 65-70°C. The dried leaves were ground in a porcelain mortar and then the micro-Kjeldahl method was used for N determination, the vanado-molybdic yellow color method for P analysis, and the Mohr method for Cl analysis. The analyzes of K, Ca, Mg, Mn, Fe, Zn, Cu, B, Na nutrients were per-formed with the ICP device (Soltanpour et al., 1979).

For the analysis of plant growth regulators, 0.1 g leaves were homogenized and poured into 1.5 ml vials, by adding 500 µl 1-propanol/Water/HCL (2/1/0.002) solution and 10-50 ng internal standard, at 4°C for 30 minutes was kept. Then 1 ml of di-chloromethane was added and incubated at 4°C for 30 min. At the end of this period, it was centrifuged at 13000 xg for 5 minutes and 1 ml of the lower phase was evaporated and dissolved again with 0.3 ml of methanol. Growth regulator analyzes were performed with LC-MS/MS device (Pan et al., 2008).

2.3. Evaluation of data

The research was established according to the randomized plots experimental design, each application with 3 replications and 5 saplings for each replication. The data obtained from the research were subjected to the Duncan multiple comparison test and the analyzes were made at the 5% significance level. SPSS 23 package program was used for analysis.

3. Results

3.1. Effects of applications on vegetative characteristics

The effect of applications on plant height was found to be statistically significant. SK-39, SK-50 and SY-43 bacterial strains increased the plant height com-pared to the control, and the highest increase occurred with SK-39 bacteria application (Table 2).

Table 2. Effects of bacteria applications on vegetative properties

Treatments	Plant height (cm)	Shoot number per plant	Shoot length (cm)	Shoot diameter (cm)	Plant fresh weight (g)	Plant dry weight (g)
Control	49.40 c*	6.40 a	28.17 c	3.08 c	10.92 cd	8.76 bc
SK-4	48.00 c	4.40 c	29.23 c	3.35 bc	9.96 d	7.18 d
SK-39	55.20 a	5.20 bc	34.86 a	4.99 a	12.50 b	9.35 b
SK-50	52.60 ab	6.00 ab	33.46 b	3.64 bc	14.14 a	11.06 a
SY-43	52.60 ab	4.60 c	32.69 b	3.79 b	11.36 c	8.78 bc
SY-48	50.60 bc	6.20 a	27.09 d	3.31 bc	10.18 d	8.26 c
LSD	2.81	0.77	1.06	0.64	1.02	1.00

*: There is no difference between the averages shown with the same letter in the same column

The effects of bacteria applications on the number of shoots were found to be statistically significant. Bacterial treatments reduced the number of shoots compared to the control. While the number of shoots decreased in SK-4, SK-39, SY-43 applications compared to the control, there was no change in the number of shoots in SK-50 and SY-48 applications compared to the control.

The effect of the applications on the shoot length was found to be statistically significant. SK-39, SK-50 and SY-43 bacteria strains increased shoot length compared to the control, and the highest increase occurred with SK-39 bacteria application.

The effect of bacteria applications on shoot diameter was found to be statistically significant. SK-39 and SY-43 bacterial strains increased shoot diameter compared to control, but the effects of other treatments were not significant.

The effects of bacteria applications on "Chester Thornless" blackberry cultivar on plant fresh and dry weights were found to be statistically significant. SK-50 (14.14 g) and SK-39 (12.50 g) bacteria strains increased plant fresh weight compared to the control, while the effects of other treatments were found to be insignificant. While there was an in-crease in the dry weight of the plant only in the ap-plication of SK-50 (11.06 g) compared to the control, there was a decrease in the application of SK-4 (7.18 g) compared to the control. The effects of other applications were found to be insignificant.

The results show that the applications have a positive effect on vegetative characteristics. The effect of these bacteria promoting plant growth on increasing the sapling height can be explained by the growth promoting substance synthesis of rhizobacteria. In addition, nitrogen is required to support shoot growth. In this respect, the strong N-fixing properties of SK-39, SK-50, and SY-43 bacterial strains, which have the most increasing effects on plant and shoot length (Table 1), support the obtained result. In a study conducted on apple seedlings, it was determined that rhizobacteria increased the sapling height (Parıltı, 2018). In addition, studies on different fruit species have reported that growth-enhancing bacterial strains significantly increase vegetative development (Eşitken et al., 2006; Aslantaş et al., 2007; Karlıdağ et al., 2007; Karakurt and Aslantaş, 2010; Coşkun and Pırlak, 2017; İpek et al., 2017b).

The effects of bacteria applications on root fresh and dry weights of "Chester" blackberry cultivar were found to be statistically significant. Except for the SY-48 bacterial strain, the treatments increased the root wet weight compared to the control. The highest increase was detected in the SK-50 application (94.42 g). The positive effect of bacteria strains on root dry weight was more limited. While SK-50 and SK-39 bacterial strains increased the root dry weight compared to the control, there was no change in other applications compared to the control (Table 3).

Table 3. Effects of bacteria applications on some root properties.

Treatments	Root fresh weight (g)	Root dry weight (g)	Root length (cm)
Control	65.76 e*	57.91 cd	65.20 b
SK-4	76.94 c	58.06 c	57.20 c
SK-39	79.70 b	66.38 b	69.60 a
SK-50	94.42 a	74.08 a	65.60 b
SY-43	72.24 d	56.91 cd	55.60 c
SY-48	61.62 f	55.88 d	73.00 a
LSD	2.36	2.00	6.59

*: There is no difference between the averages shown with the same letter in the same column

There are differences between the effects of bacteria applications on root length. SY-48 and SK-39 bacteria strains increased root length compared to con-trol, SK-4 and SY-43 decreased, and SK-50 did not cause any change compared to control. The application that increases the root length the most is SY-48. Similarly, in studies examining the effects of different bacteria strains on vegetative properties in rasp-berry and blackberry, it was reported that some bacteria increased root length and root fresh and dry weight compared to control, while others decreased (İpek et al., 2018; İpek and Eşitken, 2022).

3.2. Effects of Applications on Nutrient Content

The effects of bacteria applications on the macro and micronutrient contents of the examined leaves were found to be statistically significant, except for Mg (Table 4). Accordingly, applications increased the leaf N content significantly compared to the control, and the highest increase was determined in SY-43 and SK-39 bacterial strains. Similarly, leaf P contents increased with bacteria applications, and the applications that provided the highest increase were SK-50 and SK-39. Leaf K contents also in-creased with applications. The highest leaf K con-tents were determined in SK-4 and SK-39 bacteria applications. Ca contents also increased significantly with the applications, and the highest Ca contents were determined in SK-50 and SY-42 bacteria strains. The effects of bacteria applications on leaf Mg contents were found to be statistically insignificant. Applications also increased the leaf S contents in general compared to the control, and the highest increases were detected in SK-50 and SY-48 breeds. Bacterial treatments reduced leaf Mn contents. There are differences between the effects of applications on leaf Fe content. SK-50 bacteria strain increased the leaf Fe content compared to the control, decreased SY-43, SY48 and SK-39, and there was no change in SK-4 compared to the control. Applications significantly increased the leaf Zn content; the highest increase was determined in SK-39 bacterial strain. Likewise, the leaf Cu content increased as a result of the applications. The highest leaf Cu content was determined as 7.06 ppm in SK-4 application. The applications also increased the Na content of the leaves, and the highest increase was determined in the SK-50 bacterial strain. Leaf Na content, which was 109.54 ppm in the control, in-creased to 248.21 ppm in the SK-50 application.

It was determined that all bacteria strains used in this study increased all the nutrients examined in blackberry leaves, except for iron and manganese. Indeed, Somers et al. (2004) reported that bacteria that increase plant growth facilitate the uptake of nutrients by plants. Since the nitrogen fixing, potassium dissolving, calcium utilization and phosphorus dissolving properties of the bacteria used were determined as positive and strongly positive (Table 1), it is an expected result that they increase their in-take of this element. Mulberry (Sudhakar et al., 2000), strawberry (Köse, 2003), sour cherry (Arikan and Pirlak, 2016), pear (Ipek et al., 2017a), apple (İpek et al., 2017b) and It has also been reported in studies on raspberry (Ipek, 2019).

Table 4. Effects of bacteria applications on leaf nutrient content.

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Mn (ppm)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
Control	2.33 b*	0.19 b	1.56 c	0.76 b	0.19 a	0.13 b	30.93 ab	87.11 b	10.37 c	3.97 c	109.54 e
SK-4	2.90 a	0.29 a	2.25 a	0.98 ab	0.28 a	0.16 ab	34.06 a	86.15 b	16.68 b	7.06 a	148.91 d
SY-43	3.19 a	0.27 ab	2.03 ab	1.12 ab	0.23 a	0.16 ab	28.82 bc	73.80 c	15.52 b	6.75 a	164.42 cd
SY-48	2.68 ab	0.27 a	1.76 bc	1.03 ab	0.27 a	0.21 a	21.67 d	75.11 c	16.51 b	5.63 b	189.66 bc
SK-39	3.09 a	0.31 a	2.11 ab	1.07 ab	0.22 a	0.18 ab	23.74 cd	78.77 c	18.26 a	6.65 a	208.10 b
SK-50	2.82 ab	0.34 a	2.04 ab	1.22 a	0.22 a	0.23 a	27.15 bc	100.35 a	16.69 b	6.58 a	248.21 a
LSD	0.56	0.09	0.45	0.37	0.16	0.07	4.10	5.58	1.57	0.93	25.76

*: There is no difference between the averages shown with the same letter in the same column

3.3. The Effect of Applications on the Amount of Plant Growth Regulators

Indole acetic acid (IAA), gibberellic acid (GA), cytokinin, zeatin and abscisic acid (ABA) amounts were determined in leaf samples taken from plants belonging to Chester blackberry variety. The effects of bacteria applications on the amount of growth regulators were found to be statistically significant (Table 6). Applications significantly increased the amount of leaf IAA compared to the control, and the highest increases were detected in SK-39 and SY-43 breeds. Similarly, bacteria applications also in-creased the leaf GA contents, and the highest GA content was determined in SY-48 application. Ap-plications also significantly increased

the cytokinin content in the leaves. Compared to the control, the highest increases occurred in SY-48 and SK-39 breeds. Applications also increased the leaf zeatin content in general. While an increase was observed in the SK-4, SY-43, SY-48 and SK-39 applications compared to the control, the SK-50 application was statistically in the same group as the control. Applications increased leaf IAA, GA, cytokinin and zeatin contents, while significantly decreased ABA content. All bacteria strains decreased the leaf ABA content compared to the control, and the ABA content, which was 10282 ng mg-1 in the control, de-creased to 1647 ng mg-1 in the SK-50 application.

Table 5. Effects of bacteria applications on the amount of plant growth regulators.

Treatments	IAA (ng mg^{-1})	GA (ng mg^{-1})	Sitokinin (ng mg^{-1})	Zeatin (ng mg^{-1})	ABA (ng mg^{-1})
Control	1.78 d*	3.06 d	2.45 d	1.18 d	10281 a
SK-4	3.20 c	5.34 b	6.73 c	2.77 a	5636 b
SK-39	7.41 a	6.82 a	11.66 a	2.07 bc	1819 d
SK-50	4.85 bc	4.08 c	6.31 c	1.57 cd	1647 d
SY-43	7.14 a	6.54 a	10.48 b	2.59 ab	4113 c
SY-48	5.26 ab	6.90 a	12.25 a	2.34 ab	2633 d
LSD	1.48	0.99	0.77	0.59	16.76

*: There is no difference between the averages shown with the same letter in the same column

According to the findings obtained in this study, it was determined that bacteria applications decreased ABA. It has also been reported in previous studies that rhizobacteria indirectly contribute to plant development by affecting the production of hormones such as indole acetic acid, cytokinin and zeatin (Lindow and Brandl, 2003; Vorholt, 2012; İmriz et al., 2014).

4. Conclusions

According to the findings, the bacterial strains used in the research generally increased plant and root growth, encouraged nutrient uptake, increased growth-promoting hormones, and decreased the amount of inhibitors.

When all data are evaluated, the use of *Herbaspirillum huttiense* SK-39, *Achromobacter xylosoxidans denitrificans* SK-50, *Pantoea agglomerans* GC subgroup SY-43 and *Microbacterium ester aromaticum* bacteria in order to promote growth and development in the cultivation of blackberry saplings.

Author Contributions: Conceptualization, L.P. and Z.A.A.A.; methodology, Z.A.A.A., M.T., M.F.D.; validation, L.P., A.J.K.K.; formal analysis, L.P., A.J.K.K.; resources, Z.A.A.A.; writing—original draft preparation, Z.A.A.A., L.P., A.J.K.K.; writing—review and editing, Z.A.A.A., L.P., A.J.K.K. All authors have read and agreed to the published version of the manuscript.

Funding: Please add: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 242-247 DOI:10.15316/SJAFS.2023.024 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Investigation for Mutation in BMPR-1B (FecB) Fecundity Gene in Awassi Sheep

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HIGHLIGHTS

- Ovulation rate and litter size are important economic traits in sheep breeding.
- *Booroola (FecB)* is the first major gene identified in sheep has major effects on reproduction.
- One copy of *Booroola* gene increases the ovulation rate at 1.65 and 1.0 litter size.
- To investigate *FecB* mutation in Awassi sheep, BMPR-1B gene was amplified and analyzed.

Abstract

Reproduction related traits in sheep such as ovulation rate and litter size are traits of high economic importance but as these traits are only expressed in one sex and in mature animals, thus inclusion of them in selection strategies is limited. Therefore, studying genes associated with reproductive events provides genotypic data, which is more useful in genetic improvement of sheep in a short period of time. Such reproductive traits in sheep are genetically controlled by genes having both additive and major effects. *Booroola* is the first gene identified in Booroola Merino sheep in Australia has major effects on ewe's reproduction and has gained much popularity in sheep breeding for its immense economic value. *Booroola* or *Bone Morphogenetic Protein Receptor -1B (BMPR-1B)* gene is in chromosome 6 and *FecB* allele is the result of a single mutation in this gene where one copy of this allele results in a significant increase in ovulation rate thus outcome as increased lambing per parturition. The Awassi sheep is an indigenous breed of Turkey and identifying major genes for fecundity could greatly improve their breeding program. To identify the *FecB* gene in Awassi sheep, 88 blood samples were taken, and DNA was extracted by salting out method. After PCR amplification and *Ava*Π digestion, the samples were analyzed for *FecB* mutation and all of 88 samples were found not to carry the mutant allele (*FecB*).

Keywords: Awassi; BMPR-1B gene; Booroola; Litter size; PCR-RFLP

1. Introduction

Sheep has been a prominent member of livestock since the beginning of the known history and play a significant role in agricultural production. Sheep provides meat, milk and most importantly wool for satisfying the daily needs of humans. Apart from poultry, it is considered that there are more breeds of sheep

Citation Gedik Y (2023). Investigation for Mutation in BMPR-1B (FecB) Fecundity Gene in Awassi Sheep. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 242-247. https://doi.org/10. 15316/SJAFS.2023.024
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Received date: 19/10/2022
Accepted date: 27/03/2023

than any other livestock species with around 1155 different breeds worldwide (FAO 2015). Awassi is the most populous and ubiquitous fat tailed sheep breed in south-west Asia. It is the most common sheep breed in Iraq, Syria, and the sole indigenous sheep breed in Lebanon, Jordan, and Israel (FAO 1982). Awassi is used for production of meat, milk, and wool and has been brought to more than 30 countries on all seven continents (Galal et al. 2008). The superiority of Awassi from other breeds includes, it's diseases and parasites resistance, ability to walk long distances for grazing, strong flock instinct, well adaptation to management fluctuations, and tolerance to harsh environmental conditions, particularly those related to feed scarcity and hot weather conditions (Talafha and Ababneh 2011). In Turkey, Awassi sheep is known as Ivesi (FAO 1982) or Sarıbaş or Arabian sheep which constitutes 3.9 percent of the total sheep population and widely bred in Şanlıurfa, Gaziantep, Kilis and Hatay provinces (TİGEM 2020). Awassi ewes produce 196.5 ± 5.60 kg milk in a lactation period of 184.3 ± 2.11 days (Üstüner and Oğan 2013). Fertility, lambing rate, average litter size and twinning rate were found 89.8%, 108.2%, 1.30-1.40 and 20.5%, respectively in Turkish Awassi sheep populations (Üstüner and Oğan 2013; Gürsel et al. 2011). A recent report shows that the twinning rate of Awassi sheep in government farms is 20-30 percent and this rate increases to 35-40 percent in elite herds (TIGEM 2020).

Reproduction in sheep is both influenced by minor and major genes (Jamshidi et al. 2013). In 1980, *Booroola* gene (*FecB*) was identified as the first single major gene responsible for prolificacy in Booroola Merino sheep by analyzing their litter size records (Piper and Bindon 1983) and now it is believed that *FecB* was primarily originated in India's Garole breed (also knowun as Bengal) habituated in harsh surroundings of Sundarban (Jansson 2014; Fogarty 2009; Davis et al. 2002). The following research has revealed that a group of genes known as the fecundity (*Fec*) genes can govern the ovulation rate and litter size of sheep genetically. From now three different fecundity gene have been found in Sheep naming *bone morphogenetic protein receptor type IB* (*BMPR-IB*) or *activin like kinase 6* (*ALK-6*) or FecB, growth differentiation factor 9 (*GDF9*) or *FecG* and *bone morphogenetic protein 15* (*BMP15*) or *FecX* located on chromosome number six, five and X respectively (Pramod et al. 2013). These three fecundity genes are members of the transforming growth factor beta (TGF-β) superfamily, derived from the ovary (Çelikeloğlu et al. 2021). Mutations in FecG and *FecX* belong to higher ovulation rates in heterozygous but complete sterility in homozygous, whereas *FecB* (*Booroola*) mutations have an additive influence on ovulation rate (Polley et al. 2010). One copy of *Booroola* gene increases the ovulation rate at 1.65 (Liu et al. 2014) and one litter size (Wilson et al. 2001). *Booroola* gene is a result of a point mutation that produces a glutamine to arginine amino acid substitution at base 746 of the coding area (746 A >G) in the highly conserved intracellular kinase signaling domain of the BMPR-1B, which can greatly enhance the ovulation rate (Liu et al. 2014). BMPR-1B is mainly expressed in sheep ovaries, although it is also found in other tissues and plays a role in follicle development. Due to abnormalities in cumulus growth and fertilization, BMPR-1B knockout mice were found to be infertile. After identification of *FecB* mutation in Booroola Merino sheep, this mutation was reported in different breeds worldwide (Liu et al. 2014).

This study aims to investigate *FecB* mutation in the *BMPR-1B* gene in high litter size Awassi sheep that is linked to a high ovulation rate in sheep by using the Polymerase Chain Reaction-Restriction-Fragment Length Polymorphism (PCR-RFLP) method.

2. Materials and Methods

This study used a total of 88 blood samples with high prolificacy records called "elite" group reared in Şanlıurfa province. No approval from research ethics committee was required to accomplish the goals of this study due to the experimental material were previously taken for another project (Scientific Research Projects (BAP) of Ankara University, Project No: BAP09B4347007). Blood was collected from the jugular vein of ewes into sterile tubes and maintained a cold chain until laboratory storage at -20 °C. DNA extraction was completed by following the salting-out method and gel electrophoresis (1%) and spectrophotometer (A260 / A280 nm) were used to analyze the quality and quantity of extracted genomic DNA.

The gene region of *BMPR-1B*, which contained the FecB mutation site, was intended to be amplified by PCR developed by Davis et al. (2002). *BMPR-IB* gene with *FecB* mutation carries an *Ava*II restriction site (G↓GACC), whereas the wild type has a lack of this restriction site. DNA was amplified in a 25 µl reaction volume using a forward primer 5'-CCAGAGGACAATAGCAAAGCAAA-3' and reverse primer 5'-CAAGATGTTTTCATGCCTCATCAACACGGTC-3'. PCR reaction mixture was prepared by adding 1.5 µl of gDNA, 2.5 µl of 10 X PCR buffer, 0.75 µl MgCl2, 0.25 µl forward and reverse primer, 1 U of Taq DNA polymerase, and finally added distilled water to reach a total volume of 25 µl. The amplification was carried out using 35 cycles at 94°C for 15 sec, 60°C for 30 sec, and 70°C for 30 sec followed by 72°C for 5 min and 99°C for 15 min. The *Ava*II digested the 190-base pair (bp) product, and the resultant products were separated by electrophoresis on a 3.5% agarose gel and observed with ethidium bromide. Noncarrier products stay uncut at 190 bp, whereas *Booroola* products digest to generate a 160-bp and 30bp fragment.

3. Results and Discussion

The PCR amplification was successfully produced 190 base pair long fragments of *FecB* gene and a 50 bp ladder was used to compare the amplified length. After amplification, PCR products were subjected to *Ava*II digestion and only 190 bp fragments appeared in gel electrophoresis (Figure 1). Thus, results revealed only the existence of the wild monomorphic genotype of the *Booroola* gene and indicated a lack of *FecB* mutation in the examined 88 Awassi ewe samples.

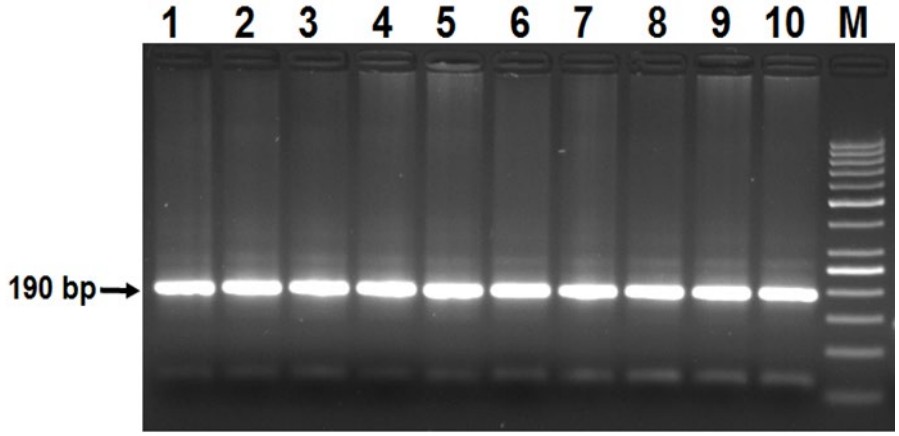

Figure 1. PCR-RFLP results of *FecB* gene by *Ava*II restriction enyzme on 3.5% agorose gel. M; Fermentas GeneRuler™ 50 bp DNA Ladder.

The results showed that there was no *FecB* mutation in the Awassi ewe samples studied, therefore all sheep were monomorphic in terms of *FecB* locus. These same samples were also investigated for Inverdale ($FecX^I$) mutation on *BMP-15* gene and reported no mutation (Gedik 2021). This finding is supported by past study of Gürsel et al. (2011) and Karslı and Balcıoğlu. (2010) where along with Awassi *FecB* was absent in indigenous Chios, Kivircik, Imrose Akkaraman, Morkaraman, Dağlıç, Tuj and Karakaş sheep breeds of Turkey. By using the PCR-RFLP method, Dinçel et al. (2015), Karslı et al. (2011), and Polat (2006) were unable to detect *FecB* gene in 71 Sakiz, 42 Kangal and 29 Güney Karaman and 406 Sakiz and Sakiz-Kivircik cross samples respectively. A recent study by Çelikeloğlu et al. (2018), used DNA base sequencing but *FecB* was not identified in 16 blood samples of Pirlak sheep. Apart from Turkey, *FecB* was absent in many prolific breeds. For example, in a study comprising samples from the world's most prolific 21 breeds and strains, the *FecB* mutation was detected exclusively in two Chinese sheep breeds Hu and Han (Davis et al. 2006). Presence of *Booroola* mutation was found in some Indian sheep breeds such as Garole, Bonpala, Kendrapada, Nilagiri, Shahabadi, Deccani, Nellore Sheep (Gootwine 2020; Liu et al. 2014). *FecB* also exists in Indonesian Javanese breed and Iranian

Kalehkoohi breed. In addition to these, some Chinese breeds such as Small-Tail Han, Merino prolific, Hu, Duolang, Zeller black, Vadi, Mongolian, Cele black, Altay, Bayanbulak have also been reported to be carriers of the productive *FecB* gene (Gootwine 2020). Thus, most *Booroola* carriers are from Asian origin whereas there is a lack of *FecB* mutation in European sheep breeds (Jansson 2014).

4. Discussion

Three different major genes were identified regulating the litter size in ewes, thus the absence of one major gene does not mean absence of other genes in a specific breed. As a result of study Awassi sheep have a lack of Booroola gene, so the reason for prolificacy in Awassi sheep with respects to major genes needs to be elucidated as some genes such as BMP15, and GDF9 not only increase litter size but also cause sterility when homozygous. When the genetic basis of Awassi sheep will be noticed it will be helpful in terms of breeding decisions. If the Awassi breed does not convey any major gene, breeding with major gene carrier breeds will also be a solution to improve production in a short period of time.

Author Contributions: The author confirms sole responsibility for the following: conceptualization, methodology, formal analysis, investigation, interpretation of results, writing—original draft preparation, writing—review and editing and visualization. The author has read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data that supports the findings of this study are available within the manuscript.

Acknowledgments: Author gratefully thanks Orhan Kavuncu (Kastamonu University, Faculty of Engineering and Architecture) for his advice in the drafting of this manuscript and Prof. Dr. Mehmet Ali Yıldız (Ankara University, Faculty of Agriculture) for technical support.

Conflicts of Interest: The author declares no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 248-257 DOI:10.15316/SJAFS.2023.025 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

The Effects of Rootstock-Scion Relationships on Yield and Quality in Grapevine cv. Ekşi Kara (*Vitis vinifera* L.)

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HIGHLIGHTS

- The nutrient uptake from the soil was at different levels when the Ekşi Kara grape variety was grown on its own roots and vine rootstocks (41 B, Rupestris du Lot and 110 R).
- Grape rootstocks affected the yield and quality characteristics of Ekşi Kara grape variety at different levels.

Abstract

Vineyards are usually established by grafting onto vine rootstocks. Vine rootstocks affect the grafted varieties directly or by environmental factors and by changing the physiology of rootstock and scion varieties. There may be great differences in mineral nutrition of grape rootstocks and grape varieties in grafted and nongrafted combinations. The choice of grape variety and vine rootstock for vineyard ecology is vital for the sustainability of viticulture, as they affect the mineral nutrient balances, biotic and abiotic stress tolerances, yield and product quality of grape rootstocks and grafted varieties, and these change with edaphic factors. This study was carried out in ~20 years old vineyards established with vines on their own roots of Ekşi Kara grape variety (Pollinator is Gök Üzüm), which is most used in production in Konya province, and seedlings grafted onto 41B, 110R and Rupestris du Lot rootstocks. The effects of rootstock and scion nutrition were searched. Yield per vine, cluster weight, cluster number, cluster length and cluster width data showed the highest values from vines on their own roots, while the order of grafted combinations changed according to the trait measured. While the differences between °Brix and total acidity (TA) values of berry were significant ($p<0.05$), differences in pH and must yield were insignificant in grafted and nongrafted combinations. Nutrient contents of leaf and root samples were different compared to grafted and nongrafted combinations. Since our study area is infested with phylloxera (*Daktulosphaira vitifoliae* Fitch) and rootstock use is obligatory, the order of preference for grapevine rootstocks was 41 B, Rupestris du Lot and 110 R, considering yield and quality characteristics.

Keywords: Grapevine; Grafting; Mineral Nutrition; Own Rooted; Quality; Rootstock Choice; Yield

1. Introduction

It is known that in grapevine rootstocks change the mineral element profile of the scion type (Cordeau, 1998; Bavaresco et al 2003). The development of cultivars Vitis vinifera under cultivation is profoundly influenced by rootstocks selected from among different Vitis species such as *V. berlandieri, V. riparia* and V. rupestris. Grapevine rootstocks are chosen by growers to provide resistance to various pathogens, tolerance to abiotic stresses such as drought, frost, lime, high salinity, and Fe deficiency, in addition to resistance to Phylloxera (Arrigo & Arnold, 2007; Corso & Bonghi, 2014). Many reports have shown that V. vinifera scion cultivars grafted onto rootstocks affect growth vigor, yield, berry development, grape quality, and wine quality (Gawel et al 2000; Ollat et al 2001; Reynolds & Wardle, 2001; Main et al 2002; Tandonnet et al 2010;

Citation: Kara Z, Yazar K, Doğan O, Akinci SPS (2023). The Effects of Rootstock-Scion Relationships on Yield and Quality in Grapevine cv. Ekşi Kara (Vitis vinifera L.). *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 248-257. https://doi.org/10. 15316/SJAFS.2023.025
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Received date: 07/10/2022
Accepted date: 12/04/2023

Gregory et al 2013). The same grape variety exhibits a different phenotype compared to the rootstock, as root characteristics (for example, water and mineral uptake and transport) strongly influence shoot and berry development at both physiological (eg stomatal conductivity affecting photosynthetic activity) and metabolic (accumulation of secondary metabolites) levels (Serra et al 2014). For this reason, it is tried to determine the most suitable scion/rootstock combinations for viticulture in a particular area (Koundouras et al 2006; Meggio et al 2014).

There are many reports of mineral uptake and distribution in vines. Varieties grafted onto rootstocks have a significant effect on mineral nutrition and they differ in their effects on the nutrient levels of the scion (Ibacache & Sierra, 2009). In addition, different results are seen when different varieties are grafted to the same rootstock. On the other hand, the effects of rootstocks on mineral absorption are different, and the differences are due to differences between rootstocks in terms of nutrient absorption and transport. Moreover, the nutrient composition of leaves depends on the scion and rootstock (Garcia et al 2001). Little is known about the mechanisms by which vine rootstocks absorb minerals (Ibacache & Sierra, 2009). Csikász-Krizsics & Diófási (2008) reported that mineral absorption depends on many factors such as root system, soil, and above-ground parts. However, differences in mineral absorption may be due to rootstock genotype (Rizk-Alla et al 2011), environmental fac-tors, and differences in compatibility in scion-rootstock combination, giving different absorption capacity or propensity for some specific minerals. Correct rootstock selection can help reduce nutrient delivery by using rootstocks with high absorption (Ibacache & Sierra, 2009).

This study was carried out to examine the change in yield, quality and mineral nutrition of Ekşi Kara grape variety grafted onto three different rootstocks (Lot, 41 B, 110 R) and on their own roots.

2. Materials and Methods

The study was carried out in Central Anatolia, Konya province, Hadim district, Yağcı Village, Aladağ Valley at 37°2'15"N 32°34'53"E, at an altitude of 1060 m above sea level, approximately 20 years old, in double-armed cordon training, in a short-pruned producer's vineyard. The trial vineyard was established in 2002 with Ekşi Kara saplings grafted on their own roots and on 3 different rootstocks. Soil analysis was carried out in the samples taken from 0-30 and 30-60 cm depths in the vineyard. At 0-30 and 30-60 cm depth, P was determined as 43.3 kg da^{-1} and 17.5 kg da^{-1}, K 61.7 kg da^{-1} and 39.8 kg da^{-1}, Mn 6.3 ppm 4.55 ppm, Zn 0.85 ppm and 0.43 ppm, B 0.4 ppm and 0.24 ppm, respectively. Gök Üzüm was used for each combination as a pollinator variety in the vineyard. Since the region is in the upper valley of the Göksu river, it is partially under the influence of the Mediterranean climate.

Numerical data obtained from the study were subjected to variance analysis by Duncan multiple comparison test and dose and duration applications in SPSS 22.0 statistical program (SPSS Inc, Chicago, IL, USA) Tukey test in JMP 13.0 statistical program (Yue et al 2017).

3. Results

The effects of rootstocks in different combinations were evaluated by analyzing their effects on yield during harvest, product quality in the samples taken, and nutritional element analyzes in root and leaf samples taken during the fall period.

3.1. Cluster quality parameters

The effect of different rootstocks on the cluster characteristics of Ekşi Kara grape variety deter-mined during the harvest period was significant. While the most clusters (45.00 ± 3.00 pieces), the heaviest cluster (379.17 ± 31.04 g), the longest cluster (18.13 ± 0.15 cm), the widest cluster (12.69 ± 0.45 cm) were obtained from Ekşi Kara on its own roots, The fewest clusters (23.00 ± 7.55 pieces), the lightest cluster (100.56 ± 6.74 g), the shortest cluster (15.90 ± 0.18 cm), the narrowest cluster (7.86 ± 0.26 cm) were obtained from Ekşi Kara grafted onto 110 R rootstock (Fig. 1).

McCraw et al (2005) found that Freedom rootstock significantly increased the average cluster weight compared to its rooted Chardonnay vine. Similarly, the total grape yield per decare was significantly lower than the own-rooted Chardonnay vines compared to other rootstocks. Satisha et al (2010), in their study in which they grafted the cv. Thompson Seedless onto five different rootstocks with its own-rooted, they obtained the highest number of clusters from vines grafted onto 110 R rootstocks, and the lowest cluster weight from their own-rooted vines.

Miele & Rizzon (2017), examined the rootstock effects of Cabernet Sauvignon (CS) vine on yield components, the variables were significantly affect-ed by the year and rootstock, the CS/Solferino combination affected the year, and the yield per vine was significantly higher than the CS/Rupestris du Lot combination. They also determined that the number of clusters per vine and cluster weight were affected by rootstock.

Although it is understood that rootstocks affect cluster weight and size in previous studies, the results obtained according to their own roots and rootstocks were inconsistent with each other. Vine rootstocks and grape varieties grafted on them are affected by environmental, edaphic, climatic, biotic, and abiotic stress factors at different levels and form dissimilar cluster compositions. Although the location where we study is infested with phylloxera, vineyards can be established on its own roots, albeit limited, but this situation is not sustainable. Since the use of rootstocks is mandatory for new vineyard plantations in the region, 41 B was the most prominent rootstock in terms of cluster weight and size, followed by Lot and 110 R.

3.2. Quality parameters

The differences between the berry weight, berry width, berry length and berry volume values deter-mined during the harvest period were significant ($p<0.05$) (Figure 2). The highest value of berry weight (3.64 ± 0.37 g) was obtained from own-rooted vines, while the lowest value was determined in Ekşi Kara grafted onto 110 R (2.40 ± 0.11 g) rootstock.

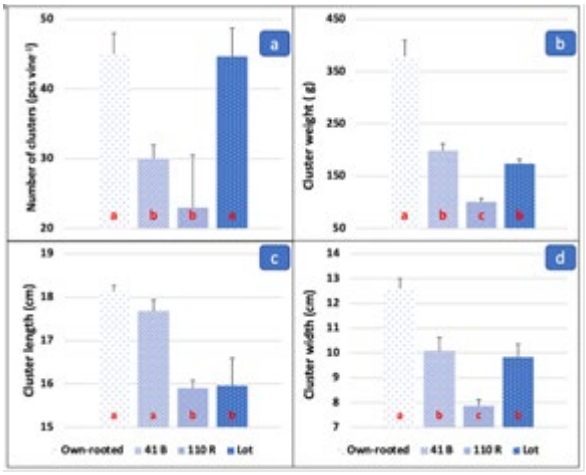

Figure 1. Number of clusters (a), cluster weight (b), cluster length (c), cluster width (d)

The highest value of berry width was determined in vines on Lot rootstock (18.66 ± 0.36 mm), while the lowest values were in vines grafted onto 110 R (13.88 ± 0.29 mm) rootstock. In terms of berry length, vines on their own roots (20.21 ± 0.30 mm) provided the highest value, while the lowest value was recorded in cv. Ekşi Kara grafted onto Lot (15.62 ± 0.19 mm) rootstock.

The highest value of berry volume (3.48 ± 0.16 ml) was obtained from own-rooted vines, the lowest berry volume (2.10 ± 0.09 ml) was determined in Ekşi Kara berries grafted on 110 R rootstock.

Satisha et al (2010), grafted cv. Thompson Seedless onto 5 different rootstocks (Dog Ridge, 110 R, 1103 P, 99 R and Lot) with their own root. In this study, seed diameter was affected by rootstock use, the lowest diameter was determined in those grafted onto Lot rootstock, while the highest diameter value was obtained

in vines grafted onto Dog Ridge rootstock. Contrary to our study, the researchers determined the lowest berry diameter values in vines grafted on Lot rootstock.

Walker et al (2010), reported that two different cultivars (Chardonnay & Merbein) grafted onto eight rootstocks generally yielded higher berry weight, cluster weight, cluster per shoot and total yield compared to vines on their own roots.

While previous studies have shown that rootstocks affect berry weight and size, inconsistent results have been reported between own-rooted grape varieties and those grafted onto rootstocks. In our study, the most prominent grape rootstock was 41 B, followed by Lot and 110 R, in the ranking made by considering berry weight and size.

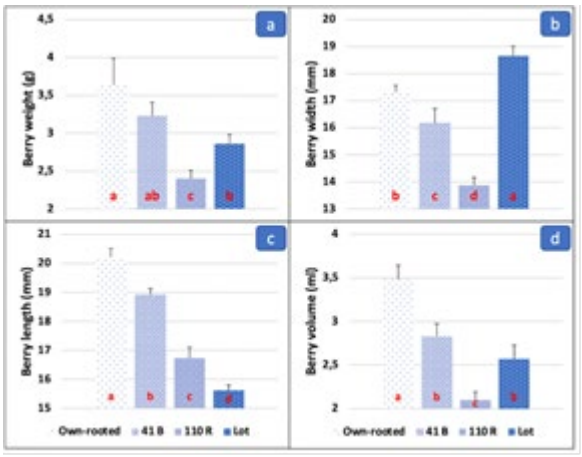

Figure 2. Berry weight (a), berry width (b), berry length (c), berry volume (d)

3.3. Effects on must composition

While the differences between °Brix and TA (%) values determined in berry samples taken during the harvest period were significant ($p<0.05$), the effects of rootstocks on pH and must yield were limited (Figure 3). In terms of °Brix, the highest value (20.97 ± 0.87) was obtained from vines on Lot rootstock, while the lowest value (17.77 ± 0.23) was found in vines on their own roots.

Climate is a factor influencing °Brix in grapevines. Grapes harvested from Chardonel grafted onto 110 R rootstock in warm climates had a higher °Brix than product harvested from vines onto Nor-ton and 5 BB rootstocks. When this study was re-peated in California, rootstocks produced a similar °Brix value (Main et al 2002).

In our study, TA was recorded highest from vines on their own roots (5.03 ± 0.14) and lowest from vines on 110 R (3.98 ± 0.15) rootstock. Chou & Li (2014) studied °Brix and TA variation by grafting cv. Kyoho on their own roots, 5 C and 1202 C rootstocks. Own-rooted Kyoho and Kyoho/5 C combinations provided a satisfactory and equal amount of °Brix on both pruning cycles.

Contrary to our results, in this study, the lowest TA was detected in self-rooted vines among the three stem/rootstock combinations. In other words, the acid decrease occurred the fastest in Ekşi Kara on its own roots. The wort yield differences by rootstock were insignificant and the ranking was Lot (63.40 ± 1.59), own-rooted (62.35 ± 0.79), 41 B (60.96 ± 3.75), and 110 R (59.60 ± 2.48).

In our study, the effects of rootstocks on must pH values were insignificant. Cirami et al (1994) examined cv. Shiraz on five different rootstocks and their own roots, they found that the pH values of the cv. Shiraz berries on their own roots were lower than those of the berries grafted on the rootstocks.

Studies with different grape varieties have shown that rootstocks affect the must composition as well as vegetative and reproductive development (Ruhl et al 1988; Reynolds & Wardle, 2001; Heuvel et al 2004). Jin et al (2016), compared the berry quality changes caused by rootstocks in Summer Black grape variety with their rooted vines and determined that cluster weights and berry structure were changed at different rates by rootstocks.

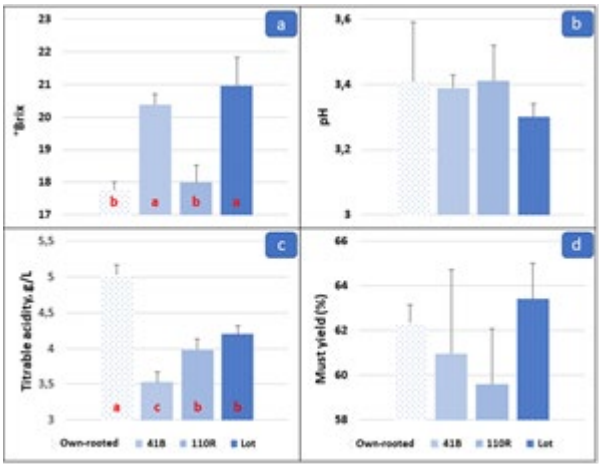

Figure 3. °Brix (a), pH (b), TA (c), must yield (d)

3.4. Effects on yield

According to the rootstocks, significant ($p<0.05$) differences were determined between the cluster number and cluster weight values during the harvest period and the calculated yield per vine and per decare (Fig 1).

While the highest value (17.05 ± 1.62 kg) in terms of yield per vine was obtained from the vines on their own roots, the lowest value was determined in 110 R (2.30 ± 0.68 kg) rootstock. The highest value in terms of yield per decare was obtained from the vines on their own roots (28415.28 ± 2698.35 kg), while the lowest value was 110 R (3825.04 ± 1129.27 kg) rootstock.

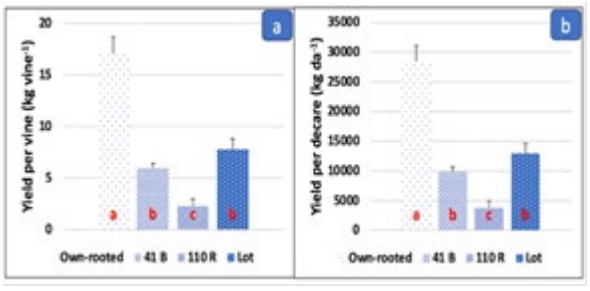

Figure 4. Yield per vine (a), yield per decare (b)

Vine rootstocks and grape varieties grafted on them are affected at different levels by environmental, edaphic, climatic, biotic, and abiotic stress factors, and different yield values occur. Ferree et al (1996), determined that Cabernet Franc and White Riesling varieties on their own roots were more productive than those grafted on different rootstocks. Walker et al (2010), determined that two different cultivars (Chardonnay and Merbein) grafted on eight rootstocks generally produced higher seed weight, cluster weight, cluster per shoot, and overall yield compared to vines on their own roots.

In another study, when cv. Thompson Seedless grafted onto five different rootstocks and own root-ed, the rootstocks caused a significant difference in terms of four-year yield average, while the highest yield was obtained from vines grafted onto 110 R rootstock, and the lowest yield was obtained from vines grafted onto Lot rootstock and own-rooted vines (Satisha et al 2010).

In our study, own-rooted vines gave the highest value in terms of yield per vine and decare, while vine rootstocks were listed as Lot, 41 B and 110 R.

3.5. K, P, B, Mn, Zn contents in roots and leaves

Macro and micro element contents were different according to analyzed plant parts and rootstocks (Figure 5). In the analysis of root samples, macro elements K (6076.92 ± 375 ppm) and P (2132.87 ± 179.50 ppm) were highest in vines on their own roots.

The lowest K (3064.27 ± 137.41 ppm) and P (951.07 ± 66.87 ppm) levels were determined in the vines grafted onto 110 R rootstock. In leaf samples, unlike the roots, the highest K content (9123.08 ± 484.26 ppm) was determined in the vines onto 110 R rootstock, while the lowest value (7165.40 ± 144.60 ppm) was detected in the vines on their own roots.

In the K content analysis of variance of root samples, vines on their own roots were in the first group with the highest content, while the K content of leaf samples had lower values.

Ibacache et al (2016), showed that rootstocks can have a significant impact on grapevine nutrition. When grafting Flame Seedless, Thompson Seedless, Superior Seedless and Red Globe grape varieties on ten different rootstocks (Freedom, Harmony, St. George, Salt Creek, SO4, 1613 C, 1103 P, 99 R, 110 R, 140 Ru, own-rooted) Flame Seedless, Red Globe and Thompson Seedless cultivars grafted onto Harmony and 1613 C rootstocks had 60% higher K values than those on their own roots.

Ahmad et al (2018), examined the effects on petiole macro element content by grafting three grape cultivars (Halawani, Baladi and Bayadi) onto 41 B, 140 Ru, SO4 and Fercal rootstocks, they determined that SO4 rootstock increased the petiole K level. Petiole K content was highest in Baladi/SO4 and Halawani/SO4 combinations (2.4% and 2.3% in 2010; 2.213% and 1.91% in 2011, respectively).

In leaf samples, P content was highest in vines on 41 B rootstock (2286.82 ± 91.22 ppm), and lowest in vines on 110 R rootstock (1878.55 ± 41.00 ppm).

In previous studies, it was determined that P up-take varied according to rootstocks (Grant & Matthews, 1996a; Grant & Matthews, 1996b). Chenin Blanc vines grafted on Freedom rootstock had little difference in root morphology compared to vines grafted on St. George, but when there was sufficient P in the soil (> 8 mg/kg dry soil according to the Bray 1 method), it took up more and provided transport (Grant & Matthews, 1996a). In another study, Freedom and 110 R rootstocks provided acceptable vine growth in low and adequate soil P conditions, while vines on St George rootstock were inhibited to grow at low soil P content (Grant & Matthews, 1996b).

Ibacache & Sierra (2009), Flame Seedless, Thompson Seedless, Superior Seedless and Red Globe grape varieties were grown on ten rootstocks (Freedom, Harmony, St. George, Salt Creek, SO4, 1613 C, 1103 P, 99 R, 110 R, 140 Ru, own-rooted) detected significant differences in nutrient content levels in all cultivars relative to rootstocks. They determined significantly higher P in the petioles of the vines grafted on Salt Creek rootstock than in the vines on their own roots. They determined at least 60% higher K levels in Flame Seedless, Red Globe and Thompson Seedless cultivars on Harmony and 1613 C rootstocks than on their own rootstocks.

B, Zn and Mn contents of microelements were different in root samples compared to rootstocks. While the highest values of B (27.18 ± 0.53 ppm) and Mn (293.62 ± 15.58 ppm) contents in root samples were in the vines on their own roots, the lowest values were in Lot (B 23.11 ± 1.68 ppm- Mn 60.01 ± 7.87 ppm) rootstock.

The B response of plants differs not only by plant species, soil type and environmental conditions, but its excess, deficiency and availability of other plant nutrients can also affect uptake. Some researchers have determined that source B can affect the accumulation and utilization of other essential nutrients as a regulator

or inhibitor (Alvarez-Tinaut et al 1979; Tinaut et al 1979). Excessive B concentration can interfere with metabolic processes, thereby affecting the absorption of other nutrients by plants (Corey & Schulte, 1973). On the other hand, B deficiency can also lower levels of phytonutrients (Carpena Artes & Carpena Ruız, 1987). A deficiency of B impairs cell division in the meristematic region, resulting in amorphous flower and fruit development and significant inhibition of root elongation, while adequate B enhances beneficial root growth (Gupta & Solanki, 2013). There is limited information on the effect of rootstocks on B uptake in vines. Leaves of the cv. Sugraone grafted onto Ramsey and Ruggeri rootstocks and irrigated at two salinity levels did not show any significant difference in B accumulation (Yermiyahu et al 2007).

Ekbic et al (2018), applied four different boric acid (H3BO3) doses (control, 0.1%, 0.2%, 0.3%) to cv. Isabella (*Vitis labrusca* L.) in two different periods (one week before and after full bloom). In Isabella, they recommended 0.3% boric acid application for high quantity and quality yield, since foliar B applications affect yield, quality, and foliar nutrition, and stimulate plant growth and development.

Tangolar & Ergenoglu (1989), determined the highest Mn content in Grüner Veltliner samples on 41 B rootstock by examining the leaf nutrient change by grafting the Grüner Veltliner grape variety to 10 different rootstocks.

The highest Zn content in root samples (4979.62 ± 843.54 ppm) was determined in vines grafted on Lot rootstock, while the lowest value (189.53 ± 14.01 ppm) was determined in vines on their own roots, unlike other microelements.

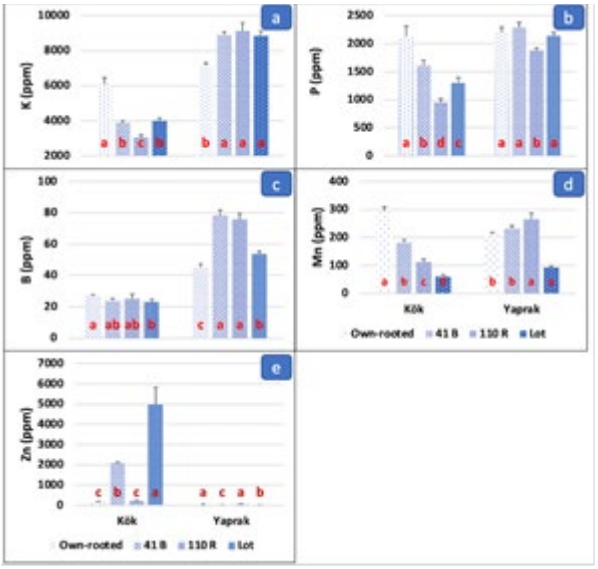

Figure 5. Root and leaf K, P, B, Mn, Zn contents

The highest values in leaf samples were deter-mined as B (78.45 ± 3.36 ppm) on vines on 41 B rootstock, Zn (58.03 ± 4.79 ppm) and Mn (264.47 ± 22.68 ppm) on vines on 110 R rootstock. The lowest values were determined as B (44.99 ± 2.17 ppm) on the vines on their own roots, Zn (14.10 ± 1.33 ppm) on the vines on 41 B rootstock, and Mn (92.67 ± 5.99 ppm) on the vines on Lot rootstock, respectively.

Kidman et al (2014), micronutrients such as Zn, B, and Mo, and macronutrient calcium are necessary for the pollination and fertilization process in vines. Rootstocks of Syrah cultivar affected feeding and reproductive performance. 1103 P showed significantly higher B level, less seedless fruit and a lower millerandage index. On the other hand, they determined Zn deficiency in grapevines grafted on 110 R and 140 Ru. They emphasized that the studies could produce site-specific responses but cannot produce precise predictions for other soil-climatic conditions or cultivars.

Zn is as important as nitrogen, potassium, etc. in terms of metabolic functions in plants. For this reason, it is of great importance for plants to find Zn in the environment where they grow, to take them in sufficient levels and to use them in their metabolism as necessary to obtain qualified and abundant products (Taban & Koç, 2006)

4. Discussion

In general, the vine rootstocks used in this study are the most widely used as they are well suited to the location of the experiment, but the correct root-stock selection depends on various aspects such as soil characteristics, climatic conditions, grape varieties and even clones and production purposes. In our study, the highest values in terms of cluster and berry quality parameters were determined in the vines on their own roots, while the lowest values were determined in the vines grafted onto 110 R rootstock.

Although some literature shows that self-rooted vines give better results in terms of berry-cluster quality characteristics, rootstock use is mandatory considering environmental, edaphic, climatic, biotic, and abiotic stress factors. In this case, since it gave the best results in terms of berry-cluster quality parameters, the rootstock that stood out locally was determined as 41 B, followed by Rupestris du Lot and 110 R.

Yield per decare and yield per vine are similar, and the highest productivity values were obtained from the vines on their own roots. In grafted vines, the highest yield per vine and decare was obtained from vines on Lot rootstock, followed by 41 B and 110 R rootstocks.

Harvested grape quality was affected by rootstocks. When quality parameters and yield were evaluated together in cv. Ekşi Kara, the highest values were obtained from vines on their own roots, while the highest values were obtained from Ekşi Kara/41B grafted combinations, followed by Ekşi Kara/Rupestris du Lot and Ekşi Kara/110 R.

According to the data we obtained from root and leaf samples, Ekşi Kara vines on 110 R rootstock gave the best results in terms of plant nutrient content, followed by 41 B and Lot rootstocks.

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Selcuk University, Scientific Research Projects (BAP), grant number 22201013.

Acknowledgments: The authors are grateful to Selcuk University Research Funds for supporting this study as 22201013 project number

Conflicts of Interest: Authors declare that they have no competing interests.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 258-273 DOI:10.15316/SJAFS.2023.026 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Morphologic And Agronomic Characteristics of Some Bean (*Phaseolus vulgaris* L.) Breeding Lines

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HIGHLIGHTS

- It is important to protect the gene pool and benefit from genetic diversity.
- Yield and quality in green bean production are still not at the desired level.
- Determining the morphological and agronomic characteristics is essential for bean breeding.

Abstract

In this study, some morphological and agronomic characteristics of 96 bean breeding lines (51 bush and 45 climbers) were investigated. Plant characteristics (anthocyanin coloration of hypocotyls, the intensity of anthocyanin coloration of hypocotyl, growth type, plant architecture, plant type, plant height, plant speed of climber), properties of leaves (intensity of green color, rigidity, terminal leaflet size, terminal leaflet shape, terminal leaflet length of the tip), flower properties (inflorescences position, size of bracts, color of flag leaf, color of wing), pod characteristics (pod length (except beak), width, thickness, shape of cross-section, ground color, intensity of ground color, presence of secondary color, secondary color, density of flecks of secondary color, stringiness of ventral suture, degree of warp, shape of warp, shape of distal part (except beak), length of beak, curling of beak, texture of surface) were determined and measured by using UPOV parameters and subjected to cluster analysis in morphological identification. In the dendrogram, bush bean lines were divided into two main groups and eight subgroups, and climber bean lines were also divided into two main groups and ten subgroups.

Keywords: : Bean (Phaseolus vulgaris L.), Morphologic and Agronomic Characteristics, Cluster Analysis.

1. Introduction

Bean (*Phaseolus vulgaris* L.) is a member of the Leguminosae family and is produced in North and Central America, South America, East and South Africa, West and South East Europe and East Asia (Adams et al., 1985). World fresh (green) bean production is nearly 24.5 million tons on an area of 1.6 million ha. While China is the first in fresh bean production with 19,5 million tons, Türkiye meets 2.6% of the world's production with 640.000 tons and ranks fourth after China, Indonesia, and India. While the world average yield is 1.53 tons per decare, it has been 1.38 tons in Türkiye (FAO 2021). In Türkiye, The Black Sea Region is the most producer

Citation: Uzar Y, Kurtar ES, (2023). Morphologic And Agronomic Characteristics of Some Bean (Phaseolus Vulgaris L.) Breeding Lines. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 258-273. https://doi.org/10. 15316/SJAFS.2023.026

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Received date: 14/11/2022

Accepted date: 22/04/2023

with 180.000 tons (especially the Central Black Sea Region), followed by the Mediterranean and Aegean Regions (165.485 tons and 100.640 tons, respectively) (TUIK 2021).

However, the agronomic and morphological characteristics of the bean are different and the consumption area is widespread and diverse in parallel revealing the necessity of bringing a different approach to the bean breeding process. Thus, it is of great importance to protect the genetic diversity of the bean cultivated and to benefit from the genetic diversity.

There has been a very important development trend in bean agriculture in recent years in land surveys and interviews with companies engaged in the trade of seeds on the subject. In addition to the dry grains of the bean, immature fruits and grains are used as vegetables. Fresh fruits and grains contain around 90% water. Although the crude protein ratio in dry grains varies according to the variety and cultivation technique, it is 22% on average (Şehirali 1988).

Bean protein is rich in Lysine, Leucine, and Isoleucine amino acids, and poor in Methionine, Tryptophan and Cystine. Grain contains more vitamin A (carotene) and vitamin C in the green maturity period and less in the dry maturity period (Anlarsal 2014). Beans, which are consumed both fresh and dry, have a superior place among similar foods in terms of the high protein content of their grains, the fact that their proteins are close to meat protein in terms of amino acid composition and that they are rich in carbohydrates, calcium, iron and especially phosphorus. On the other hand, the content of sulfur-containing amino acids in beans is higher than in other legumes, which ensures a high biological value of bean protein (Çavuşoğlu and Akçin 2007). In this context, it is understood how important a vegetable is for our country's agriculture. However, the bean is known as a self-pollinating plant and producers often choose to produce their seeds. This turns out to be the main source of many problems. In recent years, there have been important developments in the use of certified seeds in beans in Türkiye.

Despite this, yield and quality in green bean production is still not at the desired level. Among the possible reasons for this, problems arising from the cultivation technique, problems arising from not using certified seeds and pathogen problems are the first ones that come to mind. In this context, it is a fact that there is a need for green bean varieties that are highly competitive, productive, less affected by late harvest, and compatible with consumer demands, both in the domestic market and in the foreign market. Thus, gene resources consisting of commercial, domestic and foreign bean lines constitute the material of this study. Our research, which is the first step of breeding bean varieties suitable for fresh consumption, is considered original and important in this aspect.

In this study, 96 different lines were grown under greenhouse conditions. In each line grown, morphological and agronomic characteristics were tried to be determined in line with measurements and observations created by using UPOV parameters. Thus, it is aimed to create the initial material of the bean breeding project suitable for fresh consumption, which is planned to be carried out later.

2. Materials and Methods

A total of 51 bush and 45 climber bean lines, including 30 bush and 39 climber bean lines obtained from Prof. Dr. Önder Türkmen (Selcuk University, Horticulture Department of Agriculture Faculty, Türkiye), and 21 bush and 6 climber bean lines supplied from Biotek Seed Company, were used as plant material.

2.2. Methods

2.2.1. Soil preparations, planting and cultural practices

Before sowing the seeds, soil samples were taken from the 0-30 cm deep part of the greenhouse to be tested, and soil analysis was carried out. As a result of the analysis, the soil structure was loamy, pH neutral, salt-free, very calcareous, high in phosphorus, lower in potassium and low in organic matter (Table 1).

Table 1. Soil analysis results of the experimental greenhouse

Specification	Amount	Class
Soil structure	%49.5	Loamy
pH	7.36	Neutral
Calcareous ($CaCO_3$)	27.57	Very calcareous
Salt (%)	0.0675	Salt-free
Phosphorus (P_2O_5)	10.82	High
Potassium (K_2O)	31.08	Lower
Organic matter (%)	1.29	Low

The greenhouse soil was maintained with a plow and a disc harrow, the first fertilization was realized according to the soil analysis and the drip irrigation lines were adjusted following the spacing between and within the rows, and the seeds were planted with 50x20 cm spacings. 40 plants were grown from each line with 4 replications. Irrigation, fertilization (fertigation), weed control, disease and pest management were carried out regularly.

2.2.2. Determination of morphological and agronomic characteristics

The characterization of the bean breeding lines was realized according to the International Union for the Protection of New Varieties of Plants (UPOV 1998) guidelines. The examined characteristics, the classes of these characteristics and the class scores used in the rating scale are presented in Table 2.

The presence of anthocyanin in the hypocotyl and the anthocyanin density were determined when the plants had 5-6 leaves. Pod lengths (cm) and pod diameters (cm) of bean lines were measured at the fresh consumption stage (Figure 1). To obtain mature seeds, the pods whose shells begin to dry were carefully harvested and dried in a shaded area (Figure 2).

Figure 1. Measuring the length and stem diameter of pods

Figure 2. Drying of harvested pods (left side) and seeds (right side)

Table 2. Characteristics (CH), classes of these characteristics and class scores (CS) were examined in the morphological characterization of bean lines.

	CH	Classes	CS		CH	Classes	CS
PLANT	Anthocyanin in the hypocotyl	Absent	1	POD	Length (except beak)	Short	3
		Current	9			Medium	5
						Long	7
						Very long	9
	Intensity of anthocyanin in the hypocotyl	Little	3		Width	Narrow	3
		Medium	5			Medium	5
		Strong	7			Broad	7
	Growth type	Bush	1		Thickness	Thin	3
		Climber	2			Medium	5
						Thick	7
						Very thick	9
	In climber types	Pyramid	1		Shape of cross-section	Elliptical	1
		Rectangle	2			Egg	2
						Heart	3
						Round	4
	In bush types	Without spreading	1		Ground color	Yellow	1
		Spreading	2			Green	2
	Height in bush	Short	3		Intensity of ground color	Low	3
		Medium	5			Medium	5
		Tall	7			Dark	7
	Climber speed	Slow	3		Pres. of secondary color	Absent	1
		Medium	5			Current	9
		Fast	7				
LEAF	Intensity of green	Light green	3		Intensity of secondary color	Rarely	3
		Green	5			Medium	5
		Dark green	7			Intense	7
		The darkest gr.	9				
	Rigidity	Absent/Very little	1		Secondary color	Absent	1
		Low	2			Pink	2
		Medium	3			Red	3
						Violet	4
	Terminal leaflet size	Small	3		Stringiness of ventral suture	Absent	1
		Medium	5			Current	9
		Large	7				
	Terminal leaflet shape	Triangle	1		Degree of Warp	Absent/Very little	1
		Triangle-circle	2			Little	3
		Circle- rhombus	3			Medium	5
		Rhombus	4			Strong/Very Strong	7

Table 2 (Continued). Characteristics (CH), classes of these characteristics and class scores (CS) were examined in the morphological characterization of bean lines

	Terminal leaflet length of the tip	Short Medium Long	1 2 3	Shape of warp	Inwards	1 2
FLOWER	Flower location in bush at full blooming	Partly in leaf In leaf On leaf	1 2 3	Shape of distal part (except beak)	Pointed Pointed to blunt Blunt	1 2 3
	Size of the bracts	Small Medium Large	3 5 7	Length of Beak	Short Medium Long	3 5 7
	Color of flag leaf	White Pinkish white Violet	1 2 4	Curling of beak	Absent/ Very little Low Medium Strong/Very strong	1 3 5 7
	Color of wing	White Pinkish white Pink Violet	1 2 3 4	Texture of surface	Smooth/ Slig. rou. Medium rough	1 2

2.2.3. Data evaluation

Following the characterization of the bean breeding lines, the data obtained to determine the level of variation in the lines were subjected to statistical analysis in the SPSS package program. A dendrogram was created to show the similarities and differences between the lines with each other. The dendrogram created in the study is the 'Similarity between groups' dendrogram. This dendrogram was obtained by performing Cluster analysis according to Ward's method (Rohlf, 1993). The pod lengths and pod diameters of the bean lines were analyzed in the JMP 10 statistical program and grouped according to the LSD 5% significance level.

Due to the differences in some parameters of the UPOV criteria, bean lines were evaluated separately as bush and climber.

3. Results

3.1. Morphological characteristics of bush and climber bean lines

3.1.1. Plant characteristics

Anthocyanin formation was not visualized in all bush beans. Anthocyanin was found in 4 (9%) lines of the climber bean, and the anthocyanin coloration was low in 2 lines, moderate in 1 line, and strong in 1 line. In bush beans, 23 lines (45%) grew in the spreading type, while 28 lines (55%) showed growth in the non-spreading type. 3 lines (6%) were short plant height, 31 lines (61%) were medium and 17 lines (33%) were tall.

In climber beans, 32 lines (71%) had pyramid growth and 13 lines (29%) had rectangular growth shapes. The rate of climbing was determined as slow in 2 lines (4.5%), medium in 1 line (2%), and fast in 42 lines (93.5%).

There are differences in plant height between genotypes and the main reasons for these differences are; climatic and soil conditions and elevation, cultural practices and genetic predisposition (Baran, 2018). It has been reported that the main reason for the variation in plant height is the high heritability (85-92%) and also the genotype (Çiftçi and Şehirali 1984; Sözen et al. 2012; Akbalık 2019; Bıyıklı et al. 2021)

Işık (2012) reported that 73% of the lines were bush and 27% were semi-climber form, and similar results were argued by Akbulut et al. (2014). In another study, 15% of the lines were bush, 19% were semi-climber, and the rest (66%) were in the climber form (Sözen et al. 2012). In a study conducted in the Eastern Black Sea Region, 14% of the lines were found the bush, 49% semi-climber and 37% climber form (Sözen et al. 2014a).

3.1.2. Leaf characteristics

In the bush lines, the green color intensity in the leaves was predominantly green (61%). Leaf rigidity was absent or very little in the majority of the lines (69%), low in 14 lines (27%) and moderate in 2 lines (4%). The terminal leaflet size was small in 7 lines (14%), medium in 32 lines (63%), and large in 12 lines (23%).

The climber bean lines also generally had green leaf color (58%), 2 lines (4.5%) were light green, 16 lines (35.5%) were dark green and 1 line (2.2%) was very dark green. Leaf rigidity was absent or very little in 39 lines (87%) and less in 6 lines (13%). The terminal leaflet size was determined as small in 21 lines (47%), medium in 17 lines (38%) and large in 7 lines (15%). Bean lines showed 3 variations (light, medium, dark) in terms of the leaf green hue color of lines, 17.6% of subsamples had light, 71.7% medium and 10.7% dark leaf green color (Sözen et al. 2014b).

Işık (2012) reported that the lines had 4 different leaf colors green, light green, very light green and dark green, and the majority (51.5%) showed green leaf characteristics. In addition, it was determined that 12 lines showed less and 21 lines showed moderate rigidity. 42.4% of the lines had a middle-pointed leaflet shape. Similar results were found in previous reports, and most of the lines had green leaf color (Işık 2012; Sözen et al. 2012; Sözen et al. 2014a; Sözen et al. 2014b; Akbulut et al. 2014). The fact that some of our results do not correspond with previous studies is due to the difference in the lines we used.

3.1.3. Flower characteristics

In bush beans, flowers (at full bloom time) were partially in the leaf in 42 lines (82%), in the leaf in 6 lines (12%) and on the leaf in 3 lines (6%). At the size of the bracts, 32 lines (63%) were small, 5 (10%) medium and 14 (27%) large lines. It was determined that 37 lines (72.5%) were white in flag leaf color, 13 lines (25.5%) were pinkish white and 1 line (2%) was violet.

It was determined that 9 lines (20%) were small, 20 lines (44.5%) were medium and 16 lines (35.5%) were large in terms of the size of the petal in climber lines. In the evaluation made in terms of flag and wing leaf color, 27 lines (60%) were white, 9 lines (20%) were pinkish white, 2 lines (4.4%) were pink and 7 lines (15.6%) were violet.

Işık (2012) reported that 21% of the lines had white flowers and 79% had lilac flowers. The flower color in bush lines was white in 3 lines and lilac in 21 lines, while 4 lines were white and 5 lines were mauve in lanceolate forms. Akbulut et al. (2014) found a pink and white flower in bean lines. In our study, the white flower was observed at a rate of 66%. This result differs from the data obtained by Işık (2012) (72% lilac flower) due to the difference in lines used.

3.1.4. Pod characteristics

While 8 lines (16%) had short pod length (excluding beak), 21 lines (41%) had medium, 17 (33%) long pods, and 5 lines (10%) had very long pods in the bush lines. 17 lines (33%) were determined as narrow podded, 23 lines (45%) as medium and 11 lines (22%) as broad podded.

The pod thickness was found to be thin in 11 lines (22%), medium in 27 lines (53%), thick in 9 lines (17%) and very thick in 4 lines (8%). In the shape of the cross-section of the broad bean (towards the seed), 23 lines (45%) were elliptical, 9 lines (17.5%) were egg-shaped, 12 (23.5%) were heart-shaped, 7 lines (14%) were round.

It was determined that 1 line (2%) was yellow and 50 lines (98%) were green in bush beans. 7 lines (13%) had low intensity, 34 (67%) medium and 10 (20%) dark pods. While there was no second color in the pod in 47 lines (92%), it was found in 4 lines (8%). The second color of the broad bean was violet in 4 lines (8%).

There was no stringiness in 47 lines (92%) and it was present in 4 lines of bush beans (8%). 35 lines (68%) had no or very little warp in the pod, 10 lines (20%) were low, 4 lines (8%) were medium, 1 line (2%) was strong and 1 line (2%) was very strong. The pods of 16 lines (31%) were found to warp inwards, while no warp was observed in 35 lines (68.6%). In the shape of the distal part of the pod (except the beak), 26 lines (51%) were pointed, 16 lines (31%) were pointed to blunt, and 9 lines (18%) were blunt. The pod beak length was short in 10 lines (20%), medium in 23 lines (45%), and long in 18 lines (35%). It was determined that 25 lines (49%) had no or very little curling in the beak, 11 lines (21%) were low, 5 lines (10%) were medium, 7 lines (14%) were strong and 3 lines (6%) were very strong. It was determined that the pod surface structure was smooth or slightly rough in 46 lines (90%) and medium rough in 5 lines (10%).

In climber beans, pod length (excluding beak) was found to be 7 lines (16%) very short, 10 lines (22%) short, 15 lines (33%) medium, 7 lines (16%) long and 6 lines (13%) very long. determined. While 13 lines (29%) had narrow pods, 8 lines (18%) had medium and 24 lines (53%) had wide pods. It was determined that 9 lines (20%) were thin, 24 lines (53%) were medium, 6 lines (13%) were thick and 6 lines (13%) were very thick. The cross-section of the broad bean (towards the seed) was elliptical in 23 lines (51%), eggs in 8 lines (18%), heart in 13 lines (29%), and eight in 1 line (2%).

The pod's ground color was yellow for 3 lines (7%), green for 40 lines (89%), and violet for 2 lines (4%). The intensity of the pod background color was determined as low in 8 lines (18%), medium in 31 lines (69%), and dark in 6 lines (13%). While the second color did not observe in 23 lines (51%) in pods, it occurred in 22 lines (49%). The second color of the broad bean was determined as pink in 5 lines (22%), red in 1 line (5%) and violet in 16 lines (73%). The intensity of the second color spots in the pod was rare for 13 lines (29%), medium for 4 lines (9%), and intense for 5 lines (11%). While there was no stringiness in 27 lines (60%), it was determined in 18 lines (40%).

27 lines (60%) had little or no warp in the pod, low in 14 (31%) lines, medium in 3 lines (7%), and strong in 1 line (2%). While the pod warp was inward in 18 lines (40%), it was not observed in 27 lines (60%). The shape of the distal part (except the beak) was pointed in 27 lines (60%), pointed to blunt in 12 lines (27%), and blunt in 6 lines (13%). The beak length of the pod was determined as short in 10 lines (22%), medium in 22 lines (49%), and long in 13 lines (29%). It was determined that 31 lines (69%) had no or very little curling in the beak, 9 lines (20%) were low, 3 lines (7%) were medium, and 2 lines (4%) were strong. The pod texture was smooth or slightly rough in 29 lines (65%), and medium rough in 16 lines (35%).

3.1.5. Pod lengths (PL) and pod diameter (PD)

The PL of the lines varied according to the lines (Table 3). Lines O45 (24.12 cm) and O41 (22.87 cm) formed the longest pods, while O10 and O12 (12.75 cm), O36 (12.12 cm), O30 (11.65 cm) and O27 (10.12 cm) had the shortest pods. The average PL of 51 bush lines was found to be 16.38 cm. When the PD is examined, O18 and O19 (1.87 cm), O32 (1.82 cm) and O26 (1.75 cm) lines had the widest pods, O17 (0.97 cm), O16 (0.92 cm), O21 (0.90 cm), O8 (0.82 cm) and O5 (0.75 cm) produced the narrowest pods. Average PD was measured as 1.36 cm in bush lines.

Genotype differences were also found in the PL of the climber lines. S4 (26.32 cm) and S1 (25.02 cm) lines were the longest pods, while the shortest pods were harvested at S13 and S38 (8.9 cm), S12 (8.20 cm), S44 (7.82 cm) and S27 (5.80 cm). The average PL of bush lines was determined as 13.15 cm. The widest pods were in S6 (2.00 cm), S34 and S45 (1.97 cm) and S4 (1.92 cm), while S38 (1.02 cm), S14 (1.00 cm), S13 (0.97 cm), S8 (0.95 cm) and S12 (0.92 cm) formed the narrowest pods. The average PD was determined as 1.35 cm in climber lines (Table 3).

It has been reported that pod length is a genetic character and is affected by growing conditions and environmental conditions (Karasu 1988). In other studies, the pod length was between 7.42-30.59 cm (Pekşen 2005; Seymen et al. 2010; Demir 2011; Varankaya and Ceyhan 2012; Ekincialp and Şensoy 2013; Özbekmez 2015; Topal 2019; Nadeem et al. 2020; Şener and Kaya 2022). Yorgancılar (1995) determined the pod length as 7.6-13.82 cm and the thickness as 5.62-9.26 mm in dwarf bean genotypes. Sarı et al. (2016), in bean genotypes with different seed colors collected from the Black Sea Region, the pod length was between 8.53 cm and 70.28 cm. In the width of the link, the lowest value was 6.56 mm, while the widest link was 19.76 mm. Genotypes had pod thickness varying between 6.58 and 10.78 mm. Sözen et al. (2012) defined 106 genotypes to determine the biodiversity of bean populations collected from the Western Black Sea Region and stated that 90 genotypes did not show an awning feature.

Sözen et al. (2014a), as a result of the characterization study they performed on local bean populations in the Eastern Black Sea Region, found that 10 of 85 genotypes (11.7%) were narrow, 54 of them (63.5%) were medium, and the remaining 21 (24.8%) were broad pods in terms of pod width. In addition, it was determined that 8 genotypes had elliptical (9.1%) pod cross-sectional shape, 17 of them were cordate (19.3%), 40 of them were circular (47.4%) and 21 of them were 8-shaped (24.2%). While 32.9% (28 units) of the genotypes were stringiness, 67.1% (57 units) showed awny features. It has been determined that boneless genotypes can be selection material to develop varieties suitable for green beans.

Akbulut et al. (2014) observed that among the 12 genotypes, pigment formation occurred only in Black beans and the color of this pigment was "Purple". Similarly, the pigment spots in the pods were "Intense". The roughness of the pods in genotypes was generally observed as "flat". While stringiness was observed in half of the genotypes, the awning was not detected in Akbağlaklı, Gina, Karataneli, Roma, Sarıkız and Şeker. The length of the pod varied between 11 cm (White Pole) and 15 cm (Akbağlaklı, Gina and Roma), and the average length of the pod was 13.31 cm. Işık (2012) did not find mottling in any of the 33 genotypes. In addition, it was determined that all genotypes had a smooth leaf structure. Except for 3 genotypes, all genotypes showed stringiness.

The stringiness was not observed in most of the genotypes in our study, and this result was largely similar to previous studies and differed from some of them. It was determined that these differences were caused by the differences in the genotypes we used. In terms of pod width, in our study results, it was found that there was a difference between bush and climber genotypes, medium and wide.

Table 3. Pod lengths (PL; cm) and pod diameter (PD; cm) of bush and climber bean lines (L)

Bush			**Climber**		
L	**PL (cm)**	**PD (cm)**	**L**	**PL (cm)**	**PD (cm)**
O1	17.25 e-ı	1.42 ıj	S1	25.02 a	1.47 def
O2	17.17 e-ı	1.55 e-ı	S2	16.07 cde	1.15 k-q
O3	18.22 def	1.40 jk	S3	15.70 d-g	1.07 n-t
O4	15.50 l-p	1.42 ıj	S4	26.32 a	1.92 abc
O5	14.57 pqr	0.75 u	S5	15.95 c-f	1.47 def
O6	15.02 o-r	1.65 c-f	S6	21.37 b	2.00 a
O7	16.87 f-l	1.57 d-h	S7	9.55 rst	1.05 o-t
O8	17.67 e-h	0.82 tu	S8	10.77 o-r	0.95 st
O9	14.42 pqr	1.67 cde	S9	20.62 b	1.15 k-q
O10	12.75 st	1.62 c-g	S10	14.55 e-ı	1.50 de
O11	17.75 e-h	1.65 c-f	S11	11.47 n-q	1.17 j-p
O12	12.75 st	1.42 ıj	S12	8.20 t	0.92 t
O13	16.57 h-n	1.52 f-j	S13	8.90 st	0.97 rst
O14	17.55 e-h	1.00 p-s	S14	9.20 rst	1.00 q-t

Table 3 (Continued). Pod lengths (PL; cm) and pod diameter (PD; cm) of bush and climber bean lines (L)

O15	15.32 n-q	1.05 o-r	S15	10.45 p-s	1.05 q-t
O16	14.80 o-r	0.92 rst	S16	13.67 h-l	1.77 c
O17	15.00 o-r	0.97 qrs	S17	15.02 e-h	1.20 j-o
O18	18.32 de	1.87 a	S18	12.25 l-o	1.22 ı-n
O19	16.75 g-m	1.87 a	S19	12.22 l-o	1.15 k-q
O20	18.15 d-g	1.55 e-ı	S20	12.72 k-n	1.55 d
O21	14.85 o-r	0.90 st	S21	14.82 e-h	1.27 h-l
O22	14.00 qrs	1.10 n-q	S22	11.77 m-q	1.77 c
O23	17.07 e-j	1.70 bcd	S23	14.30 f-j	1.82 bc
O24	15.05 o-r	1.50 g-j	S24	10.17 p-s	1.77 c
O25	15.25 n-q	1.00 p-s	S25	15.17 e-h	1.47 def
O26	14.75 o-r	1.75 abc	S26	13.80 h-l	1.45 d-g
O27	10.12 u	1.10 n-q	S27	5.80 u	1.30 g-k
O28	15.62 k-p	1.52 f-j	S28	13.45 h-m	1.37 e-ı
O29	15.45 m-p	1.42 ıj	S29	10.42 p-s	1.12 l-r
O30	11.65 t	1.10 n-q	S30	17.12 cd	1.22 ı-n
O31	15.15 opq	1.27 kl	S31	11.87 m-p	1.37 e-ı
O32	17.87 e-h	1.82 ab	S32	14.05 g-k	1.42 d-h
O33	15.75 j-p	1.67 cde	S33	11.45 n-q	1.25 ı-m
O34	15.37 m-q	1.55 e-ı	S34	11.75 m-q	1.97 ab
O35	16.10 ı-o	1.52 f-j	S35	10.07 qrs	1.55 d
O36	12.12 t	1.20 lmn	S36	10.25 p-s	1.20 j-o
O37	17.25 e-ı	1.40 jk	S37	9.12 rst	1.12 l-r
O38	17.00 e-k	1.25 lm	S38	8.87 st	1.02 p-t
O39	12.97 st	1.12 m-p	S39	13.05 ı-n	1.32 f-j
O40	18.40 de	1.05 o-r	S40	9.12 rst	1.12 l-r
O41	22.87 a	1.57 d-h	S41	14.60 e-ı	1.42 d-h
O42	20.97 b	1.12 m-p	S42	12.40 k-o	1.32 f-j
O43	19.50 cd	1.15 l-o	S43	13.07 ı-n	1.27 h-l
O44	21.15 b	1.15 l-o	S44	7.82 t	1.10 m-s
O45	24.12 a	1.17 l-o	S45	17.50 c	1.97 ab
O46	19.90 bc	1.15 l-o	**Average**	13.15	1.35
O47	17.62 e-h	1.45 hıj		LSD : 1.745	LSD: 0.160
O48	13.65 rs	1.25 lm			
O49	16.65 h-n	1.72 bc			
O50	14.57 pqr	1.62 c-g			
O51	20.42 bc	1.15 l-o			
Average	16.38	1.36			
	LSD: 1.414	LSD: 0.141			

When the literature studies are examined, it is seen that the medium width is highly common. There is a difference between our study results and literature studies in terms of pod cross-section. However, on the presence of secondary color in the pod, our study results were compatible with the reported literature. In our study, a high rate of roughness was not observed in genotypes, this rate was found to be 50% by Akbulut et al. (2014). According to our study results, the warp shape and degree of warp in the pod are closely following the literature. Our findings in the length and width parameters of the pod agree with the Akbulut et al. (2014) findings, but not following the Sarı et al. (2016). It is thought that the main reasons why some of the results we obtained in our study did not agree with the literature were the difference in the genotypes and that our study was conducted under greenhouse conditions.

4. Discussion

4.1. Determination of the Variation in Bean Breeding Lines.

4.1.1. Dendrogram Analysis of Bush Bean Lines

All the data obtained were subjected to cluster analysis to determine the relationship between the examined traits and lines belonging to 51 genotypes. It is seen in the dendrogram (Figure 3) that the criteria we examined also vary in terms of morphological character.

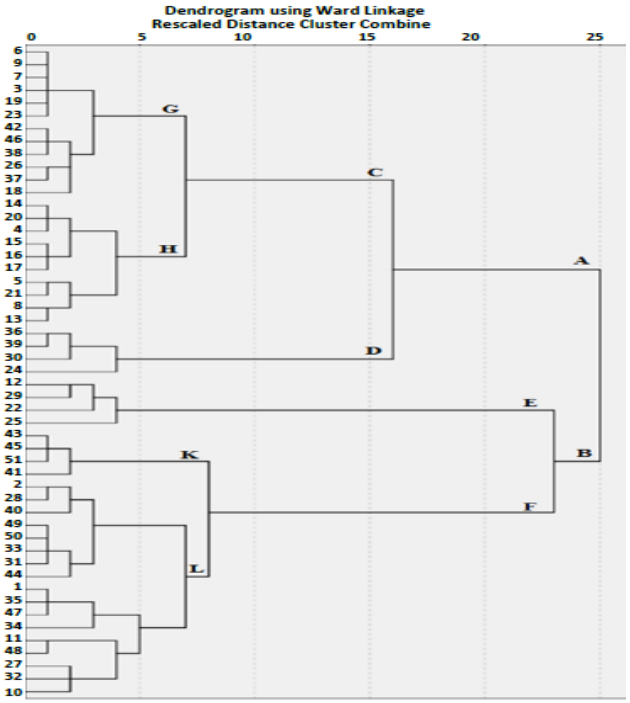

Figure 3. Dendrogram formed by morphological measurements and observations in bush lines

As presented in the dendrogram the lines were divided into two main groups (A and B). Group A is divided into two main groups, one of large (C) and the other of small (D). Of these main groups, the C is again divided into two sub-groups, one of big (G) and the other of small (H), and the G is also divided into two branches. Lines O6 and O9, O15 and O16, and O36 and O39 were found to be closely related to each other in G, H, and D, respectively.

The second large main group of the dendrogram (B) is divided into two main groups, one of large (F) and the other of small (E). Among these main groups, group F is again divided into two subgroups, one of large (L) and the other of small (K). L is also divided into two branches. In the L, lines O49 and O50, O43 and O45, O12 and O29 were found to be closely related to each other in L, K, and E, respectively. In the bush lines, the lines O6 and O9 were the closest to each other and the lines O1 and O3 were the farthest from each other. By subjecting the obtained data to principal component analysis, it was possible to explain the connection between the bush lines (Table 4).

Table 4. Proximity-distance relationships of bush genotypes according to Ward Linkage

Agglomeration Schedule

	Cluster Combined			Stage Cluster First Appears		
Stage	**Cluster 1**	**Cluster 2**	**Coefficients**	**Cluster 1**	**Cluster 2**	**Next Stage**
1	16	17	5,000	0	0	8
2	50	51	10,000	0	0	11
3	43	47	13,000	0	0	13
4	2	36	13,000	0	0	20
5	8	10	13,000	0	0	6
6	4	8	15,500	0	5	10
7	44	46	16,000	0	0	16
8	16	21	16,500	1	0	21
9	20	24	17,000	0	0	17
10	4	7	17,667	6	0	17
11	34	50	18,000	0	2	23
12	12	49	18,000	0	0	38
13	39	43	18,500	0	3	25
14	6	22	19,000	0	0	27
15	5	15	19,000	0	0	24
16	44	52	21,000	7	0	30
17	4	20	23,000	10	9	26
18	37	40	24,000	0	0	36
19	3	29	24,000	0	0	31
20	2	48	26,500	4	0	33
21	16	18	27,000	8	0	24
22	9	14	27,000	0	0	27
23	32	34	29,000	0	11	29
24	5	16	30,250	15	21	34
25	27	39	33,333	0	13	26
26	4	27	33,833	17	25	28
27	6	9	34,000	14	22	34
28	4	19	40,600	26	0	35
29	32	41	40,750	23	0	31
30	42	44	41,000	0	16	39
31	3	32	41,600	19	29	35
32	13	30	46,000	0	0	42
33	2	38	47,000	20	0	38
34	5	6	48,250	24	27	40
35	3	4	50,675	31	28	40
36	31	37	52,000	0	18	46
37	28	33	52,000	0	0	41
38	2	12	53,500	33	12	43
39	42	45	57,250	30	0	44
40	3	5	60,856	35	34	43
41	11	28	66,000	0	37	44
42	13	23	69,000	32	0	45
43	2	3	69,369	38	40	48
44	11	42	80,267	41	39	47
45	13	26	91,333	42	0	50
46	25	31	92,333	0	36	49
47	11	35	104,000	44	0	48
48	2	11	107,180	43	47	49
49	2	25	141,041	48	46	50
50	2	13	164,170	49	45	0

4.1.2. Dendrogram Analysis of Climber Bean Lines

All the data obtained were subjected to cluster analysis to determine the relationship between the examined traits and lines belonging to 45 genotypes. It is seen in the dendrogram (Figure 4) that the criteria we examined also vary in terms of morphological characters.

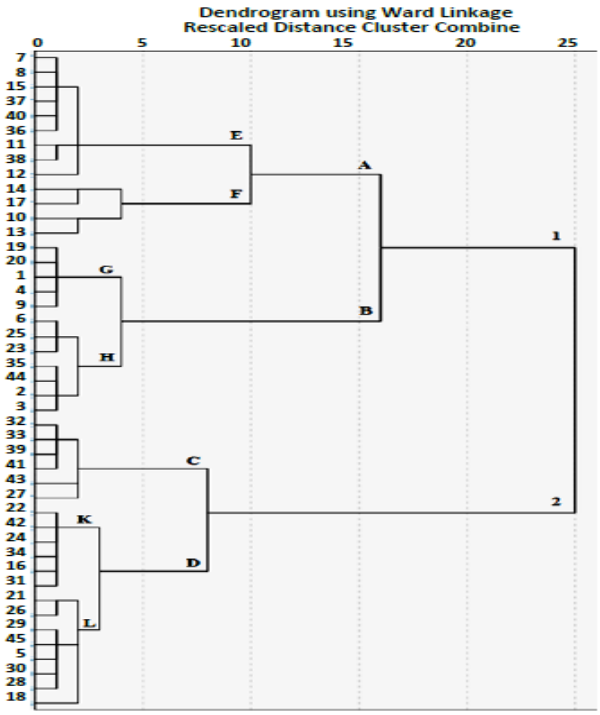

Figure 4. Dendrogram formed by morphological measurements and observations in climber lines

The lines were divided into two main groups, 1 and 2. Group 1 is divided into two main groups, one large (A) and the other small (B). Among these main groups, A is again divided into two sub-groups, one big (E) and the other small (F). Lines S7 and S8 in group E and lines S14 and S17 in group F were found to be closely related. The other main group, group B, is divided into two branches, one large (H) and the other small (G). Lines S19 and S20 in the G group, and lines S6 and S25 in the H group were found to be closely related.

The second large main group of the dendrogram, the 2 groups, is divided into two main groups, one large (D) and the other small (C). Among these main groups, the D group is again divided into two sub-groups, one large (L) and the other small (K). Lines S29 and S45 in group L, lines S24 and S34 in group K and lines S32 and S33 in group C were found to be closely similar. It was determined that there was variation between the lines, and according to the dendrogram analysis performed on the climber lines, it was determined that S7 and S8 were the closest lines to each other, and S1 and S5 were the farthest lines from each other. By subjecting the obtained data to principal component analysis, it was possible to explain the connection between the climber lines (Table 5).

Table 5. Proximity-distance relationships of climber genotypes according to Ward Linkage

Agglomeration Schedule

	Cluster Combined			Stage Cluster First Appears		
Stage	**Cluster 1**	**Cluster 2**	**Coefficients**	**Cluster 1**	**Cluster 2**	**Next Stage**
1	7	8	4,500	0	0	15
2	29	45	15,000	0	0	25
3	24	34	25,500	0	0	19
4	19	20	36,500	0	0	12
5	37	40	49,500	0	0	24
6	11	38	63,000	0	0	33
7	22	42	77,500	0	0	23
8	16	31	92,000	0	0	19
9	6	25	108,000	0	0	20
10	5	30	125,000	6	0	14
11	32	33	142,500	0	0	26
12	1	19	160,167	0	4	21
13	4	9	178,167	0	0	21
14	5	28	195,500	10	0	25
15	7	15	216,667	1	0	28
16	35	44	237,667	0	0	18
17	39	41	259,167	0	0	26
18	2	35	283,500	0	16	27
19	16	24	308,500	8	3	23
20	6	23	334,500	9	0	37
21	1	4	351,833	12	13	39
22	21	26	389,333	0	0	32
23	16	22	417,667	19	7	38
24	36	37	447,333	0	5	28
25	5	29	478,300	14	2	30
26	32	39	513,300	11	17	31
27	2	3	548,467	18	0	37
28	7	36	584,133	15	24	33
29	14	17	627,633	0	0	40
30	5	18	677,333	25	0	32
31	32	43	727,333	26	0	34
32	5	21	782,583	30	22	38
33	7	11	840,458	28	6	36
34	27	32	899,458	0	31	41
35	10	13	960,458	0	0	40
36	7	12	1023,861	33	0	42
37	2	6	1091,933	27	20	39
38	5	16	1184,492	32	23	41
39	1	2	1304,254	21	37	43
40	10	14	1439,004	35	29	42
41	5	27	1733,811	38	34	44
42	7	10	2096,168	36	40	43
43	1	7	2666,370	39	42	44
44	1	5	3596,044	43	41	0

5. Conclusion

In this study, morphological characterization was performed according to UPOV criteria in 51 bush and 45 climber bean lines. 33 morphological features were used for this characterization. In light of these, the level of variation and relations (proximity-distance) were tried to be determined. The results of our study revealed that the existing gene pool consists of lines with different characteristics that have the potential to be used for

different purposes in breeding studies. The fact that there are significant differences between some of the lines used in the study shows that different lines and eventually different cultivar candidates may emerge in future breeding studies and that the presented study may yield successful results. This situation will ensure that new bean varieties with agronomic superior characteristics, suitable for producer and consumer demands, will be brought to the market, and thus contribute to the country's economy, especially in our country where there are very few qualified bean varieties. It is thought that as well as the current breeding work carried out with the material we used in our study, can also support the breeding studies to be carried out in the future and make important contributions to the protection of bean gene resources.

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 274-284 DOI:10.15316/SJAFS.2023.027 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Evaluation of Dry Bean Farming in Konya Region and Its Importance for Sustainable Agriculture

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HIGHLIGHTS

- Dry beans are an important species of legume for a sustainable human-animal-environment supply.
- Consumption of dried beans is recommended for the prevention of many diseases, especially cancer, diabetes, celiac and heart diseases.
- In this study, the perspectives of producers for dry beans, which should be included in sustainable production systems, are presented.

Abstract

Establishing policies for the sustainability of the sector by increasing legume production and consumption is a critical issue for both Turkiye and the world and is a strategic issue that needs to be emphasized. Dry beans are an important edible legume that should alternate in sustainable agriculture, as well as providing easy supply of healthy and nutritious food to the increasing world population. Present research realized to determine the main problems faced by Konya City farmers in bean farming in 2021 and to offer appropriate solutions. For this purpose, questions about bean farming were asked to one hundred farmers who were randomly selected from the districts with the highest bean cultivation in the Konya region, and the results obtained were examined as "%" unit. As the result of the present research, it was seen that Konya farmers are insufficient in matters such as fertilization quantity and technic, irrigation density, control of diseases and pests, and usage of the certified seeds in dry bean farming. Since the cultivation techniques have direct or indirect impacts on the seed yield and seed quality of the beans, so it is necessary to correct the important deficiencies or mistakes of our farmers. In addition, intending to ensure agricultural sustainability and healthy human nutrition, it is essential to increase production and quality by determining the problems related to legumes that should be included in the rotation systems and on the food menu, and related issues are overseen inwardly the aim of the present research.

Keywords Agricultural production, Legumes, *Phaseolus vulgaris*, Producer problems, Sustainability

1. Introduction

Change in soil characteristics - production systems and adaptation technologies, consumer demand, quality perception, challenges in production and harvest, the change for income standard, conventional and

Citation: Kahraman A, Erturk E, Kiraz F (2023). Evaluation of Dry Bean Farming in Konya Region and Its Importance for Sustainable Agriculture. *Selcuk Journal of Agriculture and Food Sciences*, 37(3), 274-284. https://doi.org/10. 15316/SJAFS.2023.027
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Received date: 18/12/2023
Accepted date: 01/05/2023

organic growing, conservation of genetic diversity, fast urbanization gives a different agricultural perspective from nutritional habits to food supply (Bwengye et al., 2023; Doruk Kahraman and Kahraman, 2023¸ Wang, 2023; Zamukulu et al., 2023). In addition to the protection of soil and water resources, it significantly affects production and consumption of legumes, which are known to be a source of essential protein over one of four humans in the world. Legumes, as they are rich in nutritional values, have positive effects on the soil where they are grown, their ability to symbiotic fixation of the free nitrogen of the air to the soil, and the popularity of environmentalism and sustainable agriculture increases the importance of these plants.

It is important to include legumes, which are an important family for both human and animal nutrition and soil improvement, in crop rotation systems and to carry out the necessary research for producers to be more conscious. The dry bean plant, which is an important species in the edible legumes' family, is the most produced legume type in the world.

Thomas (1998) reported for the definition of the questionnaire, it as a material consisting of a set of questions aimed at determining the conditions, behavior patterns, belief phenomena or tendencies of human beings in life. Compared to the techniques used for the collection of some other data (interview, observation), the surveys can be applied to the more crowded masses in different places and are lower in cost. However, it is also noted that the questionnaire is based on two basic assumptions: "the respondent can read and understand the survey items" and "the respondent is ready to answer the items honestly" (Wolf, 1988). There are various types of survey methods. One of the benefits of a face-to-face survey method is that the interviewer can assist the participant with questions that are difficult to understand.

According to TURKSTAT 2019-2020 marketing year data, our country's adequacy rate for dry beans is 88% (Anonymous, 2022). Dry beans are an excellent pre-plant for sugar beet and wheat, which are widely grown in Konya, which has a share of 33% in seed production in Turkiye. Significant yield increases are observed in sugar beet and wheat planted after dry beans.

Human welfare depends on quality soil and proper land use. It is quite important that we take the necessary measures to the lands we use in crop production for a longer term and more efficiently. Unfortunately, legume production has been decreasing in recent years in Turkiye, which has traditionally been an important producer and exporter of legumes. This situation has a significant impact on the sustainability of legume production. It is necessary to meet the important needs of the farmers and to carry out studies in line with the determined needs. With a view to increase the yield per unit area in dry beans, cultural processes must be conducted both on time and appropriately, and the selection of the most suitable genotypes for ecological conditions is also important. Additionally, increased production and consumption of dry beans due to being a legume plant; essential for sustainable agriculture. For these reasons, this research was carried out in 2021 aiming to determine the common current problems in dry bean production in Konya ecological conditions.

2. Materials and Methods

This research was conducted in 2021 by interviewing (face to face) randomly selected farmers from the districts of Konya where dry beans are widely produced (Çiçek and Erkan, 1996; Şenol, 2012).

The survey development process is formulated in different ways in the literature. For example, Anderson (1990) describes the survey creation process as "determining general research questions", "listing of sub-questions", "design of materials", "ordering of items", "Editing the survey" and "preliminary application of the questionnaire" examined in sub-stages. As a matter of fact, within the scope of this research, it has been modified by taking the mentioned literature into consideration.

This study was carried out with a total of 100 dry bean producers in Konya Province: 48 in Altınekin, 13 in Çumra, 8 in Cihanbeyli, 8 in Yunak, 6 in Sarayönü, 5 in Kadınhanı, 5 in Karapınar, 4 in Ereğli, 1 each in Bozkır - Ilgın and Karatay. The results obtained were evaluated with the Microsoft Excel program and expressed as a percentage (Kahraman, 2022a).

Within the scope of the study, the survey questions prepared to obtain basic data were created in order to inspected various sources prepared to reveal the basic needs in agricultural production and to bring them into a form suitable for the purpose of this research.

3. Results

In this section, the Questions are abbreviated as "Que".

Que 1) What size of land do you produce beans on? (1 da = 1 decare= 1000 m2)

A) 0-50 da= 40%

B) 50-150 da= 36%

C) 150-250 da= 14%

D) 250 da= 3%

E) More than 250 da = 7%

As it can be understood from the examination of Question 1, it is seen that bean farming is generally carried out in small areas.

Que 2) How many years have you been engaged in bean farming?

A) 0-5 year= 23%

B) 5-10 year= 28%

C) 10-15 year= 17%

D) 15-20 year= 12%

E) More than 20 years = 20%

Looking at Question 2, it is seen that bean farming has been dealing with for 5-10 years.

Que 3) When do you do the first soil preparation in beans?

A) Spring= 30%

B) Autumn= 70%

It is seen that there was a problem in terms of tillage in Konya closed basin in previous years, but there is no problem now. These results show that the results of previous studies (Varankaya and Ceyhan, 2012) are reversed.

Que 4) Do you apply crop rotation?

A) Yes= 97%

B) No= 3%

While 97% of the surveyed farmers said that they practice rotation, it was revealed that 3% did not practice rotation. The results were determined in the survey studies conducted by Ülker and Ceyhan (2006).

Que 5) Which plants do you use in the crop rotation?

A) Cereals= 96%

B) Forage crops= 4%

According to the research, it is seen that 96% of the farmers apply the rotation with cereals.

Que 6) After which front crop do you get a higher yield from the bean planted?

A) Fallow= 15%

B) Forage Crops= 9%

C) Cereals= 76%

Crop rotation is essential in sustainable agriculture, and many years are needed for results to be consistent. As a matter of fact, this result obtained based on the experience of the producers is extremely valuable, and it has been revealed that higher yields are obtained if beans are grown after cereals.

Que 7) Do you use certified seeds?

A) Yes= 52%

B) No= 48%

It has been determined that approximately half of the producers use certified seeds.

Que 8) Why not use certified bean seeds?

A) Low yield = 24%

B) Because seeds are expensive = 28%

C) Because it is not resistant to diseases = 22%

D) Because it has no market value = 8%

E) Since I have available seeds = 16%

F) Insufficient government support = 2%

It is essential that dry bean producers prefer to use certified seeds of varieties that are adapted to the climate, have higher seed yield besides higher quality, and are more tolerant to diseases (Doruk Kahraman and Gökmen, 2022). As a result of this research, it is seen that some aspects of registered varieties are not preferred by the farmers. It is of great importance to reveal the differences by screening the gene pool of different genotypes and wild types of beans, which has a wide genetic variation, as in other plants (Nadeem et al., 2020; Toker et al., 2021; Uysal et al., 2021).

Que 9) Where do you get the seeds from?

A) My own production = 17%

B) From the seed dealer = 58%

C) From other farmers = 25%

As can be seen in Question 9, 58% of our farmers obtain dry bean seeds from seed dealers.

Que 10) How many kg da-1 of seeds do you use?

A) 10 kg and below = 77%

B) 10-12 kg = 18%

C) 12-14 kg = 4%

D) 14 kg and more= 1%

As seen in Question 10, 77% of the farmers use seeds of 10 kg da-1 or less.

Que 11) When do you sow the bean seed?

A) April 1-15= 0%

B) April 15-30= 2%

C) May 1-15= 19%

D) May 16-30= 79%

Beans are affected by temperatures below 00C. Therefore, it should be planted after the last frosts (Şehirali, 1988). This is until the first half of May for the Central Anatolian region (Akçin, 1988). On the other hand, researcher Önder and Şentürk (1996) stated that when the seed sowing time is delayed, there is a decrease in grain yield.

Que 12) What is your sowing method in beans?

A) Spreading= 0

B) With Seeder= 100%

According to the research, sowing of the bean seeds is done by seeders.

Que 13) What is your sowing depth for beans?

A) 2 cm= 0%

B) 3 cm= 26%

C) 5 cm= 62%

D) 8 cm= 12%

Previous studies on the subject (Ülker and Ceyhan, 2006; Varankaya and Ceyhan, 2012) show that most of the farmers plant at suitable depths.

Que 14) What is the row spacing in seed sowing?

A) 30-40 cm= 0%

B) 40-50 cm= 99%

C) 50-60 cm= 1%

D) 60-70 cm= 0%

When the results of the research are evaluated, it shows a great deal of similarity with the findings related to the sowing norm stated in the literature (Şehirali, 1988; Akçin, 1988; Önder and Şentürk, 1996).

Que 15) What is the up spacing in seed planting?

A) 5 cm= 5%

B) 8 cm= 48%

C) 10 cm== 32%

D) 12 cm= 11%

E) 15 cm= 4%

When question 15 was examined, 48% of the farmers stated that they adjusted the up spacing as 8 cm, 32% as 10 cm, 11% as 12 cm, 5% as 5 cm and 4% as 15 cm.

Que 16) Do you inoculate bacteria in bean farming?

A) Yes= 8%

B) No= 82%

C) I don't know about inoculation= 10%

Based on these findings, it has been understood that the yield can be increased by bacterial inoculation and the cost can be reduced by minimizing the use of fertilizers. As a matter of fact, it has been revealed in a study that a remarkable change in grain yield and quality will occur with fertilization at the appropriate dose and in the appropriate period in legumes as in other plants (Bozoğlu et al., 2007; Athar et al., 2020).

Que 17) Do you fertilize in bean farming?

A) Yes= 100%

B) No= 0%

All the surveyed farmers are fertilizing in dry bean farming.

Que 18) When do you apply fertilizer?

A) With seed sowing = 16%

B) Before planting = 84%

C) As top fertilizer = 0%

Que 19) Which fertilizer do you apply before planting?

A) DAP (18-46)= 75%

B) 20-20-20= 1%

C) 15-15-15= 14%

D) 20-20= 1%

E) Others= 9%

Many of the surveyed farmers prefer DAP fertilizer in the bean cultivation base fertilizer application.

Que 20) How much nitrogen do you use for the base in bean production?

A) 2 kg da-1= 1%

B) 3 kg da-1= 6%

C) 4 kg da-1= 43%

D) 5 kg da-1= 16%

E) 6 kg da-1= 16% F) Other= 18%

In different survey studies, it has been revealed that the farmers mostly use similar amounts of nitrogen fertilization (Ülker and Ceyhan, 2006; Varankaya and Ceyhan, 2012).

Que 21) Do you apply herbicides before sowing the seeds?

A) Yes= 80%

B) No= 20%

Que 22) How many times do you hoe the beans?

A) 1 time= 33%

B) 2 times = 55%

C) 3 times = 11%

D) More than 3 times = 1%

Que 23) Which irrigation method do you use in bean farming?

A) Drip Irrigation= 28%

B) Release Irrigation= 0%

C) Sprinkler Irrigation= 72%

Researcher Muirhead (1978) determined that the drip irrigation system increased bean growth positively. As can be understood from this, it is seen that drip irrigation in dry beans will increase the quality and yield of dry beans, save water and the farmers should switch to drip irrigation in dry beans.

Que 24) How many times do you irrigate in bean farming?

A) 3 times = 0%

B) 4 times = 2%

C) 5 times = 4%

D) 6 times = 17%

E) More than 6 times = 77%

In a study conducted in Konya ecology in order to examine the amount of irrigation water as well as the seasonal water consumption in dry beans, it was found to be 453-520 mm (Topak et al., 2009). As it can be understood from here, the farmers should be informed about irrigation.

Que 25) What are the diseases you encounter in your field in bean farming?

A) Rust Disease= 9%

B) Powdery Mildew= 14%

C) Root Rot= 23%

D) Bacterial Blight = 4%

E) Anthracnose = 14%

F) Leaf Blight = 14% G) Other= 8%

It has been stated in different studies that root rot (*Fusarium* ssp. and *Rhizoctonia* ssp.) is commonly seen in the closed basin of Konya in dry bean agriculture (Ülker and Ceyhan, 2006; Varankaya and Ceyhan, 2012).

Que 26) How do you combat with diseases?

A) Late sowing = 27%

B) Use of resistant varieties = 2%

C) Seed spraying= 2%

D) Surface spraying= 63%

Considering that in various survey studies conducted on the subject (Ülker and Ceyhan, 2006; Varankaya and Ceyhan, 2012) all of the farmers stated that they were fighting with pesticides, it is seen that in the fight against diseases, late sowing is tried to be prevented in addition to surface spraying.

Que 27) What pests do you encounter in bean farming?

A) Agrotis sp. = 3%

B) Aphids = 1%

C) Legume Seed Beetle = 37%

D) Red Spider= 32%

E) Other= 8%

Que 28) How do you combat with these pests?

A) Early Sowing = 1%

B) Late Sowing = 10%

C) Seed Spraying = 1%

D) Surface Spraying = 86%

Considering that in other survey studies conducted on beans (Ülker and Ceyhan, 2006; Varankaya and Ceyhan, 2012), all the farmers stated that they were fighting with pesticides, it is seen that in the fight against pests, late sowing is tried to be prevented in addition to surface spraying. It was stated in another study conducted in Konya ecology that planting time has a significant effect on the mineral composition of beans (Kahraman and Önder, 2018).

Que 29) Do you use top fertilization by nitrogen in bean farming? If yes; what is the amount?

A) Yes= 100%

B) No= 0%

Although there is no need for overhead nitrogen fertilization, the bean producers apply high amounts of nitrogen fertilizer in case of bacterial inoculation in dry beans. For this reason, the soils are polluted and production costs are increasing more than normal.

Que 30) What is your dry bean seed yield on average?

A) 100-150kg/da= 2%

B) 150-200 kg/da= 2%

C) 200-250 kg/da= 9%

D) 250-300 kg/da = 23%

E) 300-350 kg/da = 24%

F) 350-400kg/da = 33%

G) 400-450 kg/da= 7%

Like the findings of this research, it is seen that the grain yield of beans varies in a wide range, the highest seed yield was determined as 371.89 kg per decare (Önder and Özkaynak, 1994), 318.58 kg/da (Önder and Şentürk, 1996), 303.80 kg/da (Ülker and Ceyhan, 2006) in Konya conditions.

In addition to the selection of seeds suitable for the soil and ecological conditions in plant production, it has been emphasized in many studies that significant increases not only in yield but also in quality can be achieved by performing appropriate cultural processes (Ceyhan et al., 2014; Harmankaya et al., 2016; Gülsoy et al. et al., 2019; Kahraman, 2022b).

4. Conclusions

When the results of the research are examined, dry bean production in Konya is in rotation with grains, instead of using certified seeds due to the high cost, the producers use their own seeds or obtained from other producers and dealers selling sifted seeds, they plant seeds using seeders, and the fertilizer applied from the top. When looked at, an average of 40 kg/da of UREA (46% nitrogen) was given, and DAP (18% N, 46% P) was preferred as base fertilizer, irrigation is done more than 6 times, the disease is quite common and the most important one is root rot, surface spraying and late planting are done to prevent root rot.

Farmers who do not use certified or registered seeds in bean cultivation; they stated that registered or certified bean seeds are expensive, low yield, lack of market value, registered or certified bean seeds are not resistant to diseases, there are seeds available and government support is insufficient. In the production of edible legumes in the Konya region; it understood that the farmers performed the rotation, the region has an important share and potential for seed production in Turkiye, and the herbicides are widely used after planting and pre-emergence. With a focus on ensure the sustainability of legume production in the long term, it is necessary to conduct studies focusing on both producer and consumer demands. As a conclusion, there is a need for studies to take sustainable agriculture systems as a basis and to spread this awareness in dry beans.

Author Contributions: Conceptualization and methodology, A.K.; investigation and realization of the research A.K., E.E. and F.K.; resources, data curation, writing—original draft preparation, writing—review and editing, visualization, and supervision A.K., E.E. and F.K. All authors have read and agreed to the published version of the manuscript.

Funding: No support has been received for this research.

Acknowledgments: We thank all the interviewers who participated in the research.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 285-290 DOI:10.15316/SJAFS.2023.028 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Effects of Different Viol Types on Egg Shell Microbiology in Table Eggs at Different Storage Temperatures

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HIGHLIGHTS

- Plastic box viols were found to have lower levels of TAMP and mold-yeast than cardboard viols.
- Regarding coliform, there was no significant difference between cardboard viols, cardboard box viols and plastic box viols.
- Higher total bacteria and mold-yeast loads were detected in eggs stored at 4°C than those stored at 25°C.
- Regarding coliform, there was no significant difference between 4°C and 25°C.

Abstract

The purpose of this research was to examine the impact of storing table hen eggs in egg cardboard box viol, plastic box viol, and cardboard viols at various temperatures on the microbiology of the egg shell. A total of 150 table chicken eggs were used in the study. The eggs were randomly distributed into three groups: standard cardboard viol, plastic box viol, and cardboard box viol. The eggs were stored at room temperature and in the refrigerator for 28 days. On the 0, 7, 14, 21, and 28 days of the experiment, five eggs from each group were analyzed for total bacteria (TAMB), mold-yeast, and coliform. The Viol type x storage temperature interaction effect was significant ($P<0.05$) only on egg shell mold-yeast, but its effect on the TAMB and coliforms was insignificant. The effect of viol types on shell coliforms was insignificant. Egg TAMB and mold-yeast counts were found to be lower in plastic box viols than in other groups ($P <0.05$). TAMB and mold-yeast count were found to be higher in eggs that were stored in refrigerator conditions than in room conditions ($P <0.05$). From a microbial perspective, it can be said that storing eggs in plastic box viols is more suitable in terms of hygiene during storage.

Keywords: Viol; Eggshell, Total Aerobic Mesophilic Bacteria, Mold-Yeast, Coliform, Storage

1. Introduction

Although eggs are an animal protein source, their importance in human nutrition is high due to their containing unsaturated fatty acids, vitamins, and minerals (Şenköylü 2001; Sarıca and Erensayın 2014; Puglisi and Fernandez 2022; Tian et al. 2022). An egg obtained from a healthy animal has the highest quality value at the moment it is laid, but its quality may decrease depending on storage conditions, leading to marketing problems (Aygun 2017; Aygün and Narinç 2017; Brasil et al. 2019; Yenilmez and Bulancak 2020; Sariyel et al. 2022). There are between 300 and 500 bacteria on the shell when it is laid (North and Bell 1990). Within an hour

Citation: Parmak ZA, Aygun A (2023). Effects of Different Viol Types on Egg Shell Microbiology in Table Eggs at Different Storage Temperatures. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 285-290. https://doi.org/10. 15316/SJAFS.2023.028
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Received date: 09/12/2022
Accepted date: 05/05/2023

of the egg being laid, this number may quickly reach 20,000 or 30,000 bacteria (North and Bell 1990). In the market, cardboard viols with a capacity of 30 eggs are used for storing or transporting eggs. However, in recent years, cardboard box viol and plastic box viol with a capacity of 6, 10, and 15 eggs have also started to be used. The use of cardboard box viol with a capacity of 6, 10, and 15 eggs during the sale of eggs makes it difficult for consumers to choose eggs based on their outer appearance, as the dirt on the surface of the eggshell cannot be seen. On the other hand, plastic box viols provide convenience for consumers in terms of choice. However, foreign materials on the surface of eggs in plastic box viol can be seen more easily, making it easier to evaluate the eggs based on their appearance. Additionally, during storage or sales, there is a possibility of condensation on the egg surface or inside the viols, which can lead to the eggs becoming wet and causing the preference for viols to become important. The number of bacteria present on an eggshell can vary depending on a number of factors, such as the hygiene practices used during egg handling, storage conditions, and the presence of any pathogens in the environment.

Uysal et al. (2002) did not find a significant difference in bacterial and fungal load between plastic box and cardboard egg viols for hatching eggs. Jones et al. (2004) studied the concentrations of bacteria, yeast, and mold on eggshells during a 10-week storage period at 4 °C. They found that the concentration of aerobic bacteria on the eggshell increased from 4.0 log CFU/ml to 5.3 log CFU/ml after 8 weeks of storage. As the storage period continued, the concentration of yeast and mold increased, reaching the highest levels of 2.9 and 2.6 log CFU/ml at 8 and 10 weeks, respectively. According to Huneau-Salaün et al. (2010), contamination increased with hen age, airborne dust concentration, manual packing of the eggs, and plastic packing as opposed to recycled-pulp egg-flats increased.

In our literature review, it was observed that there are a limited number of studies on the effect of storing table chicken eggs in cardboard box viols or plastic box viols (with a capacity of 6, 10, and 15 eggs) on egg quality. Therefore, the main question of the research is which tray type can preserve egg quality for a longer period of time during storage under different storage conditions. Therefore, the aim of this study is to investigate the changes in egg quality by storing table chicken eggs in cartons, cardboard box viol, and plastic box viols under room and refrigerator conditions.

2. Materials and Methods

Table eggs that were daily purchased from the Konya commercial egg producer were used in the study. A total of 150 table eggs were used. The research was carried out in the Egg Quality Laboratory of the Department of Animal Science, Faculty of Agriculture, Selcuk University.

Eggs were randomly distributed into 3 groups: cardboard viol, plastic box viol, and cardboard box viol. Eggs were stored in viols at room temperature (25±2°C) and in the refrigerator (4±2°C) for 28 days. On the 0, 7, 14, 21, and 28 days of the experiment, total bacteria, mold-yeast, and coliform analyses were performed in the egg shells of 5 eggs from each group.

For microbiological analysis, each egg sample was transferred into sterile pouches containing 50 ml of peptone water (0.1%) (Merck, Germany), and they were kept in these solutions for 2-3 minutes. After that, serial decimal dilutions were prepared, and 1 mL of appropriate dilutions were spread on agar plates in duplicate. The count of total aerobic mesophilic bacteria (TAMB) was determined on Plate Count Agar (PCA; Merck) incubated at 37°C for 48 h while mold-yeast counts on Potato Dextrose Agar acidified by sterile tartaric acid (10 %) (Merck) were incubated at 25°C for 5 days. Coliform bacteria were cultured on Violet Red Bile Agar (VRBA; Merck) anaerobic incubated at 37°C for 24 h (Aygun and Sert, 2013). The results are given as log CFU/g.

The experiment was carried out in 2x3 randomized plots according to a factorial design in order to compare the shell microbial load of eggs packed in plastic box viol, cardboard box viol, and cardboard viols to be stored at room temperature and in the refrigerator (Duzgunes et al. 1987). The statistical analyses were conducted

using the One-Way Analysis of Variance (ANOVA). The MINITAB 16 package program was used in the analysis, and the Tukey multiple comparison test was used to determine the different groups.

3. Results

3.1. Total mesophilic aerobic microorganisms

Table 1 summarizes the effects of storage temperature, viol types, and the storage temperature x viol type interaction on total mesophilic aerobic microorganisms. In all periods, the effect of storage temperature x viol type interaction on total mesophilic aerobic bacteria was not significant. The effect of viol types on eggshell TAMB was significant in all weeks except the second week ($P<0.05$). On the 28th day of storage, group C had the highest TAMB value (4.47 log cfu/g egg) ($P<0.05$), and the difference in TAMB value between the CB (3.98 log cfu/egg) and Pl (3.99 log cfu/g egg) groups was statistically insignificant. The effect of storage temperature on eggshell TAMB was significant in all weeks except the first week ($P<0.05$). The shell TAMB levels of eggs stored at 4 °C (4.32 log cfu/g egg) were found to be higher than those stored at 25 °C (3.97 log cfu/g egg) after 28 days of storage.

Table 1. The effect of storage temperature, viol types and storage x viol type interaction on Total aerobic mesophilic bacteria (Log cfu/g egg)

Treatment		Fresh eggshell TAMB	Total aerobic mesophilic bacteria			
			7 days	14 days	21days	28 days
Storage Temperature (°C)	25	4.19	3.80	3.78	3.94	3.97
	4	4.19	3.97	4.17	4.25	4.32
	SEM	0.032	0.074	0.095	0.069	0.083
	P-value	0.977	>0.05	<0.05	<0.05	<0.05
Viol type[1]	C	4.23	3.51^{b}	3.86	4.29^{a}	4.47^{a}
	CB	4.19	4.16^{a}	4.04	4.05^{ab}	3.98^{b}
	PL	4.16	3.99^{a}	4.02	3.95^{b}	3.99^{b}
	SEM	0.039	0.090	0.116	0.084	0.103
	P-value	0.541	<0.05	>0.05	<0.05	<0.05
Storage Temperature (°C) x Viol Type	25 x C	4.20	3.52	3.59	4.15	4.23
	25 x CB	4.19	4.09	3.85	3.87	3.82
	25 x PL	4.19	3.79	3.89	3.81	3.87
	4 x C	4.25	3.49	4.12	4.43	4.71
	4 x CB	4.19	4.23	4.22	4.24	4.13
	4 x PL	4.13	4.19	4.15	4.09	4.11
	SEM	0.055	0.127	0.164	0.119	0.144
	P-value	0.624	>0.05	>0.05	>0.05	>0.05

$^{a-b}$Significant differences exist between the means of a column using different superscripts ($P<0.05$); [1]C: Cardboard viol; CB: Crbboard box viol; PL: Plastic box viol; SEM: Standard Error Mean

3.2. Mold-yeast

At the beginning of this study and after 7 days of storage, no mold-yeast was found in the eggshell (Table 2). Except for 14 days of storage, the effect of the storage temperature x viol type interaction on mold-yeast was significant at 21 and 28 days of storage ($P<0.05$). On the 28th day of storage, the highest mold-yeast value was found in eggs stored at 4 °C in cardboard viols, and the lowest mold-yeast value was found in eggs stored at 25 °C in plastic box viols ($P<0.05$). On the other hand, when the viol types were investigated, the highest amount of mold was found in the C group and the lowest amount of mold was found in the PL group at the

end of storage (P<0.05). On the 28th day of storage, eggs stored in the refrigerator had a higher mold value than those stored at room temperature (P<0.05).

Table 2. The effect of storage temperature, viol types and storage x viol type interaction on egg mold-yeast (Log cfu/g egg)

Treatment		Fresh eggshell mold-yeast	Mold-yeast			
			7 days	14 days	21days	28 days
Storage Temperature (°C)	25	0.000	0.000	0.501	1.821	2.117
	4	0.000	0.000	0.747	3.001	3.473
	SEM			0.308	0.089	0.086
	P-value			>0.05	<0.05	<0.05
Viol type[1]	C	0.000	0.000	0.245	3.280[a]	3.882[a]
	CB	0.000	0.000	0.784	2.434[b]	2.850[b]
	PL	0.000	0.000	0.844	1.519[c]	1.653[c]
	SEM			0.377	0.110	0.106
	P-value			>0.05	<0.05	<0.05
Storage Temperature (°C) x Viol Type	25 x C	0.000	0.000	0.490	3.113[ab]	3.790[ab]
	25 x CB	0.000	0.000	0.494	2.350[b]	2.560[c]
	25 x PL	0.000	0.000	0.520	0.000[c]	0.000[d]
	4 x C	0.000	0.000	0.000	3.448[a]	3.973[a]
	4 x CB	0.000	0.000	1.074	2.518[b]	3.140[bc]
	4 x PL	0.000	0.000	1.168	3.038[ab]	3.307[ab]
	SEM			0.533	0.154	0.149
	P-vaalue			>0.05	<0.05	<0.05

[a-d]Significant differences exist between the means of a column using different superscripts (P<0.05); [1]C: Carrdboard viol; CB: Cardboard box viol; PL: Plastic box viol; SEM: Standard Error Mean

3.3. Coliform

Table 3 summarizes the effects of storage temperature, viol types, and the storage temperature x viol type interaction on coliform load. In all periods, the effect of storage temperature, viol types and storage temperature x viol type interaction on coliform load was not significant.

4. Discussion

Eggs stored at four degrees have been found to have higher TAMP and mold-yeast levels in their shells compared to eggs stored at room temperature (P<0.05). This result is consistent with the studies of Board and Tranter (1995), which indicate that bacteria penetrate the shells of eggs stored at high temperatures (37 °C) less than those stored at lower temperatures (20 °C). It can be said that the number of microorganisms that pass from the shell to the inside of the egg is higher in eggs stored at high temperatures. The result that the storage temperature has no effect on the coliform load during storage contradicts the study of Aygun and Sert (2013), which found that eggs stored in refrigerator conditions contained less coliform than those stored at room temperature.

Eggs stored in plastic and covered cardboard cartons have been found to have a lower TAMP and mold-yeast load on their shells compared to eggs stored in standard cardboard cartons. This may be due to the easy contamination of the environment with microorganisms. It has been observed that storing eggs in closed packages limit the possibility of contamination by microorganisms. In other words, packaging and storing eggs limit the possibility of contamination by microorganisms. The result of our study, which found that eggs stored in plastic cartons have a higher TAMP load than eggs stored in standard cardboard cartons, contradicts the Huneau-Salaün et al. (2010) study, which found that the bacterial load in eggs stored in plastic cartons was

higher than that of eggs stored in cardboard cartons. The reason is that the cartons used in our study were a new brand. According to Huneau-Salaün et al. (2010), recycled pulp viols were destroyed after use, but plastic box egg viols could be reused by farms.

Table 3. The effect of storage temperature, viol types and storage x viol type interaction on coliform (Log cfu/g egg)

Treatment		Fresh eggshell coliform	Coliform			
			7 days	14 days	21days	28 days
Storage Temperature (°C)	25	0.000	0.298	0.133	0.000	0.000
	4	0.000	0.313	0.609	0.353	0.692
	SEM		0.205	0.226	0.176	0.270
	P-value		>0.05	>0.05	>0.05	>0.05
Viol type[1]	C	0.000	0.200	0.284	0.260	0.000
	CB	0.000	0.269	0.630	0.269	0.420
	PL	0.000	0.447	0.200	0.000	0.618
	SEM		0.251	0.277	0.216	0.331
	P-value		>0.05	>0.05	>0.05	>0.05
Storage Temperature (°C) x Viol Type	25 x C	0.000	0.000	0.000	0.000	0.000
	25 x CB	0.000	0.000	0.400	0.000	0.000
	25 x PL	0.000	0.894	0.000	0.000	0.000
	4 x C	0.000	0.400	0.568	0.520	0.000
	4 x CB	0.000	0.538	0.860	0.538	0.840
	4 x PL	0.000	0.000	0.400	0.000	1.236
	SEM		0.355	0.392	0.306	0.468
	P-value		>0.05	>0.05	>0.05	>0.05

[1]C: Cardboard viol; CB: Cardboard box viol; PL: Plastic box viol; SEM: Standard Error Mean

In our study, it was concluded that storage temperature and viol types did not have a significant effect on eggshell coliform load during storage. This is consistent with Uysal et al. (2002), who found that different viol types had a negligible effect on shell coliform load during storage of hatching eggs.

5. Conclusions

Our study revealed that different types of viols used in the storage of table eggs have a significant effect on eggshell total bacteria and mold-yeast load. It was observed that storing eggs in plastic box viols resulted in lower eggshell total bacteria and mold-yeast load compared to storing them in cardboard viols. Different types of viols did not have a significant effect on eggshell coliform load. It was determined that the total bacteria and mold-yeast load in eggs stored at 4 °C were higher than those stored at 25 °C. From a microbial perspective, it can be said that storing eggs in plastic box viols is more suitable in terms of hygiene during storage.

Author Contributions: Conceptualization, Z.A.P. and A.A.; methodology, Z.A.P. and A.A.; investigation, Z.A.P. and A.A.; resources, Z.A.P. and A.A.; writing, Z.A.P. and A.A.; Review and editing, A.A.; The published version of the work has been reviewed and approved by all authors.

Funding: This research was funded by SELÇUK UNIVERSITY BAP, grant number 18201140.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 291-300 DOI:10.15316/SJAFS.2023.029 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Classification of Pistachio Images with The ResNet Deep Learning Model

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HIGHLIGHTS

- Correct classification of Pistachio is very important in terms of trade.
- In this study, the results for each fold of the dataset are listed.

Abstract

Pistachio, which is grown in many parts of the world today, has an important place in the agricultural economy. In order to maintain this economic value, the post-harvest industrial classification process is very important to obtain efficiency from this harvest. In the process of separating pistachios, an efficient classification process is needed in order for different pistachio species to appeal to different markets. For this reason, the classification process of pistachios is very important. In this study, Kirmizi and Siirt pistachio classification with 2148 images was made using ResNet architecture. After the statistical experimental studies, the highest classification accuracy was obtained from fold-1 as 88.5781% and the Accuracy value was 0.86168 after the classification process.

Keywords: Pistachio Classification, Deep Learning, ResNet

1. Introduction

Pistachio, whose homeland is the Middle East, is produced in our country, especially in Gaziantep; It grows in Siirt, Şanlıurfa, Adıyaman, Kahramanmaraş, Diyarbakır provinces. Pistachio is grown in Turkey, India, Iran, Iraq, Mexico, America, China, Greece and Syria. In 2019, global pistachio production was approximately 0.9 million tons, with Iran and the United States as leading producers, accounting for 74% of the total. Secondary producers were China, Turkey and Syria (Anonymous, 2022). The 2020 report stated that almost half of global pistachio production in 2019 came from the United States (Anonymous 2020; Anonymous 2021). Table 1 shows the pistachio production data for 2019 (Anonymous, 2022).

World total pistachio production in 2019 decreased from 1,390,269 tons in 2018 to 911,829 tons in 2019. Pistachio cultivation studies for international markets were carried out in Georgia and neighboring Caucasus countries in 2019 (Anonymous 2020).

Pistachio is produced in more than 40 provinces in Turkey. However, the Southeastern Anatolia Region, which has a large area that meets the climatic demands of Pistachio to a large extent, provides approximately 95% of Turkey's production. It grows mostly in almost every region near Şanlıurfa, Gaziantep, Nizip, Siirt,

Citation: Avuçlu E (2023). Classification Of Pistachio Images with The ResNet Deep Learning Model. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 291-300. https://doi.org/10. 15316/SJAFS.2023.029

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Received date: 20/12/2022

Accepted date: 07/05/2023

Kahramanmaraş, Adıyaman, Diyarbakır, Karaman and Göksu. While Gaziantep has the largest pistachio production area in Turkey for years, Şanlıurfa had the largest production area in 2014 (Anonymous 2014). Approximately 80% of Turkey's pistachio area is in the provinces of Şanlıurfa and Gaziantep (Anonymous 2019).

Table 1. Pistachio production amount of countries

Pistachio production, 2019	
Country	Production (tons)
Iranian	337,815
ABD	335,660
Chinese	106,155
Turkey	85,000
Syria	31,813
World	911,829

Pistachio is known to affect many aspects, especially heart health (Dreher, 2012; Kay et al., 2010). Among the foods we eat, pistachios are one of the most nutritious products. It provides 560 calories per 100 g and is a rich source of protein, several dietary minerals and B vitamins (Ertürk et al., 2011). Figure 1 shows the basic parts of the pistachio (Ozkan et al., 2021).

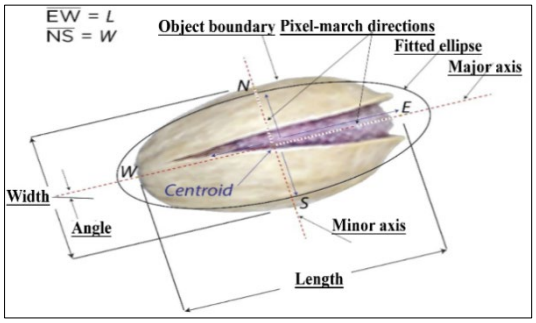


Figure 1. Basic parts of pistachio

There is more interest in red and Siirt pistachio varieties because of their higher economic value (Tunalıoğlu and Taşkaya 2003). In the literature, different studies have been carried out to provide more economic gain from peanuts and by applying different methods. Çetin et al. developed an algorithm to determine the closed and open state of the peanut shell. They made the open and closed states of pistachio shells with a success rate of 99% (Cetin et al., 2004). Casasent et al. achieved an 88% classification success of x-ray images of pistachios (Casasent, 1998). Automatic classification is required for product types from different suppliers. In this way, the value of pistachios in the market is also increased. For this reason, it is very important to develop the processes applied in the post-harvest processes of pistachio. Thus, by using new techniques and technologies, more efficiency is obtained from products with high economic value (Atay, 2007). In a different study, Abbaszadeh et al. used deep auto-encoder neural networks to divide peanuts into two different classes as

problematic and unproblematic. As a result of this study, they reported that they achieved 80.3% correct classification success of problematic pistachios (Abbaszadeh et al., 2019). Rahimzadeh and Attar developed an image-processing-based system to determine whether different peanut species are open-mouthed or closed-mouthed. After extracting the features of pistachio images, CNN-based ResNet50, ResNet152 and VGG16 models were used to classify. The average classification success achieved as a result of applying these models is 85.28%, 85.19% and 83.32%, respectively (Rahimzadeh and Attar, 2021). Table 2 shows the studies on Pistachio in the literature.

Table 2. Pistachio studies in the literature.

(Dini et al., 2020)	**Data Pieces** **958**	**Class** **2**	**Method** **ResNet**	**Accuracy (%)** **97.20**
[14]	305	2	Deep Auto-encoder Neural Network	80.30
[15]	3927	2	ResNet50	85.28
			ResNet152	85.19
			VGG16	83.32
This study	2148	2	ResNet	86.16

2. Materials and Methods

In this study, ResNet architecture was used to classify pistachio images belonging to 2 different species. In experimental studies, 5-fold crossvalidation was performed. Experimental studies were carried out with confisioun matrix as a statistical method. In general, the formulas related to CM are shown in Figure 2.

Sensitivity or True Positive Rate	$TPR = \frac{TP}{TP+FN}$	**False Negative Ratio**	$FNR = \frac{FN}{TP+FN}$
Specificity or True Negative Rate	$TNR = \frac{TN}{TN+FP}$	**Accuracy**	$ACC = \frac{TP+TN}{TP+TN+FP+FN}$
Precision or Positive Predictive Value	$PPV = \frac{TP}{TP+FP}$		
Negative Predictive Value	$NPV = \frac{TN}{TN+FN}$	**F-Measurements**	$FM = \frac{2}{\frac{1}{TPR}+\frac{1}{PPV}}$
False Positive Ratio	$FPR = \frac{FP}{TN+FP}$	**Matthews Correlation Coefficient** $MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TP+FP)(TP+FN)(TN+FP)(TN+FN)}}$	

Figure 2. Statistical measurements

The parameters used in the ResNet architecture are shown in Table 3.

Sample images of pistachio cultivars used in the database are shown in Table 4. (Ozkan et al., 2021; Sıngh et al., 2022).

Table 3. Parameters of ResNet architecture

inputSize	32x32
MiniBatchSize	16
MaxEpochs	10
ExecutionEnvironment	Gpu
Shuffle	Every-epoch

Table 4. Pistachio Types

2.1. ResNet Architecture

It is the convolutional neural network model that won the ILSVRC competition by Kaiming He et al. in 2015 with a 3.57% error rate. ResNet is designed to train more layers than previous models and consists of a total of 152 layers. ResNet has now introduced a method called a learning block to solve the "disappearing gradient" problem. The most important feature of this architecture is that it now consists of learning blocks. An approach called jump links is used in this block. The skip link connects directly to the output, skipping the training several layers. This approach is that instead of the layers learning from the underlying mapping, the mesh now allows the mesh to conform to the mapping. This allows to train much deeper neural networks (Kaya, 2021). The residual learning block structure that makes up the network is given in Figure 3. (He et al., 2016).

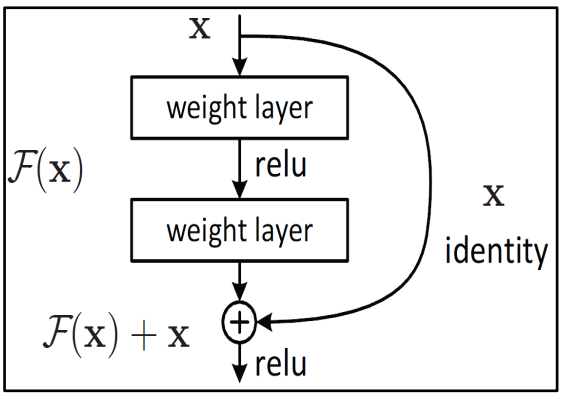


Figure 3. Residual learning block structure

The value (x) taken as input in the residual learning block is processed with two weight layers to obtain the $F(x)$ function. Then, x is added to the $F(x)$ function to obtain the $H(x)$ function. This situation is expressed as $H(x) = F(x) + x$ (He et al., 2016; Kaya et al., 2020). In the classical network model, $H(x)$ is equal to the $F(x)$ function, while the original data is added to the input in the ResNet model (Toğaçar and Ergen, 2019). Figure 4. shows an example of the classic 34-layer network structure model and the ResNet model structure (He et al., 2016).

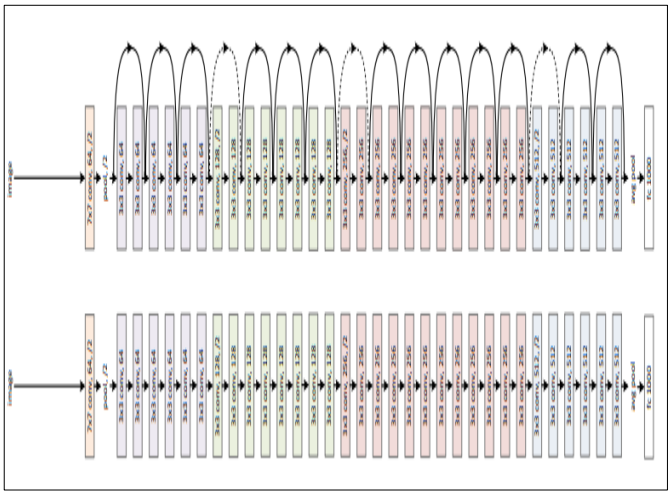


Figure 4. (Bottom) Classical network structure model (Upper) ResNet model structure

3. Results

In this study, experimental studies on the database were tested statistically. The results obtained from CM are shown in Table 5.

Table 5. Statistical results from CM

		Cl_1	Cl_2		Cl_1	Cl_2		Cl_1	Cl_2		Cl_1	Cl_2		Cl_1	Cl_2
Precision	**Fold-1**	0.8924	0.8764	**Fold-2**	0.7826	0.9007	**Fold-3**	0.9107	0.7912	**Fold-4**	0.9041	0.8473	**Fold-5**	0.9244	0.8137
Sensitivity		0.9105	0.8524		0.9473	0.6448		0.8259	0.8907		0.8821	0.875		0.8455	0.9071
Specificity		0.8524	0.9105		0.6448	0.9473		0.8907	0.8259		0.8750	0.8821		0.9071	0.8455
Accuracy		0.8857	0.8857		0.8186	0.8186		0.8534	0.8534		0.8790	0.8790		0.8717	0.8717
F-measure		0.9014	0.8642		0.8571	0.7515		0.8662	0.8380		0.8930	0.8609		0.8832	0.8578

When we examine the Table 5., it is seen that the highest Accuracy value is obtained from fold-1 with 0.8857. It is seen that the highest Sensitivity value is obtained from the 2nd fold and the Kirmizi Class with a value of 0.9473. Table 6 shows the CM results and Roc Curves for each fold

Table 6. CM results and Roc Curves

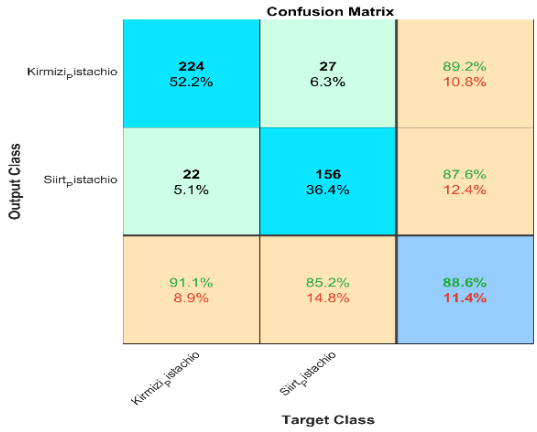
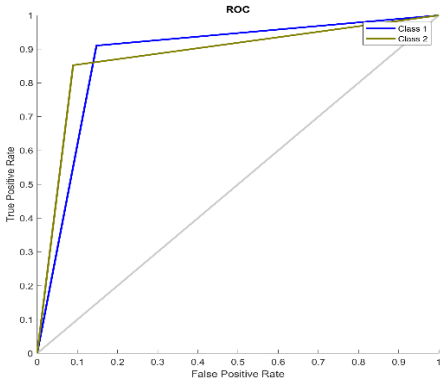
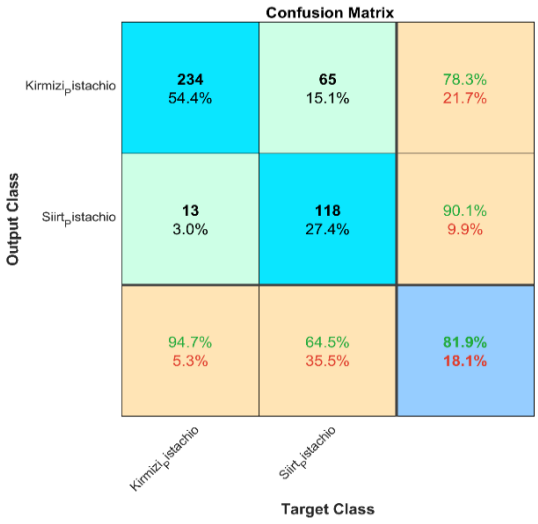
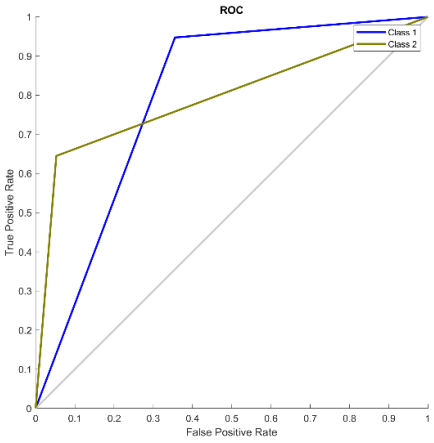
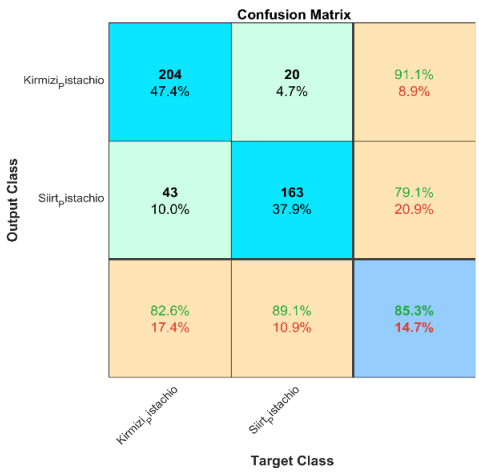
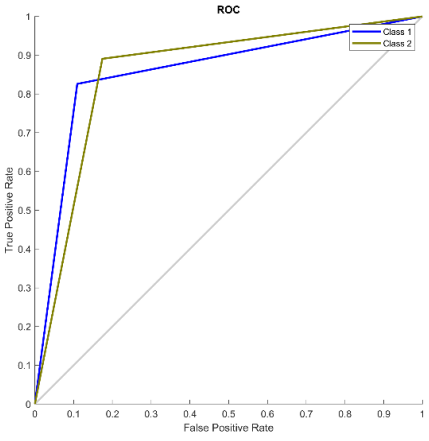
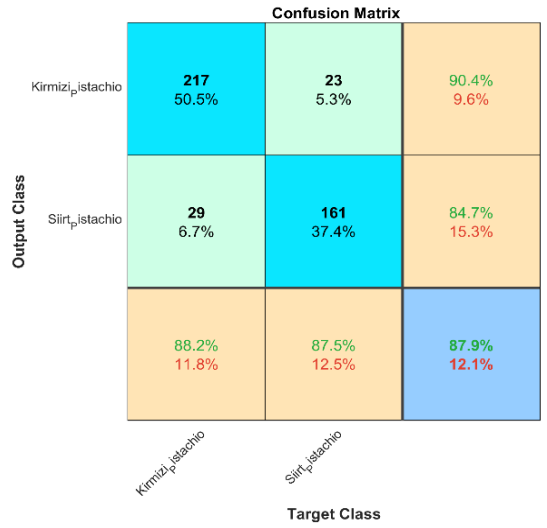
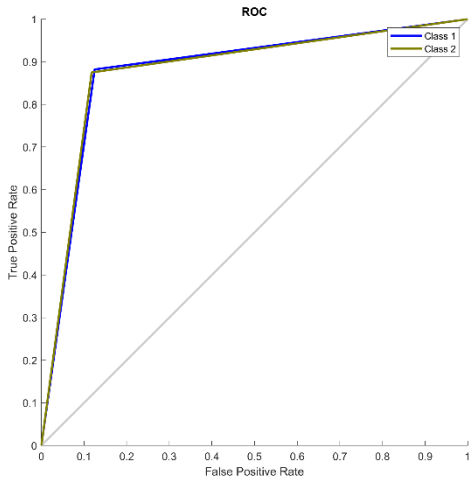
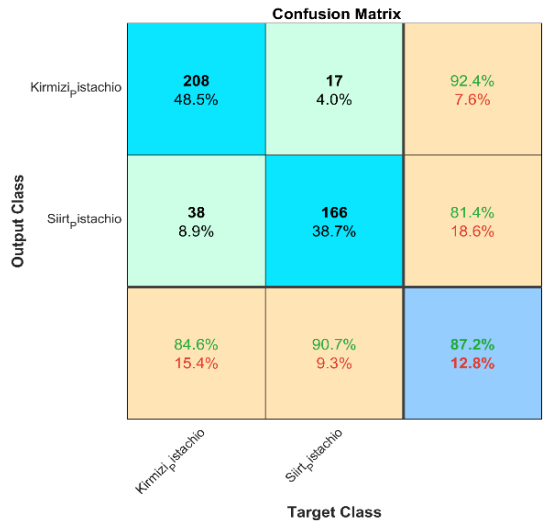
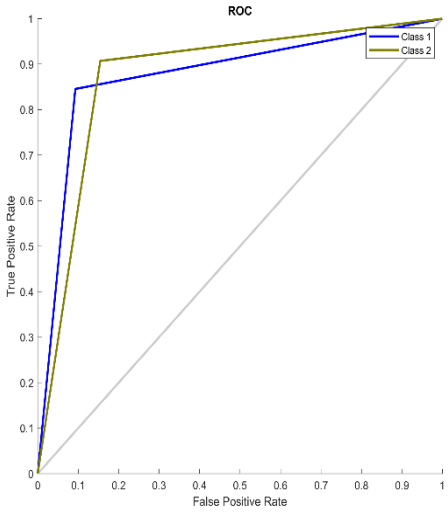
	Folds-CM Results	Folds-Roc Curve
Fold-1		
Fold-2		
Fold-3		

Table 6 (Continued). CM results and Roc Curves

Fold-4		
Fold-5		

When we examine Table 6, we see that the lowest classification success was obtained from the 2. fold with 81.9%. 88.6% classification success was obtained from fold 1. Obtained 85.3% from fold 3. The highest classification rate was obtained from fold 4 at 87.9%, which was the highest value. A value of 87.2% was obtained from fold 5.

4. Conclusions And Future Works

Together with certain countries, the pistachio market constitutes a very common trade network in Turkey. The classification process of this product, which has a widespread trade network, is also of great importance before the process of separating it into certain groups before export. In this study, two pistachio species with

high commercial potential, called kirmizi and siirt, were classified using the ResNet deep learning model. In this study, two pistachio species with high commercial potential, called kirmizi and siirt, were classified using the ResNet deep learning model. After the pistachio classification process, the highest Sensitivity value from the kirmizi pistachio was obtained as 0.9473 from the 2nd fold. In future studies, classification performance can be made with different models. In addition, better classification results can be obtained by developing different hybrid models.

Author Contributions: Methodology, analysis, investigation, writing—original draft preparation, review and editing, ….. All authors have read and agreed to the published version of the manuscript.

Funding: This work did not receive any funding.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 301-312 DOI:10.15316/SJAFS.2023.030 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

The Quality of Silage and Yield in Hungarian Vetch and Forage Crops and Rye Intercropping System

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HIGHLIGHTS

- The intercropping is a widespread cultivation system based on land use efficiency.
- The silages from same ratios in legume/cereal intercropping were prepared and analysed for quality.
- 80%Rye+20%Pea treatment was in both with high yield before ensiling and silage quality.
- Consequently, H. vetch and F. pea with rye silage combinations were in complementary.
- Features and chemical contents defined in silages confirm that sole treatments are not profitable for silage.

Abstract

The aim of the study was to determine silage yield and quality of Hungarian vetch/forage pea (V/P) with rye (R) mixed in an intercropping system that provides maximum level of faulting from the field. The field experiment was conducted in 2021-2022 to examine the effects of different binary sowing ratio (20:80%R/P, 40:60%R/P, 60:40%R/P; 80:20%R/P; 20:80%R/V, 40:60%R/V, 60:40%R/V; 80:20%R/V, 100%R, 100%P, 100%V) in 3 replications. The treatments were harvested in July 2022 for silage, and hay yield and fresh yield were determined in the intercropping treatments before ensiling. On the same day, silages were filled by the same mix ratios in plastic cans. After fermentation, the dry matter ratio, pH, sucrose, crude protein, ADF, NDF, mineral matters and organic acid were defined in silages. Before ensiling the highest fresh and dry yield were obtained from 80:20%R/P. Yield values were decreased by increase of rye ratio in the mix. The dry matter, crude protein, lactic acid formation, the inhibition of undesirable micro-organisms and nutritional quality has been improved in rye silages prepared with H. vetch and F. pea contribute. Consequently, the combinations of the H. vetch and F. pea contribute to rye silage are complementary, and the intercropping of the binary combination made profitable forage yield and silage quality, according to sole treatments. The positive effects in the investigated parameters are in all mixed ratios, but, 80:20R/P, 60:40R/P and 80:20R/V silages were more superior to the others. Intercropping system, mix silage, rye, legumes, silage quality

Keywords: Intercropping System, Mix Silage, Rye, Legumes, Silage Quality

Citation: Doğrusöz MÇ, Mut H, Başaran F, Gülümser E (2023). The Quality of Silage and Yield in Hungarian Vetch and Forage Crops and Rye Intercropping System. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 301-312. https://doi.org/10. 15316/SJAFS.2023.030

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Received date: 18/12/2022

Accepted date: 07/05/2023

1. Introduction

Intercropping of annual legumes with winter cereals is a very common practice for forage production in many countries. Legumes are highly nutritious forage crops produced both as grass and seeds due to their high protein content (30-35%), inorganic minerals, calcium and phosphorus, and vitamins. In addition, leguminous proteins are characterized as proteins of high biological value, making them an essential component of animal feed in addition to grains. Especially, forage peas and vetch crops have a high potential in intercropping due to their widespread cultivation in Turkey and their high protein content. Rye, on the other hand, is a grain whose use as a fodder is inactive, has low crude protein (CP) and is rich in fiber. Its forage quality can be improved by mixing with legumes rich in CP. According to some research, legumes-cereals intercropping ensure stable biomass yield and feed quality (Lithourgidis et al., 2007; Galanopoulou et al. 2019). Especially in dry agriculture, many studies have been carried out with legumes-cereals intercropping by aimed at silage or forage grazing (Crusciol et al. 2013; Pariz et al. 2016) and thus the intercropping system has proven to be a way to improve the quality of silage (Lima et al. 2010; Amado et al. 2012; Gulumser et al. 2021a). Besides all these, the intercropping system stands out as an opportunity to reduce the environmental impact of animal production due to the reduction in rumen methanogenesis and increased protein supply for animals (Melesse et al. 2017).

The quality of the silage material is a fundamental consideration in any forage production system. High quality forage should have high intake, digestibility and efficiency in use (Costa et al. 2014). It is known that quality silages have higher dry matter, protein and nutrient content and high-quality fiber content, low pH. Neutral detergent fiber (NDF) is a measure of the total cell wall fraction, and acid detergent fiber (ADF) forms the indigestible portion of the forage mix. Lactic acid in silage is the dominant fermentation product, another important evaluation index of silage quality. Organic acids present in properly fermented silage are energy sources that affect the performance of ruminants (Daniel et al. 2013). The most important of these organic acids, lactic acids, are produced by lactic acid bacteria (LAB), which is naturally present in the plant. Epiphytic LAB convert water-soluble carbohydrates (WSC) into lactic acid (LA) under anaerobic conditions. There is great variation by species in LAB numbers in crops (Broberg et al. 2007; Comino et al. 2014).

Because legumes have low WSC, silage quality is low, but DM and protein content are high. On the other hand, rye is just the opposite. Moreover, some undesirable properties such as low dry matter, nutritional value, protein and quality fiber content, including intense alcoholic fermentation, when cereals are ensiled in pure form, limit the use of silage (Lopes and Evangelista, 2010; Pedroso et al. 2005; Rezende et al. 2011; Siqueira, et al. 2012). The less and slow lactic acid is formed, the more acetic and butyric acid are increased (Guo et al. 2018). High concentration of acetic acid, the main metabolite of Acetobacter, always leads to a higher pH, which benefits the unwanted microorganism Clostridia (Zheng et al. 2017). This reduces the quality of silage by causing a decrease in protein content and nutritional value, and silage deteriorates. To prevent these problems, additives such as urea, calcium oxide, virgin lime, limestone, sodium chloride and LAB are used (Ribeiro et al. 2010; Balieiro Neto et al. 2007; Amaral et al. 2009; Rezende et al. 2011). However, additives can increase production costs and adversely affect the environment. The best sustainable and cost-effective alternative to improve silage quality is the legume-cereal intercropping system. In this way, both the efficiency of land use is increased and cheap and high-quality roughage is obtained.

Intercropping forage pea (*Pisum sativum* spp arvense L.) or Hungarian Vetch (*Vicia pannonica* CRANTZ.) with rye (*Secale cereale* L.) is an alternative way of cropping to improve forage yield and quality for hay production compared to mono-cropping. However, it has been determined that the water, nutrient and light competition of cultivated plants generally reduces the yield of the mixture compared to monoculture (Lithourgidis et al. 2011, Lithourgidis and Dordas 2010). Therefore, it is important to choose the intercropping system with the appropriate sowing rate. In this context, binary mixes of H. vetch and F. pea with rye were

grown at four different ratios and silages were prepared at the same ratios. As a result of the study, the effect of sowing rates on the chemical composition and yield of silages was investigated.

2. Materials and Methods

2.1. Field experiment

The field experiment in 2021–2022 years was conducted at the Agriculture Production and Research Centres at Yozgat Bozok University (39° 38′ 17″ N, 34° 28′ 1″E), Turkey. According to the data of the Turkey meteorology general directorate, the monthly minimum, maximum temperature and total precipitation of this field are 11.6°C, 22.7°C and 174 mm, respectively. The soil samples taken from the three sites at a depth of 0–30 cm were analyzed by the University-Industry-Public Cooperation Development Application and Research Center (USKIM) laboratory. According to this analysis result, the soil at the field is a clay loam texture with moderate organic matter, lightly salted and highly phosphorus.

Table 1. Sowing method of mix plots and seeding rate by weight and component crop seeding ratio of legumes–rye intercrops.

Treatments	Component crop seeding ratio (%)	Seeding rate by weight (kg da^{-1})	Sowing method of mix plots (o=rye, ж= intercrop legume species)
Rye	100	22	o ж o ж o ж
H. Vetch	100	12	o ж o ж o ж
F. Pea	100	12	o ж o ж o ж
20:80 R/P	20:80	4.4:9.6	o ж o ж o ж
40:60 R/P	40:60	8.8:7.2	o ж o ж o ж
60:40 R/P	60:40	13.2:4.8	o ж o ж o ж
80:20 R/P	80:20	17.6:2.4	o ж o ж o ж
20:80 R/V	20:80	4.4:9.6	o ж o ж o ж
40:60 R/V	40:60	8.8:7.2	o ж o ж o ж
60:40 R/V	60:40	13.2:4.8	o ж o ж o ж
80:20 R/V	80:20	17.6:2.4	- 30cm - 30cm - 30cm - 30cm - 30cm -

o: rye, ж: legumes

For each legume, binary mixtures of forage pea (*Pisum sativum* ssp. *arvense* L., "P") and Hungarian vetch (*Vicia pannonica* CRANTZ.; "V") and rye (*Secale cereale* L.; "R") four different ratios were used in the experiment. The field trial was in a randomized block experiment design with four replications. Seeding rate (kg da^{-1}) and mixture ratios in the intercropping system are given in Table 1. Sowing was done in October 2021 into 6 rows on 6 meter long plots with a distance of 30 cm. The mixture plots were in the form of one row of rye and one row of legume (Table 1). The plots were harvested on 18 July 2022 for silage, in account the development period of rye. The fresh yield (kg da^{-1}) was determined by weighing the plants that were separated by hand to each species and in 1 m2 area located homogeneous of the plots (3 repeat). Hay yield (kg da^{-1}) was calculated by weighing after drying at 65 ^{0}C. The Materials and Methods should be described with sufficient details to allow others to replicate and build on the published results. Please note that the publication of your manuscript implies that you must make all materials, data, computer code, and protocols associated with the publication available to readers. Please disclose any restrictions on the availability of materials or information at the submission stage. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited.

2.2. Silage experiments

After harvest, plants were chopped in 2 cm size (Gulumser et al., 2021b) with same mix ratios and filled in 1.0 kg plastic cans with 3 replications. The silages, which were sealed in an airtight way, were left for fermentation at 25±2 ^{0}C for 45 days. When the cans were opened after fermentation, the tops of 3-4 cm were discarded. The dry matter ratio was calculated by weighing after dried 100 g samples from each silage at 105 ^{0}C. To determine the sucrose and pH of the silages, 20 g of sample was mixed homogeneously with 100 ml of distilled water in a blender and filtered into 50 ml eppendorf tubes with filter paper (Basaran et al. 2018). The pH was determined with the HANNA Edge digital pH meter. The sucrose content was determined with a refractometer (HANNA HI 96801 Digital Refractometer 0.85% Brix) device.

For chemical analysis of silage, the 100 g silage sample was dried at 65 0C until the constant weight was ground (<1 mm). ADF (acid detergent fiber), NDF (neutral detergent fiber), crude protein (CP), Ca, Mg, K and P ratios were determined by Foss NIR Systems Model 6500 Win ISI II v1.5 device with IC-0904-FE calibration program. The organic acids (lactic, acetic and butyric acids) were determined on HPLC (Shimadzu, Kyoto, Japan) auto sampler system model LC - 20AT equipped with four pumps and an SPDM20A diode array detector (DAD) at YOBU Science and Technology Application and Research Center. However, in the result analysis, butyric acid was not detected.

2.3. Statistical analyzes

All of the data were analyzed using the SPSS 20.0 (SPSSInc., Chicago, IL, USA) Duncan test was performed to determine the significant differences among treatments and those with a p value less than 0.05 were considered significant differences.

3. Results

The fresh and hay yields of legume-rye intercropping were in significant differences ($p<0.01$) among the treatment combinations (Figure 1). Since high yield is directly related to high biomass, both yields peaked in sole rye, as expected. Also 80:20 R/P and 80:20 R/V mixing ratios are in the same group with sole rye. The lowest value was obtained from the sole H. vetch and F. pea plots.

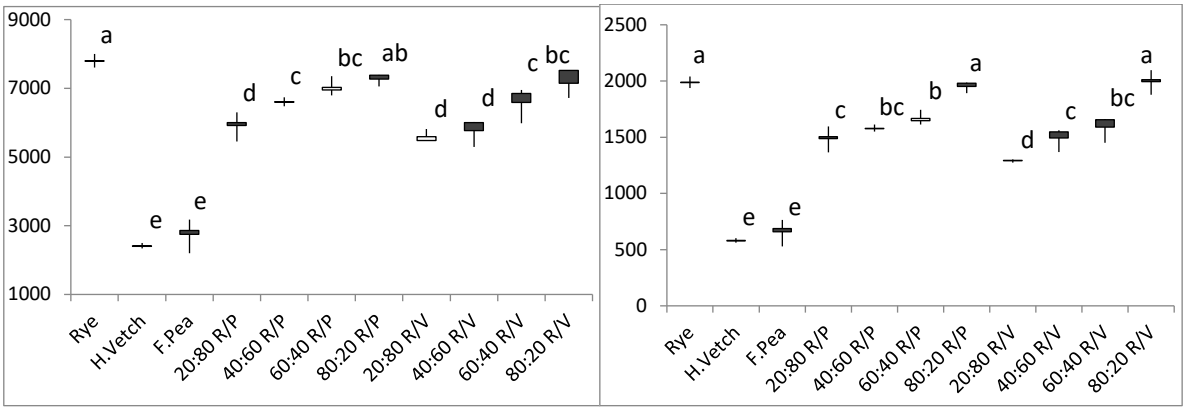

Figure 1. Effects of the legumes-rye binary mixture ratio on fresh** and hay yield** (There is no difference between the means shown in the same letter ($p<0.05$). **:$P<0.01$)

Table 2. Chemical composition (%) of silages.

Treatments	pH**	Sucrose **	DM**	CP**	ADF**	NDF**
Rye	4.74 bc	4.50 a	37.76 a	6.41 h	39.76 a	70.72 a
H. Vetch	4.98 a	2.27 b	23.83 e	18.81 b	33.46 bc	46.78 g
F. Pea	4.78 b	4.40 ab	22.75 e	22.82 a	22.82 e	39.78 h
20:80 R/P	4.71 cd	4.53 a	28.07 d	14.70 d	34.24 b	53.90 ef
40:60 R/P	4.68 de	4.50 a	30.13 cd	13.26 d	35.74 b	58.22 de
60:40 R/P	4.62 fg	4.50 a	33.67 b	10.00 ef	39.15 a	65.59 bc
80:20 R/P	4.58 g	4.50 a	36.86 a	8.61 fg	40.48 a	68.39 ab
20:80 R/V	4.72 cd	2.30 b	28.89 d	16.51 c	29.05 d	51.54 f
40:60 R/V	4.62 fg	2.37 b	31.60 bc	13.93 d	30.99 cd	56.22 ef
60:40 R/V	4.62 fg	3.80 ab	33.99 b	11.13 e	34.75 b	61.43 cd
80:20 R/V	4.65 ef	4.60 a	37.32 a	7.50 gh	40.06 a	70.47 a
Means	4.70	3.85	31.35	13.06	34.59	58.46

**:p<0.01There is no difference between the means shown in the same letter (p<0.05).

The chemical components presented in Table 2 were significantly affected by legume-rye mix silages. The highest pH was determined in H. vetch (4.98), while the lowest was in 80:20 R/P (4.58). The pH of mixture silages were dramatically reduced when rye ratio was increased. The best results of sucrose were determined in all applications except sole H. vetch, 20:80 R/V and 40:60 R/V. The sucrose content of silages was affected more positively by F. pea compared to H. vetch contribution. The DM was much higher in the 80% rye combinations and sole rye than in the other mixed arrangements. The lowest values were in sole H. vetch (23.83%) and F. pea (22.75%). Therefore, the effect of both legumes on rye silage DM was similar. An increased legume contribution in the mixture increased the rye silage CP. However, among intercrops, F. pea affected the CP of rye silages much more than the H. vetch. The ADF content of the silages varied between 22.82 (sole F. pea) and 40.48% (80:20 R/P), while NDF ranged from 39.78% (sole F. pea) to 70.72% (sole rye).

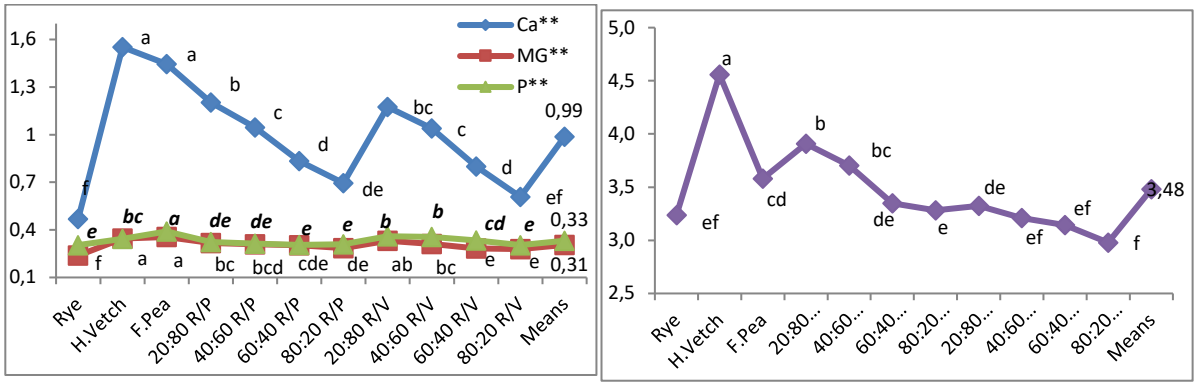

Figure 2. Effects of the legumes-rye binary mixture ratio on lactic** and acetic acid** ratio of silages *(There is no difference between the means shown in the same letter (p<0.05). **:P<0.01)*

The mineral content of the silage samples was significantly affected by the mixing ratios (Figure 2). Mineral content of sole legume silages was higher than rye silage. Therefore, in parallel with the increase in the legumes ratio in the mixture, Ca, P, Mg and K of the silages increased. Forage pea contribution to Ca and K contents of rye silage was more effective than the cowpea contribution. In terms of Mg content, both legumes were equally effective, while H. vetch was more effective in P content. Organic acids were primarily influenced by the effects

of sainfoin with maize and sorghum binary mix ratios (Figure 3). The highest lactic acid (LA) was found in sole rye (3.05%), 80:20 R/P (3.10%), 60:40 R/V (3.12%) and 80:20 R/V (3.08%). In other words, unlike the mineral matter, lactic acid increased in parallel with the rye ratio. The lowest LA was in sole forage pea (2.08%). The acetic acid (AA), which is directly related to the spoilage of silages, ranged from 0.31 (80:20 R/V) to 0.53% (20:80 R/P). Due to the low water-soluble carbohydrates of legumes, the lactic acid level has increased with increasing rye ratio, but acetic acid level decreased. The best result of AA content was defined in 80:20 R/V. As a last observation, the effect of H. vetch added silages on organic acids was greater than that of F. pea.

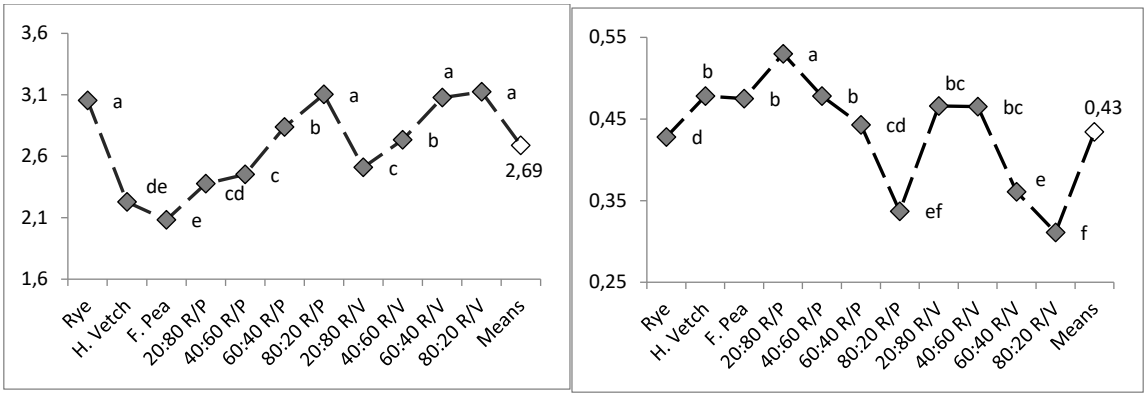

Figure 3. Effects of the legumes-rye binary mixture ratio on lactic** and acetic acid** ratio of silages (*There is no difference between the means shown in the same letter (p<0.05). **:P<0.01*

4. Discussion

Intercropping legumes with cereals is an alternative way to improve forage yield and quality for hay production compared to mono-cropping. The fresh and dry yield accumulate of silage plants is should be sufficient to produce the best quality profitable of silage, before ensiling (Jeroch et al. 1999).The yield parameters examined for this purpose were obtained from the highest 80:20R/P mixture, except sole sowing. Also, the decrease in the rate of rye with high biomass in the mixtures caused a decrease in yield. Many researches (Gianoli et al. 2006; Basaran et al. 2017; Lienhard et al. 2020; Igbal et al. 2021) support these results.

For quality animal production, DM in silages should be 25-40% (Panyasak and Tumwasorn 2013). The DM was found suitable in mixed silages, but it was low in sole legumes. Low DM in the silages increased pH (sole H. vetch) and decreased sucrose (sole H. vetch, 20:80 R/V and 40:60 R/V). The all mix silages yielded a pH within the range of 3.8 to 4.8, which is considered ideal for good quality silage (Fiyla 2001). Moreover, sucrose decreased with increased percentage of H. vetch silage in the mixtures possibly due to sole H. vetch having a low WSC content suitable for lactic acid production. This situation can be explained that if the DM is going out of ideal limits, anaerobic bacteria can grow and decompose sucrose and protein into butyric acid and ammonium. In addition, increasing the unwanted epiphytic microorganisms reduces the fermentation process and quality of the silage (Jeroch et. al. 1999).

Intercropping legumes with cereals in silage is mainly aimed at increasing the silage CP content, since grasses such as rye have low CP levels (Neres et al. 2012). Minson (2012) reported that minimum protein level in the feed should be 7% CP for ruminal fermentation. The CP content of other silages except sole rye was found above this value. Thus, including 20% legumes in rye silage provided the minimum CP content for good ruminal functioning. The increase in CP of mix silages is explained by the legumes' high CP content (Amaefule et al. 2011). ADF and NDF of silages are factors affecting energy intake and milk yield of dairy cows (Ferraretto

et al. 2015; Tharangani et al. 2020). NRC (2001) reported that quality silages are typically expected to have 25-35% ADF and 40-50% NDF. It has been observed that the ADF content of the mixtures with high legume contribution is between these limits. The decrease in these contents may be due to the plant species, the harvest period as well as the competition from high mixed sowing density. Similar results were found in some studies in which the CP, ADF and NDF contents of legume-grass silages were determined (Baležentienė and Mikulionienė 2006; Seydoşoğlu 2019; Mut et. al. 2020; Gulumser et al. 2021a).

Successfully fermented silages generally have a higher nutrient content (Kung et al. 2018). The mineral substances examined in silages are the elements that must be met from the feed in order for the animals to perform their functions in a healthy way (Yogeshpriya and Selvara 2018; Ahemad et al. 2009; Trailokya et al. 2017; Arnoud 2008). Kidambi et al. (1993) and Tekeli and Ateş (2005) concluded that at least 0.8% K, 0.21 P, 0.3 Ca and 0.1 Mg in forage for balanced nutrition of animals are reported. In addition, legumes have a richer nutritional content than grass (Dumlu Gul and Tan 2018). All silages in the study had minerals above these values. Also, mineral content rye silage has been increased with the legumes contributing and this result is similar to Gulumser et al. (2021b).

Organic acids present in properly fermented silage are energy sources that affect the performance of ruminants (Daniel et al. 2013). Lactic acid in silage is the dominant fermentation product, another important evaluation index of silage quality. Acetic acid and Butyric acid are indicators of increased unwanted organisms and unsuccessful fermentation in silages. In all of the silages, the existence of high LA, low AA and lack of butyric acid determined and it indicate the quality fermentation, which is an indicator of well preservation (Auerbach et al. 2013). Also, lactic acid should be above 2% and acetic acid should be below 0.8% in quality silage (Alcicek and Özkan 1997), and our results were found to be within these limits. However, the highest LA and lowest AA were determined in 80:20 R/P and 80:20 R/P mix silages. These results show that the addition of legumes to high carbohydrate rye silage is successful.

With the ratio H. vench and F. pea contributed to rye silages, the pH and acetic acid were decreased, lactic acid formation was increased, and better-quality silage was obtained compared to the lean ones. The effect of H. vetch added silages on organic acids was greater than that of F. pea. This finding was consistent with previous data and Gulumser et al. (2021b) stated that can increase lactic acid content with mixtures, while Basaran et al. (2018) reported that levels of different ratios of mixed have varying effects (Li et al. 2022). However, some studies (Li et al. 2016; König et al. 2019) have shown different effects. These differences in silage quality may be due to plant species, cultivation, climatic conditions, soil fertility, growing period and harvest time.

5. Conclusions

In this study, the quality of silages obtained from different mixtures of legume-rye grown by making maximum use of the unit area was examined. The main purpose of this study was to reduce DM loss; support lactic acid formation, the inhibition of undesirable micro-organisms and the improvement of nutritional quality in rye silages prepared with H. vetch and F. pea contribute. Consequently, the combinations of the H. vetch and F. pea contribute to rye silage are complementary, and the intercropping of the binary combination made profitable forage yield and silage quality. The forage yield of the mixtures before ensiling was higher than the sole legumes, and the highest yield was determined in 80:20R/P. Positive indices such as CP, lactic acid and chemical contents defined in H. vetch and F. pea rye mix silages confirm that sole rye is not profitable for silage. We have determined that the positive effects in the investigated parameters are in all mixed ratios. However, 80:20R/P, 60:40R/P and 80:20R/V silages were more superior to the others.

Author Contributions: Conceptualization and methodology, M.C.D.; software, validation, formal analysis and investigation M.C.D., H.M. and U.B.; resources, data curation, writing—original draft preparation, writing—review and editing, visualization and supervision M.C.D., H.M. and E.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 313-325 DOI:10.15316/SJAFS.2023.031 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Agricultural and Food Products Sectors During and Post The Covid-19 Pandemic From Consumer Perspective in Türkiye

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- **HIGHLIGHTS**
- The Covid-19 pandemic has reminded the whole world of the importance of the agricultural and food sectors.
- Consumers believe that Türkiye will prove to be a self-sufficient country in the agricultural and food sectors.
- Consumers think that the number of agricultural entrepreneurs will increase for the post-pandemic period.

Abstract

The purpose of this research is to determine and analyze the opinions of consumers in Türkiye on agricultural and food products sectors during and post pandemic, the points they pay attention to while purchasing agricultural and food products, and their degree of satisfaction with their place of living. The main material of the research consists of the data collected by means of an online survey conducted on the consumers (n=1945) living in Türkiye. The data obtained were used to present their socio-demographic structure with frequency distributions. In addition, a chi square test was conducted to analyze the relationship between their opinions on agricultural and food products sectors during and post pandemic and their demographic characteristics. 5-point Likert scale was employed to demonstrate their attitudes and opinions. According to the results of the research, consumers strongly agreed that agricultural and food products' prices had increased during the pandemic. 61.9% of the consumers strongly agreed that agricultural and food products' prices had increased during the pandemic. 60.5% of the consumers indicated they wanted to live in a rural area during the pandemic. The relationship between consumers' opinions on agricultural and food sectors and most socio-demographic characteristics was found to be significant for the period of pandemic and thereafter. This study may be useful in to predict the change of food and agricultural products consumer demand in post-pandemic.

Keywords: Agricultural and food products; consumer; COVID-19; pandemic; Türkiye

1. Introduction

Coronavirus disease 2019 (COVID-19) was first identified in December 2019 in the Huanan Seafood Wholesale Market located in Wuhan, Hubei, China and has spread almost all over the world, particularly in China. The World Health Organization eventually declared the coronavirus outbreak a global pandemic (WHO 2020). As of 10 May 2022, there are 515748861 cases and 6255835 deaths throughout the world (WHO

Citation: : Can Aydın B (2023). Agricultural and Food Products Sectors During and Post The Covid-19 Pandemic From Consumer Perspective in Türkiye. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 313-325 https://doi.org/10. 15316/SJAFS.2023.031
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Received date: 11/05/2022
Accepted date: 14/05/2023

2022). Türkiye, with 1858 cases and 7 deaths on the same date, is thought to be among the countries which have the potential of getting through the pandemic with less loss thanks to the early measures taken.

In the short term, key sectors such as agriculture, food, tourism, transportation and especially health were negatively affected by the pandemic. This process started to threaten the global economy, and life in many countries of the world came to a standstill (Yorulmaz and Kaplan 2020). Agriculture is one of the substantial sectors for the world economy and indispensable for human development (Lopez-Ridaura et al. 2019). With the outbreak of pandemic, agriculture and health came into prominence as two strategic sectors in almost all countries of the world (Lopez-Ridaura et al. 2019; Abdelhedi and Zouari 2020; Kogo et al. 2020). Following the declaration of pandemic, people flooded into supermarkets to buy cereals, legumes, fruits and vegetables, indicating that people were in a struggle for meeting their basic needs rather than buying expensive items. This is because nutrition is vital for people to survive, strengthen their immune system and stay healthy (Dogan and Dogan 2020).

People always need sufficient, safe and nutritious agricultural and food products for an active and healthy life. During the pandemic, consumers have been meeting their food needs predominantly from online groceries because they think going shopping can increase the risk of being infected with COVID-19. In China and Europe, online shopping for food has been on the rise since the beginning of pandemic (Cheng 2020; Von Abrams 2020; Goddard 2020), which has resulted in long delivery times (Gray 2020; Debter 2020). According to a research conducted by Nielsen Research Company in March 2020, about half (49%) of the consumers in Türkiye expressed they were planning to buy products such as food and beverages online in the medium and long term. Since consumers are expected to be isolated at home within this period, cooking at home has become even more important. As a result, there has been a tremendous increase in the demand of staple food products such as flour, yeast and pasta. In the study conducted on consumers in Türkiye, it was found that consumers mostly bought pasta and dried pulses products during the pandemic period (Ince and Kadıoglu, 2020). At the onset of pandemic, people rushed into supermarkets to pile up food (Royte 2020). Panicked consumers were stockpiling the foods, which in turn affected food availability and price (Poudel et al. 2020).

With the emergence of pandemic, it has become evident, not only in Türkiye but also in the world, that agriculture is a vital and strategic sector. The emergence of pandemic coincided with the period of sowing, planting, fertilizing, pest control and maintenance for vegetables and crops such as corn, cotton, sunflower, etc. in Türkiye. Problems occurring during this period or omissions made in fundamental matters such as sowing, planting, maintenance, etc. may lead to yield loss for a season and keep consumers from reaching adequate amounts of food (Dogan and Dogan 2020). Moreover, travel bans imposed in numerous countries of the world have caused farmers to face the shortage of agricultural inputs like seed, fertilizer and pesticides in global trade. China is the leading fertilizer producer and exporter of the world. The lockdown in China has severely affected international fertilizer trade (Poudel et al. 2020). For this reason, the agricultural sector can play a lifesaving role in the future of countries through accurate, efficient and timely measures to be taken in this critical process. By improving nutrition, agricultural development should facilitate combating infections (Nouh et al. 2020).

The online mapping systems regarding trade restrictions as shared by the International Food Policy Research Institute (IFPRI) and the International Trade Centre (ITC) allows for monitoring different types of protective policy trends adopted by countries. Accordingly, since the beginning of pandemic, 18 countries have introduced temporary restrictions or bans on the export of 26 agricultural products (Eren 2020). The restrictions to be imposed by countries on agricultural and food products for the purpose of meeting their own needs in the upcoming days may cause consumers to purchase products at higher prices in food markets.

Both agricultural and food sectors are vital for people to satisfy their nutritional requirements to survive during and post pandemic. Therefore, maintaining the continuity of these sectors is of great importance. Most

of the studies on the COVID-19 pandemic have been conducted in the field of health. There are also studies on countries' agricultural and food sectors during the pandemic. There are several studies on effects of the pandemic on food and food systems (Blay-Palmer et al. 2020; Chow 2020; Cheng 2020; Dogan and Dogan 2020; Emmad and Pena 2020; Eren 2020; Ergenc 2020; Galanakis 2020; Yu et al. 2020). Some of the other studies are also related to socioeconomic effects of the pandemic on countries (Acıkgoz and Gunay 2020; Alpago and Alpago 2020; Bapuji et al. 2020; Guven 2020; Nicola et al. 2020; Zhang et al. 2020; Castellini et al. 2021), impacts of the pandemic on agriculture (Meine 2020; Poudel et al. 2020; Villulla 2020; Mishra et al. 2021) and food and nutritional security in the pandemic (Lal 2020; Nouh et al. 2020; Mukiibi 2020; Nyamwanza and Sinyolo 2020; Shahbaz et al. 2020). However, the number of studies on consumers during this period is limited (Cakıroglu et al. 2020; Danısmaz 2020; Song et al. 2020; Qi et al. 2020; Ince and Kadıoglu, 2020; Widayat 2020; Chenarides et al. 2021; Temizkan et al. 2021; Tolun and Bulut, 2021; Roe et al. 2021; Kılıc and Eryılmaz, 2022; Tepe et.al., 2022).

Thus, it is significant to investigate consumers' attitudes towards agricultural and food products and their opinions on these two sectors during the ongoing pandemic and also necessary for determining the measures that can be taken for the post-pandemic period.

The purpose of the present research is to determine and analyze the demographic characteristics of consumers in Türkiye as well as their opinions on agricultural and food products sectors for the period of pandemic and for post-pandemic period, the points they pay attention to while purchasing agricultural and food products, and their degree of satisfaction with their place of living.

2. Materials and Methods

The main material of this research consists of the primary data obtained from the consumers living in Türkiye. The research data were collected from 1945 consumers that were selected by conveniency sampling by means of an online survey conducted in May 2020. Since the research subject is current, the data were collected in a short span of time. An online survey was preferred to a face-to-face one for health and safety reasons due to the pandemic. In addition, available publications, articles and internet records were used. The research survey is made up of 3 parts with 45 questions in total. There are 11 questions determining socio-demographic characteristics in the first part. The second and third parts comprise 34 questions determining consumers' behavior patterns in purchasing agricultural and food products and their opinions on agricultural and food sectors during and after the pandemic, respectively.

Before the survey form used in the research was created, it was standardized online and tested on Google Forms. The online survey was conveyed to as many consumers as possible by means of social media (Facebook and Twitter) and mobile phone so as to be answered within one month. A total of 1945 survey forms were received back and evaluated as the research data.

5-point Likert scale was employed to designate consumers' point of views of and attitudes towards agricultural and food sectors for the period of pandemic and for post-pandemic period. In the questionnaire form, the Servqual scale developed by Parasuraman et al. (1988) was used based on the 5-Likert Scale (1 = Strongly disagree; 5 = Strongly agree).

In the analysis of the data obtained, SPSS 22.0 statistical analysis software package was used. Consumers' socio-demographic structure was demonstrated with frequency distributions. Besides, the relationship between consumers' opinions on agricultural and food products sectors for the period of pandemic and for post-pandemic period and their demographic characteristics was analyzed by means of a chi-square test.

3. Results and Discussion

3.1. Socio-economic characteristics of consumers

Information about the socio-economic characteristics of consumers is given in Table 1. Of the consumers who took part in the survey, 53.4% were female and 46.6% were male. The age group of 20 to 29 years had the biggest share (57.4%), followed by that of 30 to 39 years (15.7%) and that of 40 to 49 years (12.2%), respectively. Since the rate of Internet and social media use is higher among the youth, it was predominantly younger people who joined the survey. In terms of educational background, the largest group consisted of high school graduates (33.1%), followed by bachelor's degree holders (27.9%) and associate degree holders (21%), respectively. 59.2% of the respondents were single, while 40.8% were married. 69.1% of them were the owner of the property they lived in. In terms of profession, 30.6% were students, 25.8% were private sector employees, and 12.2% were housewives. 33.2% of the respondents had monthly income of family between 3001 TRY and 5000 TRY, and 31.1% between 1001 TRY and 3000 TRY. 46.7% lived in a district center, 39.5% in the provincial center, and 13.8% in a town/village. The consumers who had 3-4 members in their family ranked first (54.4%), followed by those with 5-6 family members (29%) and those with 1-2 family members (11.8%), respectively.

Table 1. Socio-economic characteristics of consumers

	n	%		n	%
Gender			*Profession*		
Female	1038	53.4	Public sector	203	10.4
Male	907	46.6	Private sector	502	25.8
Total	1945	100.0	Self-employed	146	7.5
			Student	596	30.6
Age			Housewife	238	12.2
20-29	1116	57.4	Retired	148	7.6
30-39	305	15.7	Unemployed	112	5.9
40-49	238	12.2	Total	1945	100.0
50-59	191	9.8			
60 and above	95	4.9	*Family income (month/TRY)*		
Total	1945	100.0	1000 TRY and below	80	4.1
			1001 TRY - 3000 TRY	605	31.1
Educational Background			3001 TRY - 5000 TRY	645	33.2
Literate	15	0.8	5001 TRY - 7000 TRY	314	16
Primary school	120	6.2	7000 TRY and above	301	15.6
Secondary school	162	8.3	Total	1945	100.0
High school	643	33.1			
Associate degree	408	21.0	*Place of living*		
Bachelor's degree	542	27.8	Provincial center	767	39.5
Master degree	55	2.8	District center	909	46.7
Total	1945	100.0	Town/village	269	13.8
			Total	1945	100.0
Marital Status					
Married	793	40.8	*Number of family members*		
Single	1152	59.2	1-2	229	11.8
Total	1945	100.0	3-4	1057	54.4
			5-6	564	29.0
Home ownership			7 and above	95	4.8
Owner	1344	69.1	Total	1945	100.0
Tenant	573	29.5			
Public Housing	28	1.4			
Total	1945	100.0			

3.2. Opinion of consumers on their place of living

The consumers who took part in the research were asked the question "Are you satisfied with your place of living?", and 1641 (84.4%) of them responded "Yes", while 304 (15.6%) of them "No". As is seen, the majority of consumers were satisfied with the place they lived in.

In the survey, consumers were asked the question "has the pandemic caused you to want to live in a rural area?", and 1177 (60.5%) of them responded "yes", while 768 (39.5%) of them "no". Population is usually denser in city centers, and population density is a significant factor in the spread of pandemic. For this reason, consumers preferred rural areas to the city center because they thought being in a rural area was safer. As a result of chi-square analysis, the relationship between consumers' place of living and their willingness to live in a rural area was found to be significant ($p<0.05$) (Table 2). The group that wanted to live in a rural area most (64.1%) consisted of the consumers living in the provincial center. Besides, of the consumers who were willing to live in a rural area, 50.5% were female and 49.5% were male.

Table 2. Relationship between consumers' place of living and their willingness to live in a rural area

Willingness to live in a rural area	Place of living						Chi-square test result		
	Provincial center		District center		Town/village		χ^2	df	p
	n	%	n	%	n	%			
Yes	492	64.1	531	58.4	154	57.2	7.109	2	0.029*
No	275	35.9	378	41.6	115	42.8			

*statistically significant ($p<0.05$)

3.3. Opinions of consumers on agricultural and food products sectors during the pandemic

The answers given to the questions intended to find out the consumers' preferences while buying agricultural and food products during the pandemic and their opinions on these two sectors were assessed. The frequency of agreement with the statements given was assessed based on percentages and mean points (Table 3).

The statement that agricultural and food products' prices have increased during the pandemic was the one agreed by consumers most with an mean point of 4.29. During the pandemic, consumers have spent more time at home and allocated a bigger share to food expenses. Moreover, due to travel restrictions, compared to the pre-pandemic period, they have paid higher prices for agricultural and food products. Based on study by Qi et al. (2020), during COVID-19 crisis, they revealed that high prices of green food.

According to the findings, the risk of being infected with COVID-19 is higher for the middle aged and above and due to legal restrictions, consumer preferred to buy such products from the nearest supermarket during this period. Likewise, Temizkan et al. (2021) conducted a study on consumers at during the pandemic and stated that needs of 65% of the respondents preferred to buy from market.

The survey showed that consumers who strongly agreed with the statement "I have been preferring to pay by credit card instead of cash while buying agricultural and food products from the supermarket" (36.4%). In a study they conducted on consumers in China, Song et al. (2020) suggested to make electronic payment instead of using cash as a means of protection from contracting coronavirus. Another study conducted in Türkiye also found that 90% of the participants preferred credit card as a paying method during the pandemic (Ozsaatci and Karaboga, 2022)

Out of the consumers who strongly agreed with the statement "I have been preferring to buy agricultural and food products from the online grocery because it is safer" between the age of 20 and 29 (63.0%) had the biggest shares. Danısmaz (2020), in a study she carried out on consumers in Türkiye during the pandemic,

founded out the percentage of online grocery shopping increased from 18% (pre-epidemic) to 44.5% (during the epidemic). Likewise, Widayat (2020) conducted a study on adolescent consumers at the age of 15-25 during the pandemic and reported that 42% of the respondents usually ordered food online. The present study has similar findings.

Out of the consumers who strongly agreed with the statement "I have been preferring to consume the agricultural and food products that strengthen my immune system", the largest group was the age group of 50 to 59 years (48.2%), indicating that older age groups have been taking better care of their nutrition during the pandemic to protect themselves. Galanakis (2020), suggests that the pandemic may also increase demand for food products that are believed to boost immune systems.

Table 3. Opinions of consumers on agricultural and food products sectors during the pandemic

Statements	1		2		3		4		5		Mean
	n	%	n	%	n	%	n	%	n	%	
Agricultural and food products' prices have increased.	64	3.3	74	3.8	297	15.3	306	15.7	1204	61.9	4.29
It has been harder to find imported agricultural and food products.	518	26.6	339	17.4	593	30.5	214	11.0	281	14.4	2.74
Interprovincial travel restrictions have made it harder to find agricultural workers.	200	10.3	172	8.8	551	28.3	339	17.4	683	35.1	3.58
Seasonal agricultural workers have lost revenue.	115	5.9	127	6.5	437	22.5	392	20.2	874	44.9	3.91
Consumers have been preferring to buy packaged food products.	120	6.2	133	6.8	489	25.1	420	21.6	783	40.3	3.82
I have been preferring to buy agricultural and food products from the supermarket.	150	7.7	126	6.5	479	24.6	424	21.8	766	39.4	3.78
The frequency of buying agricultural and food products from the street market has decreased.	268	13.8	224	11.5	529	27.2	327	16.8	597	30.7	3.39
My consumption of convenience foods has decreased, while that of natural foods has increased.	133	6.8	166	8.5	540	27.8	412	21.2	694	35.7	3.70
I have been ordering food online more frequently.	760	39.1	197	10.1	340	17.5	247	12.7	401	20.6	2.65
I have been buying agricultural and food products from the supermarket in higher amounts and more frequently.	214	11.0	178	9.2	472	24.3	408	21.0	673	34.6	3.59
The increase in agricultural and food products' prices is a result of lack of production.	335	17.2	244	12.5	548	28.2	354	18.2	464	23.9	3.18
I have been preferring to pay by credit card instead of cash while buying agricultural and food products from the supermarket.	230	11.8	188	9.7	459	23.6	360	18.5	708	36.4	3.58
I have been preferring to buy agricultural and food products from the online grocery because it is safer.	595	30.6	268	13.8	489	25.1	261	13.4	332	17.1	2.72
I have been preferring to consume the agricultural and food products that strengthen my immune system.	108	5.6	113	5.8	457	23.5	480	24.7	787	40.5	3.88

1=strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree

3.4. Opinions of consumers on agricultural and food products sectors for the post-pandemic period

5-point Likert scale was used to evaluate consumers' preferences while buying agricultural and food products and their degree of agreement with the opinions on these two sectors for the post-pandemic period (Table 4).

Of all statements with which the consumers agreed for the post-pandemic period, the statement "hygiene will be a determining factor in buying agricultural and food products" had the highest mean point (4.13),

followed by "the demand for the agricultural and food products that strengthen the immune system will increase" (3.86) and "the number of entrepreneurs planning to invest in agriculture will increase" (3.71), respectively. Djekic et al.(2021), in a study she carried out companies confirmed implementation of more restrictive hygiene procedures during the pandemic. After the pandemic, hygiene will constitute an important element for consumers in food consumption.

According to the findings, the consumers who strongly agreed with the statement "agricultural and food products' prices will increase", those with a family income up to 1000 TRY (41.3%) and those retired (51.4%) had the biggest shares. Consumers in India have also noted that food prices have increased in the pandemic (Cariappa et al. 2021). For example, (Ruan et al. 2021), the daily price of chinese cabbage sharply increased by 46% initially in China.

Out of the consumers who strongly agreed with the statement "hygiene will be a determining factor in buying agricultural and food products", women (61%) and retired consumers (64.2%) constituted the largest groups.

The results showed that consumers who strongly agreed with the statement "the number of entrepreneurs planning to invest in agriculture will increase", the highest percentages belonged to those having a family income of 7000 TRY and above (31.2%) and those retired (40.5). After the pandemic, farming can give entrepreneurship opportunities to many jobless people and can meet the demand of growing population (Mishra and Pattnaik 2021).

According to survey data, consumers who strongly agreed with the statement "agricultural education will gain importance".

Table 4. Opinions of consumers on agricultural and food products sectors for the post-pandemic period

Statements	1		2		3		4		5		Mean
	n	%	n	%	n	%	n	%	n	%	
There will be a decrease in our agricultural production.	479	24.6	306	15.7	539	27.7	292	15.0	329	16.9	2.83
Agricultural and food products' prices will increase.	154	7.9	187	9.6	522	26.8	442	22.7	640	32.9	3.63
I am planning to make agricultural production.	473	4.3	302	15.5	487	25.0	270	13.9	413	21.2	2.92
The demand for the agricultural and food products that strengthen the immune system will increase.	92	4.7	132	6.8	476	24.5	496	25.5	749	38.5	3.86
Countries may impose restrictions or a quota on imported agricultural and food products.	169	8.7	187	9.6	586	30.1	441	22.7	562	28.9	3.53
Hygiene will be a determining factor in buying agricultural and food products.	69	3.5	95	4.9	367	18.9	390	20.1	1024	52.6	4.13
There will be no problem in finding seasonal agricultural workers.	145	7.5	175	9.0	562	28.9	458	23.5	605	31.1	3.61
The number of entrepreneurs planning to invest in agriculture will increase.	92	4.7	170	8.7	568	29.2	495	25.4	620	31.9	3.71
Rural settlement will grow.	175	9.0	241	12.4	593	30.5	468	24.1	468	24.1	3.41
Agricultural sector may become one of the most revenue-generating sectors.	113	5.8	202	10.4	642	33.0	478	24.6	510	26.2	3.55
Agricultural education will gain importance.	120	6.2	189	9.7	544	28.0	495	25.4	597	30.7	3.64
Türkiye will become one of the leading exporters of different agricultural and food products.	211	10.8	242	12.4	583	30.0	420	21.6	489	25.1	3.37
Türkiye will prove herself as a self-sufficient country in agricultural and food sectors.	197	10.1	178	9.2	502	25.8	425	21.9	643	33.1	3.58

1=strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree

3.5. Opinions of consumers on agricultural and food products sectors with demographic characteristics the pandemic and post-pandemic period

The data results of χ^2 test showed that there are significant relationship between the level of education and consumption of convenience foods has decreased ($p<0.01$) and preferring to consume the agricultural and food products that strengthen the immune system in the during pandemic(Table 5). A study carried out in Italy,

psyclogical reactions to COVID-19 emergency have effected the consumers intention to purchase sustainable food products (Castellini et al. 2021).

Additionally, there is a significant ($p<0.05$) relationship between the frequency of buying agricultural and food products from the street market has decreased and level of education. Therefore in consumer with high-education level, the frequency of going to street market has decreased.

Chi-square analysis show that significant in ($p<0.05$) profession groups and consumer have been preferring to buy packed good products. The student (28.8 %) and private sector (26.2 %) are the groups most willing to buy packed food.

According to the data, the most of those who say, "I have been ordering food online more frequently" are those with incomes of 3001 TRY-5000 TRY.

Table 5. Comparison of consumer opinions on agricultural and food products sectors with demografic characteristics at the during pandemic and post post-pandemic period

During Pandemic Period	χ^2	**df**	**p**
Consumers have been preferring to buy packaged food products – Profession	40.278	24	0.020**
My consumption of convenience foods has decreased, while that of natural foods has increased – Educational Background	57.684	24	0.000*
I have been ordering food online more frequently – Family Income	27.210	16	0.039**
I have been preferring to buy agricultural and food products from the supermarket – Number of Family Members	41.142	24	0.016*
I have been buying agricultural and food products from the supermarket in higher amounts and more frequently – Gender	19.655	4	0.001*
The frequency of buying agricultural and food products from the street market has decreased – Educational Background	37.931	24	0.035**
The press statements on the consumption of agricultural and food products that strengthen the immune system are effective in product choices – Educational Background	39.268	24	0.026**
I have been preferring to consume the agricultural and food products that strengthen my immune system – Educational Background	55.763	24	0.000*
I have been preferring to buy agricultural and food products from the online grocery because it is safer – Place of Living	22.951	8	0.003*
Post Pandemic Period	χ^2	**df**	**p**
Agricultural and food products' prices will increase – Family Income	26.884	16	0.043**
The demand for the agricultural and food products that strengthen the immune system will increase – Age	33.949	16	0.006*
The number of entrepreneurs planning to invest in agriculture will increase – Family Income	30.964	16	0.014*
Hygiene will be a determining factor in buying agricultural and food products – Educational Background	40.734	24	0.018*
Agricultural education will gain importance – Profession	61.093	24	0.000*
Rural settlement will grow – Marital Status	15.973	4	0.003*
Agricultural sector may become one of the most revenue-generating sectors – Profession	39.429	24	0.025**
Türkiye will become one of the leading exporters of different agricultural and food products – Gender	16.099	4	0.003*
Türkiye will prove herself as a self-sufficient country in agricultural and food sectors – Gender	17.918	4	0.001*

*statistically significant ($p<0.01$), **statistically significant ($p<0.05$)

A chi-square analysis was conducted to designate the relationship between consumers' opinions on agricultural and food products sectors for the post-pandemic period and their demographic characteristics, and the results are given in Table 5. According to the analysis results, the relationship between the opinions that the demand for the agricultural and food products that strengthen the immune system will increase and age is significant ($p<0.01$). 45% of consumers aged 60 and over are the group most involved in this idea.

According to the data, the relationship between the opinion that agricultural sector may become one of the most revenue-generating sectors and profession is also significant ($p<0.05$). According to a research conducted

by Mishra and Pattnaik in 2021, urban agriculture can play a significant role in developing healthy and sustainable urban cities.

The relationship between the opinion that rural settlement will grow and marital status is significant ($p<0.01$). It was found that 45.05% of singles and 52.58% married consumers are willing to live in rural settlement.

The results showed that the relationship between the opinion that Türkiye will become one of the leading exporters of different agricultural and food products and and gender is significant ($p<0.01$).

4. Conclusion

Since its emergence, the COVID-19 pandemic has considerably affected people's view of life, habits and preferences as well as consumption patterns. In fact, throughout the human history, epidemics have led to massive social changes for both current and future years (Guven 2020).

During the pandemic, as the number of cases has risen, governments have ordered curfews and travel restrictions in an attempt to halt its spread, which in turn has impacted the global food system and resulted in delays especially in the delivery of imported products to consumers. In the first days of pandemic, local agricultural and food products were sold at higher prices. Disruptions in agricultural production and food production, inter-country restrictions on marketing, consumers' stockpiling of products due to food concerns, and disruptions in the supply of agricultural production inputs were effective in increasing prices of agricultural and food products. As can be seen from the results of the present research, 61.9% of the consumers agreed that agricultural and food products' prices had increased for the pandemic period, while the percentage dropped down to 32.9 for the post-pandemic period. These figures indicate that consumers believe agricultural and food products' prices will return to normal after the pandemic.

During the pandemic period, by The Ministry of Agriculture and Forestry especially for farmers, special brochures containing measures to be taken in the field, greenhouse, barn and poultry were distributed. Brochures were also distributed for bread and bakery businesses and inspections for food businesses were increased. In addition, farmers' loan debts were deferred and interest-free installment. It is believed that support such as increasing the amount of agricultural support and Grant seed support to ensure the security of agricultural production and supply will also make a significant contribution to farmers.

The current COVID-19 pandemic demonstrates to the entire world that agricultural and food sectors are and will be the most vital and strategic ones. In this respect, governments should pursue the policies and take the measures necessary for maintaining existing agricultural areas and increasing agricultural production against probable epidemics and natural phenome-non. Thanks to having different climates and ecological conditions as well as rich vegetation, Türkiye has the potential of producing many different types of fruits, vegetables and field crops to meet nutritional requirements and is highly advantageous in fighting the pandemic with an increase in agricultural and food production.

According to the results of the research, during the pandemic, most of the consumers have preferred supermarkets over street markets, credit card over cash, and online shopping over physical shopping for buying agricultural and food products, which has resulted in the adoption of virtual applications by numerous supermarkets and new employment opportunities for people. Additionally, among young and single consumers, those who buy agricultural and food products from a online supermarket are more likely. Because young people were more adept at technology and believed it was safer in a pandemic, they preferred the online supermarket.

Most of the consumers stated they took care to consume the agricultural and food products strengthening the immune system and buy packaged products manufactured in accordance with hygiene rules. So, growers

and producers are suggested to take such opinions and especially a potential increase in the demand of products strengthening the immune system into consideration in production for the post-pandemic period.

The period of pandemic can influence consumers' choice of place of living in the forthcoming years. In the scope of this research, 60.5% of the consumers indicated they wanted to live in a rural area during the pandemic, supported by the popular desire for a house with a garden far from the city. So, this can be taken into account in city and regional planning and house building.

Consumers think that the number of agricultural entrepreneurs will increase for the post-pandemic period. The number of investments can go up and several people can become an entrepreneur with the increase to be made by the government in the amount and range of agricultural production. Thus, Türkiye stands a good chance of producing some of the agricultural and food products imported.

In conclusion, according to the results of this re-search conducted, consumers are in the opinion that Türkiye will prove herself as a self-sufficient country in agricultural and food sectors and become one of the leading exporters of several products. Türkiye has the opportunity to turn the position she holds in agricultural and food sectors into an advantage. Agricultural and food production should be planned by taking into consideration the experiences gained during the pandemic, consumers' preferences as well as probable epidemics and natural phenomenon and creating safer and more sustainable agricultural and food systems in line with the digital age. As the pandemic continues to threaten the world, the importance of the agricultural and food sectors is growing in meeting the international nutritional needs. For this reason, the importance and strategies that countries will take in the agriculture and food sectors should be the most important priority issues for the post-epidemic.

Author Contributions: The author has read and agreed to the published version of the manuscript.

Conflicts of Interest: The author declares no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 326-336 DOI:10.15316/SJAFS.2023.032 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

The Effect of Mycorrhiza Applications on Growth and Yield in Some Strawberry Cultivars under Calcareous Soil Conditions

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HIGHLIGHTS

- *Glomus clorodum* alone and in combination, increases stem and root fresh weight.
- *Glomus etunicatum* + *Glomus clorodum* and *Glomus deserticola* + *Glomus etunicatum* applications had the best results.
- *Glomus etunicatum* and *Glomus clorodum* can be used to promote plant growth in strawberry calcareous soil conditions.

Abstract

This study was conducted in the research and practices of greenhouses at the University of Selçuk, Faculty of Agriculture and Horticulture Department. The effects of three different mycorrhiza species and combinations of strawberry plants on plant growth and nutrition were investigated in three different strawberries cultivars. According to the results, it was determined that *Glomus chlorodum* mycorrhiza alone and in combination increased stem fresh and root fresh weights, leaf relative water content, number of stems, and number of leaves compared to control plants. However, no significant changes could be obtained with mycorrhizal applications on membrane permeability and chlorophyll values in all strawberry varieties used. Nutrient analysis of nitrogen, magnesium, iron, manganese, and boron in the leaves of the application of mycorrhiza with significant increases has been achieved. *Glomus etunicatum* + *Glomus chlorodum* and *Glomus deserticola* + *Glomus etunicatum* applications had the best results. As a result of this study, it can be suggested that *Glomus etunicatum* and *Glomus chlorodum* can be used to promote plant growth in strawberry calcareous soil conditions.

Keywords: Calcareous; *Glomus* spp. Mycorrhiza; Plant Growth; Strawberry

1. Introduction

Strawberries are the most widely cultivated type of berry-like fruit. Due to their high adaptability to different climates and soil conditions, their cultivation has rapidly increased in our country (Paydaş and Kaşka 1989). Additionally, the suitability of strawberries for greenhouse and tunnel cultivation is an important factor in this growth. Alongside the rapid expansion of production areas, strawberry growers are increasingly facing problems. The most significant issues affecting strawberry cultivation in Turkey are alkaline and saline soils, as well as diseases and pests. As a result, stunted plant growth and reduced yields are the most commonly

Citation: Arıkan Ş, İpek M, Lütfi P, Eşitken A, Şahin M (2023). The Effect of Mycorrhiza Applications on Growth and Yield in Some Strawberry Cultivars under Calcareous Soil Conditions. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 326-336. https://doi.org/10.15316/SJAFS.2023.032

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Received date: 09/12/2022
Accepted date: 14/05/2023

encountered problems. A large portion of Turkish soils have formed under arid-semiarid climatic conditions and consist of alkaline soils with high pH levels. The most prominent issue resulting from the high lime content in the soil is leaf chlorosis. Therefore, iron deficiency is one of the most frequently encountered micronutrient deficiencies in our country. Lime-induced chlorosis is a term often used to describe chlorosis associated with impaired iron metabolism in soils with high calcium content (Faust 1989). While fruit species, in general, are quite sensitive to high lime content in the soil, strawberries, peaches, and pears exhibit an even greater sensitivity. As a result, significant yield losses occur in such areas due to ineffective photosynthesis. Rectifying iron deficiency is more challenging compared to other micronutrients. Currently, synthetic iron chelates are widely used commercially to prevent and alleviate lime-induced iron chlorosis in fruit trees. However, these applications are costly and have temporary effects, and the effectiveness of iron treatments can be low. This is because there are many factors that influence the availability of iron to plants. Obtaining positive results from every iron fertilization is not always possible. As a result, growers are compelled to implement an intensive fertilization program to solve the problem, leading to a significant increase in input costs.

Strawberries hold an important position among fruit species cultivated worldwide. In fact, they ranked 13th among the most produced fruits, with a production of 9.175.384 tons in 2021 (FAO 2023). Moreover, Turkey is the third-largest strawberry producer in the world, with a production of 669.195 tons. The major strawberry production in our country takes place in the provinces of Mersin, İzmir, Şanlıurfa, Aydın, and Çanakkale accounting for approximately 84% of our total production (TUIK 2023). However, in regions such as Central Anatolia where the soil is not suitable for strawberry production, cultivation can only be carried out in limited areas. Due to the delicate nature of strawberry fruits and their limited shelf life, production should ideally be conducted in proximity to the target markets (Suutarinen et al. 1998; Zhu and Zhou 2007). Nevertheless, economic strawberry production is not feasible everywhere due to varying soil and climate conditions.

Mycorrhizal fungi positively influence plant development and fruit yield by enhancing nutrient uptake in the plants they colonize (Marschner 1995; Bayözen 2007). Due to these benefits, profitable strawberry production can be achieved through mycorrhizal applications in calcareous and nutrient-deficient soils. Mycorrhizal fungi affect the uptake of water and dissolved minerals in inoculated plants, suppress soil-borne pathogens, reduce damage caused by diseases, positively influence plant root structure and chemistry, and increase yield and quality, providing opportunities for cultivation in challenging soil conditions. *Glomus deserticola*, *Glomus etunicatum*, and *Glomus chlorodum* are species of arbuscular mycorrhizal (AM) fungi that have been extensively studied for their positive effects on plant growth and development. These fungi form mutualistic symbiotic associations with the roots of various plant species, providing numerous benefits that contribute to enhanced plant performance. The use of these mycorrhizal species in agriculture and horticulture practices has gained considerable attention. Their ability to enhance nutrient uptake, improve plant resistance to environmental stresses, and promote sustainable farming methods makes them valuable tools for improving crop productivity and reducing reliance on chemical fertilizers. Further research is ongoing to better understand the mechanisms underlying their beneficial effects and optimize their application in various agricultural systems. Based on these considerations, this study aims to investigate the effects of three different mycorrhizal species (*G. deserticola, G. etunicatum,* and *G. chlorodum*) applied alone or in combination on plant characteristics and nutrient uptake in three strawberry varieties (Camorasa, Kabarla, and Rubygen) under calcareous soil conditions.

2. Materials and Methods

The research was conducted at the Research and Application Greenhouse of the Department of Horticulture, Faculty of Agriculture, Selçuk University. Three different strawberry varieties (Camorasa,

Kabarla, and Rubygem) propagated under *in vitro* conditions were used as plant materials in the experiment. Camorasa and Rubygem varieties exhibit short-day characteristics, while Kabarla strawberry varieties show a neutral-day response. The mycorrhizal strains *G. deserticola*, *G. etunicatum*, and *G. chlorodum* were employed in the study, both individually and in combination.

Glomus deserticola is known for its ability to thrive in arid and semiarid environments. This species of AM fungus has been found to improve plant growth under drought conditions by enhancing the plant's water uptake and drought tolerance. Additionally, *G. deserticola* aids in the absorption of phosphorus, which is often limited in dry soils, thereby improving nutrient acquisition and overall plant health (Ruiz-Lozano et al. 1995; Prisa 2021). *Glomus etunicatum* is one of the most widely studied AM fungi and has been shown to have beneficial effects on plant growth and nutrient uptake. It also contributes to improved resistance against various stresses, including drought, salinity, and heavy metal toxicity. Additionally, *G. etunicatum* has been reported to stimulate root development and enhance the production of plant growth-promoting hormones, further supporting plant growth and development (Ruiz-Lozano et al. 1995). *Glomus chlorodum* is another species of AM fungus that plays a significant role in plant growth and development. It forms symbiotic associations with plant roots, leading to improved nutrient uptake, particularly phosphorus. *G. chlorodum* has been found to enhance the plant's tolerance to abiotic stresses, such as drought and salinity, by improving water and nutrient availability. This species also aids in the establishment and maintenance of healthy soil microbial communities, contributing to overall soil fertility and ecosystem functioning (Bhattacharjya et al. 2018).

2.1. Propagation of Plant Material

In the study, stolons from strawberry varieties were collected and subjected to *in vitro* clonal propagation through shoot tip culture under sterile conditions. After surface sterilization of the stolons, the MS (Murashige and Skoog 1962) medium was used as the basal nutrient medium in the tissue culture multiplication stage, supplemented with %3 sucrose, 1 mg l^{-1} BA, and 7 g l^{-1} agar to adjust the pH to 5.78. The obtained plantlets in the multiplication medium were transferred to MS nutrient medium containing 1 mg l^{-1} IBA for the rooting stage. The strawberry seedlings propagated under *in vitro* conditions were transferred to a medium containing peat and perlite in a 1:1 ratio to facilitate their adaptation to the external environment. After 45-60 days, the strawberry seedlings were ready for the planned study.

2.2. Application of Mycorrhizal Inoculation

Mycorrhizal inoculations were carried out by sprinkling an amount equivalent to 500 spores per plant, with half of the inoculum spread throughout the potting soil and the remaining half placed 4 cm below the soil surface in the pot (Altay 2017). This approach aimed to ensure dense mycorrhizal colonization both during the initial stages of seedling root development and in the later stages. The applied treatments in the experiment are as follows:

- Control
- *Glomus deserticola*
- *Glomus etunicatum*
- *Glomus chlorodum*
- *G. deserticola* + *G. etunicatum*
- *G. deserticola* + *G. chlorodum*
- *G. etunicatum* + *G. chlorodum*
- *G. deserticola* + *G. etunicatum* + *G. chlorodum*

2.3. Experimental Design

The experiment was set up according to a randomized complete block design with 3 replications, and each replication consisted of 5 plants. A mixture of soil, sand, and perlite in a ratio of 3:1:1 was used as the growing medium. The plants were planted in 5-liter pots. After the planting in mid-April, regular watering, weed control, and removal of flowers and side shoots until they reached sufficient size were carried out. Morphological measurements such as stem and root fresh weights, root length, leaf area, leaf number, and number of stem (Ipek et al. 2014), as well as physiological measurements including membrane permeability, leaf relative water content, chlorophyll value (Karlıdag et al. 2011), and nutrient element analysis in the leaves, were conducted in the experiment. Micro-Kjeldahl in N determination, vanado molybdic yellow color method in P analysis, Mohr's method in Cl analysis, and other nutrient elements (K, Ca, Mg, Mn, Fe, Zn, Cu, B, and Na) analyses were made using an ICP device (Soltanpour et al. 1979).

2.4. Statistical Analysis

The Duncan multiple comparison test was applied at a 5% significance level to compare the obtained data. The SPSS 23.0 program was used for statistical analysis.

3. Results and Discussion

Lime-rich soils are among the significant factors that limit strawberry cultivation. Plant species sensitive to alkalinity, such as strawberries, cannot be grown in soils with a high lime content. To address this issue, mycorrhizal applications, which enhance the uptake of plant nutrients from the soil, can provide a significant contribution to strawberry cultivation in these types of soils. When examining our results, it was determined that mycorrhizal applications to all varieties of strawberries under lime conditions significantly contributed to plant development.

Upon examining the stem and root fresh weights, the applications of *G. chlorodum* (32.41g), *G. etunicatum* + *G. chlorodum* (31.60g), and *G. deserticola* + *G. etunicatum* (29.68g) in the Rubygem strawberry variety, and the application of *G. deserticola* + *G. chlorodum* (29.42g) in the Kabarla strawberry variety yielded the best results in stem fresh weight compared to the control group (Table 1). In terms of root fresh weights, the highest increase was observed in the Rubygem strawberry variety with the applications of *G. etunicatum* + *G. chlorodum* (33.71g), *G. deserticola* + *G. etunicatum* + *G. chlorodum* (33.49g), and *G. deserticola* + *G. etunicatum* (32.86g). In the Camarosa strawberry variety, the highest increase was achieved with the application of *G. chlorodum* (38.05g). The application of *G. deserticola* + *G. etunicatum* + *G. chlorodum* in the Kabarla strawberry variety resulted in the highest number of stems (4.67 pcs per plant^{-1}) (Table 1). This was followed by the application of *G. etunicatum* + *G. chlorodum* (4.33 pcs per plant^{-1}) in the Rubygem strawberry variety and *G. chlorodum* (4.00 pcs per plant^{-1}) in the Camarosa strawberry variety. Similar studies to ours have also indicated the positive effects of mycorrhizal applications on plant growth under stress conditions. Abbaspour et al. (2006), Sinclair et al. (2014), and Elhindi et al. (2017) found that mycorrhizal applications in pistachio, strawberry, and sweet basil, respectively, were beneficial for plant growth under saline soil conditions. When examining the effects of mycorrhizal applications on leaf number, the application of *G. deserticola* + *G. chlorodum* provided the best results in terms of leaf number in the Kabarla (115.7 pcs per plant^{-1}) and Rubygem (100.7 pcs per plant^{-1}) varieties compared to other applications. Mycorrhizal fungi significantly enhance plant root and shoot development, fruit yield, and quality by increasing the uptake of water and dissolved nutrients from the soil. Studies conducted on different plant species and varieties such as peppers, eggplants, tomatoes, carrots, corn, apple-cherry-citrus rootstocks, citrus fruits, strawberries, and pomegranates support this (Araujo et al. 1997; Aguilera-Gomez et al. 1999; Kim et al. 2002; Ortas et al. 2003; Özkan et al. 2003; Ortaş et al. 2006; Ertan et al. 2007; Uçgun et al. 2009; Almaca et al. 2010; Akpınar 2011; Akay and Karaaslan 2012; Kiracı et al. 2014). According to the results obtained from leaf area measurements of plants, the application of *G. etunicatum* + *G. chlorodum* increased leaf area by 90.2% in the Camarosa strawberry variety compared to the control group, while in the Rubygem strawberry variety, the application of *G. chlorodum* increased leaf area by 58.3%, and the

application of *G. deserticola* + *G. chlorodum* increased leaf area by 52.7% compared to the control group (Table 1). A study reported positive results of mycorrhizal applications in pistachio plants grown under drought conditions (Abbaspour et al. 2012). In our study, it was found that the application of *G. chlorodum* mycorrhizal strains, either alone or in combination, increased stem and root fresh weights, sibling plant count, and leaf count compared to the control plants. Mycorrhizal application in carob trees grown in lime-rich soil conditions has been reported to result in significant increases in parameters such as shoot length, root collar diameter, leaf count, and leaf area (Davis et al. 1983).

Table 1. Effects of mycorrhizal applications on plant vegetative growth

Treatment	Variety	Stem Fresh Weights (g)	Root Fresh Weights (g)	Root Length (cm)	Number of Stems (per plant^{-1})	Leaf Area (cm^2)	Leaf Number (per plant^{-1})
Control	Camarosa	25.24 cdef	23.26 efgh	38.67 bcd	2.67 efg	31.14 m	57.0 n
Control	Kabarla	18.89 hıjk	25.45 def	31.67 ghı	3.00 def	47.07 de	65.0 l
Control	Rubygem	13.81 l	19.11 ghı	44.33 a	2.33 fg	36.53 k	46.0 r
G. deserticola	Camarosa	19.93 ghıj	21.25 fghı	34.33 efg	2.67 efg	43.93 g	54.0 o
G. deserticola	Kabarla	15.99 ıjkl	18.65 hı	28.67 ı	3.00 def	36.71 k	50.0 p
G. deserticola	Rubygem	27.13 bcd	27.24 de	29.33 ı	2.00 g	48.40 d	94.0 d
G. etunicatum	Camarosa	24.48 defg	26.44 def	34.67 efg	2.00 g	40.06 ıj	81.0 g
G. etunicatum	Kabarla	25.45 cdef	24.26 defg	32.00 ghı	2.67 efg	37.27 k	76.0 hı
G. etunicatum	Rubygem	23.86 defg	28.29 cde	28.67 ı	3.00 def	41.16 hı	60.0 m
G. chlorodum	Camarosa	26.30 cde	38.05 a	33.33 fgh	4.00 abc	45.72 ef	45.0 r
G. chlorodum	Kabarla	13.33 l	23.35 efgh	35.00 efg	2.00 g	34.79 l	91.0 e
G. chlorodum	Rubygem	32.41 a	29.82 bcd	33.33 fgh	3.33 cde	57.84 a	83.0 g
G. deserticola + *G. etunicatum*	Camarosa	24.48 defg	21.23 fghı	40.00 bc	3.33 cde	43.31 h	58.0 mn
G. deserticola + *G. etunicatum*	Kabarla	22.01 efgh	18.23 hı	29.00 ı	2.33 fg	34.04 l	64.0 l
G. deserticola + *G. etunicatum*	Rubygem	29.68 abc	32.86 abc	33.33 fgh	2.67 efg	41.09 ıj	74.0 ıj
G. deserticola + *G. chlorodum*	Camarosa	22.42 defgh	26.60 def	33.33 fgh	3.67 bcd	51.29 c	98.0 c
G. deserticola + *G. chlorodum*	Kabarla	29.42 abc	25.63 def	30.00 hı	3.00 def	35.28 l	100.7 b
G. deserticola + *G. chlorodum*	Rubygem	25.56 cdef	26.08 def	40.33 bc	2.33 fg	55.80 b	115.7 a
G. etunicatum + *G. chlorodum*	Camarosa	20.23 ghı	26.03 def	37.67 cde	2.33 fg	59.25 a	68.3 k
G. etunicatum + *G. chlorodum*	Kabarla	15.26 jkl	15.97 ı	36.33 def	3.00 def	34.17 l	72.0 j
G. etunicatum + *G. chlorodum*	Rubygem	31.60 ab	33.71 ab	42.00 ab	4.33 ab	44.51 fg	78.0 h
G. deserticola + *G. etunicatum* + *G. chlorodum*	Camarosa	19.93 ghıj	18.36 hı	34.33 efg	2.67 efg	48.40 d	86.0 f
G. deserticola + *G. etunicatum* + *G. chlorodum*	Kabarla	20.85 fgh	25.34 def	30.00 hı	4.67 a	39.64 j	69.0 k
G. deserticola + *G. etunicatum* + *G. chlorodum*	Rubygem	14.46 kl	33.49 abc	37.00 cdef	3.67 bcd	48.37 d	51.0 p

Mycorrhizal applications in strawberries under lime-rich soil conditions significantly influenced the leaf relative water content (LRWC) statistically. The lowest LRWC value was obtained from the leaves of plants in the *G. deserticola* + *G. chlorodum* treatment (39.42%) in the Camarosa strawberry variety, while the highest LRWC value was obtained from the *G. deserticola* + *G. etunicatum* + *G. chlorodum* treatment (58.50%) in the Rubygem strawberry variety. The LRWC values in the Kabarla strawberry variety fell within these ranges. Membrane permeability values showed variations among strawberry varieties depending on the applied mycorrhizal strains and combinations (Table 2). The lowest membrane damage was observed in the *G.*

etunicatum treatment (13.84%) in the Camarosa strawberry variety, while the highest membrane damage was observed in the *G. chlorodum* treatment (21.83%) in the Rubygem strawberry variety. In the Kabarla strawberry variety, the *G. etunicatum* treatment (16.40%) resulted in less membrane damage compared to the other treatments. When examining the effects of mycorrhizal applications on the chlorophyll value in strawberry leaves, the highest value was found in the control group of the Kabarla strawberry variety (40.00 SPAD). The *G. etunicatum* + *G. chlorodum* and *G. deserticola* + *G. etunicatum* + *G. chlorodum* treatments resulted in significant increases in leaf LRWC compared to the control plants (Table 2). Similarly, in their study, Davies et al. (2002) reported positive results of mycorrhizal applications on leaf water potential in pepper plants grown under drought conditions. Another study conducted on peppers also indicated that *G. intraradices* inoculation increased the plants' phosphorus content and positively affected their physiological performance (Demir 2004).

Table 2. Effects of mycorrhiza treatments on physiological parameters in strawberry

Treatment	Variety	Membrane Permeability (%)	LRWC (%)	Chlorophyll Value (SPAD)
Control	Camarosa	18.61 de	40.04 mn	32.56 ef
Control	Kabarla	17.32 efg	56.39 bc	40.00 a
Control	Rubygem	17.53 efg	50.30 fg	36.52 bc
G. deserticola	Camarosa	17.22 fgh	49.83 gh	24.96 m
G. deserticola	Kabarla	16.99 fgh	57.21 bc	30.04 hı
G. deserticola	Rubygem	15.49 ı	51.07 e	35.32 c
G. etunicatum	Camarosa	13.84 j	46.47 j	31.38 fg
G. etunicatum	Kabarla	16.40 hı	42.27 l	36.34 bc
G. etunicatum	Rubygem	18.97 de	40.58 m	26.96 l
G. chlorodum	Camarosa	17.87 ef	52.88 d	26.10 l
G. chlorodum	Kabarla	20.36 bc	46.06 j	29.12 ıj
G. chlorodum	Rubygem	21.83 a	40.03 mn	26.72 l
G. deserticola + *G. etunicatum*	Camarosa	16.93 fgh	49.35 hı	27.14 l
G. deserticola + *G. etunicatum*	Kabarla	17.48 efg	53.43 d	23.32 n
G. deserticola + *G. etunicatum*	Rubygem	17.07 fgh	43.60 k	34.48 d
G. deserticola + *G. chlorodum*	Camarosa	19.51 cd	39.42 n	32.94 de
G. deserticola + *G. chlorodum*	Kabarla	21.65 ab	48.71 ı	28.28 jk
G. deserticola + *G. chlorodum*	Rubygem	18.11 ef	57.29 b	29.04 ıjk
G. etunicatum + *G. chlorodum*	Camarosa	16.50 ghı	49.36 ghı	31.14 gh
G. etunicatum + *G. chlorodum*	Kabarla	16.86 fghı	50.69 ef	27.96 k
G. etunicatum + *G. chlorodum*	Rubygem	17.99 ef	59.56 a	35.76 bc
G. deserticola + *G. etunicatum* + *G. chlorodum*	Camarosa	17.41 efg	55.20 c	20.04 o
G. deserticola + *G. etunicatum* + *G. chlorodum*	Kabarla	19.63 cd	48.74 hı	31.90 efg
G. deserticola + *G. etunicatum* + *G. chlorodum*	Rubygem	21.71 a	58.50 a	37.34 b

The effects of the applications on the macro- and micronutrient contents were found to be statistically significant based on the results of the nutrient element analysis in the leaves. When examining the nitrogen (N) content in the leaves, the highest value was obtained from the *G. deserticola* + *G. etunicatum* + *G. chlorodum* treatment (3.07%) in the Camarosa strawberry variety. In the Rubygem strawberry variety, the *G. deserticola* + *G. chlorodum* treatment followed with a nitrogen content of 3.03%. In terms of phosphorus content, the control (2969.7 mg kg^{-1}) and *G. deserticola* + *G. etunicatum* + *G. chlorodum* (2867.3 mg kg^{-1}) treatments in the Kabarla strawberry variety had the highest values. Similarly, in the Camarosa strawberry variety, the *G. deserticola* + *G. etunicatum* + *G. chlorodum* treatment resulted in a phosphorus content of 2846.7 mg kg^{-1}. The highest potassium content was obtained from the control group (21468.0 mg kg^{-1}) in the Kabarla strawberry variety, while in the Camarosa strawberry variety, the *G. deserticola* + *G. etunicatum* + *G. chlorodum* treatment followed with a potassium content of 20780.0 mg kg^{-1}.

Table 3. The effect of mycorrhiza treatments on the macronutrient content of strawberry leaves

Treatment	Variety	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})
Control	Camarosa	2.78 ıjk	2566.3 de	18690.3 bcde	6171.3 hıj	3307.3 bcde
Control	Kabarla	2.70 kl	2969.7 a	21468.0 a	8087.7 a	2821.7 h
Control	Rubygem	2.75 jk	2573.7 de	18272.0 bcde	6669.3 efg	2879.7 gh
G. deserticola	Camarosa	2.84 fghıj	2594.0 cde	19025.3 abcde	6181.3 hıj	3193.7 def
G. deserticola	Kabarla	2.78 ıjk	2572.3 de	18720.7 bcde	6258.3 hı	3606.7 a
G. deserticola	Rubygem	2.89 cdefg	2646.0 bcde	19013.3 abcde	6284.3 hı	3624.0 a
G. etunicatum	Camarosa	2.97 bc	2701.3 bcde	19669.0 abcde	7342.7 b	3131.0 efg
G. etunicatum	Kabarla	2.85 efghıj	2483.0 e	17544.7 cde	6071.0 ıj	3510.7 ab
G. etunicatum	Rubygem	2.89 cdefg	2729.3 bcd	19933.3 abcd	6452.3 gh	3420.7 abcd
G. chlorodum	Camarosa	2.78 ıjk	2746.0 bcd	18152.3 bcde	6207.7 hı	2982.7 fgh
G. chlorodum	Kabarla	2.86 defghı	2666.0 bcde	19244.7 abcde	6269.0 hı	3367.7 abcde
G. chlorodum	Rubygem	2.64 l	2723.0 bcd	20264.3 abc	8021.3 a	2835.3 h
G. deserticola + G. etunicatum	Camarosa	2.88 cdefgh	2724.3 bcd	19583.7 abcde	7248.7 bc	2915.3 gh
G. deserticola + G. etunicatum	Kabarla	2.94 bcde	2712.7 bcd	17346.7 de	7022.7 bcd	2803.3 hı
G. deserticola + G. etunicatum	Rubygem	2.75 jk	2721.0 bcd	18634.3 bcde	5885.7 j	3397.3 abcd
G. deserticola + G. chlorodum	Camarosa	2.80 ghıjk	2586.3 de	18464.7 bcde	6622.7 fg	2556.7 ı
G. deserticola + G. chlorodum	Kabarla	2.92 cdef	2684.7 bcde	18491.3 bcde	7215.7 bc	2919.0 gh
G. deserticola + G. chlorodum	Rubygem	3.03 ab	2815.3 abc	19913.3 abcd	7190.0 bc	3181.0 def
G. etunicatum + G. chlorodum	Camarosa	2.81 ghıj	2588.3 de	17114.3 e	6943.0 cde	2924.7 gh
G. etunicatum + G. chlorodum	Kabarla	2.79 hıjk	2604.0 cde	17318.3 de	5976.0 ıj	3200.7 cdef
G. etunicatum + G. chlorodum	Rubygem	2.84 efghıj	2750.0 bcd	19989.3 abcd	6428.0 gh	3457.7 abc
G. deserticola + G. etunicatum + G. chlorodum	Camarosa	3.07 a	2846.7 ab	20780.0 ab	7316.3 b	2732.3 hı
G. deserticola + G. etunicatum + G. chlorodum	Kabarla	2.95 bcd	2867.3 ab	19275.3 abcde	7304.7 b	2790.7 hı
G. deserticola + G. etunicatum + G. chlorodum	Rubygem	2.81 ghıj	2613.7 cde	18264.3 bcde	6854.3 def	2896.7 gh

Table 4. The effect of mycorrhiza treatments on the micronutrient content of strawberry leaves

Treatment	Variety	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	B (mg kg^{-1})
Control	Camarosa	164.67 bcde	40.83 abcd	43.83 ab	16.77	12.76 abc
Control	Kabarla	151.00 cdef	35.33 bcd	45.79 a	15.46	12.57 abc
Control	Rubygem	136.33 efg	36.44 abcd	34.66 cde	14.72	14.52 ab
G. deserticola	Camarosa	174.00 abc	46.72 abc	43.73 ab	17.21	13.40 abc
G. deserticola	Kabarla	190.33 ab	43.94 abcd	39.76 abcde	16.63	12.96 abc
G. deserticola	Rubygem	176.00 abc	46.87 abc	41.64 abcd	16.79	12.67 abc
G. etunicatum	Camarosa	150.33 cdef	34.02 bcd	39.61 abcde	15.84	12.72 abc
G. etunicatum	Kabarla	182.00 ab	44.05 abcd	41.46 abcd	17.16	13.22 abc
G. etunicatum	Rubygem	177.67 abc	44.40 abcd	41.71 abcd	16.95	14.25 abc
G. chlorodum	Camarosa	181.00 ab	45.65 abcd	41.17 abcd	16.71	14.90 ab
G. chlorodum	Kabarla	192.67 ab	47.49 ab	43.37 ab	17.27	15.02 ab
G. chlorodum	Rubygem	138.67 defg	36.87 abcd	43.23 ab	14.80	11.98 bc
G. deserticola + G. etunicatum	Camarosa	134.67 fg	40.04 abcd	33.95 cde	15.33	12.90 abc
G. deserticola + G. etunicatum	Kabarla	144.33 defg	39.09 abcd	32.68 e	15.64	13.66 abc
G. deserticola + G. etunicatum	Rubygem	197.67 a	45.53 abcd	41.62 abcd	16.08	15.30 a
G. deserticola + G. chlorodum	Camarosa	117.00 g	33.43 cd	32.88 e	14.41	14.52 ab
G. deserticola + G. chlorodum	Kabarla	134.67 fg	38.30 abcd	33.48 de	15.67	13.09 abc
G. deserticola + G. chlorodum	Rubygem	133.00 fg	32.18 d	38.08 abcde	15.97	11.39 c
G. etunicatum + G. chlorodum	Camarosa	124.00 fg	35.06 bcd	41.92 abc	15.10	14.63 ab
G. etunicatum + G. chlorodum	Kabarla	165.67 bcd	42.87 abcd	43.73 ab	17.62	13.97 abc
G. etunicatum + G. chlorodum	Rubygem	201.00 a	49.37 a	44.27 ab	16.57	14.39 abc
G. deserticola + G. etunicatum + G. chlorodum	Camarosa	139.67 defg	38.61 abcd	35.93 bcde	15.98	13.92 abc
G. deserticola + G. etunicatum + G. chlorodum	Kabarla	124.00 fg	35.60 bcd	36.42 bcde	15.49	13.09 abc
G. deserticola + G. etunicatum + G. chlorodum	Rubygem	135.00 fg	33.63 cd	36.97 bcde	14.88	11.98 bc

Regarding calcium content in the leaves, the highest value of 8087.7 mg kg^{-1} was obtained from the control treatment in the Kabarla strawberry variety, and in the Rubygem strawberry variety, it was 8021.3 mg kg^{-1} from the *G. chlorodum* treatment (Table 3). The highest iron content of 201.00 mg kg^{-1} was obtained from the *G. etunicatum* + *G. chlorodum* treatment in the Rubygem strawberry variety. This value was followed by the *G. deserticola* + *G. etunicatum* treatment in the Rubygem strawberry variety, with an iron content of 197.67 mg kg^{-1}. The highest manganese content of 49.37 mg kg^{-1} was obtained from the *G. etunicatum* + *G. chlorodum* treatment in the Rubygem strawberry variety. There was not a significant difference in zinc content among the treatments, but the highest value was obtained from the control group (45.7937 mg kg^{-1}) in the Kabarla strawberry variety. When examining the microelement boron, the highest value was observed in the *G. deserticola* + *G. etunicatum* treatment in the Rubygem strawberry variety (Table 4). There was no statistically significant difference in copper content among the treatments. In many studies, it has been demonstrated that VAM fungi play a crucial role in nutrient uptake by plants, resulting in more efficient nutrient acquisition (Özkan et al. 2003; Korkmaz 2005; Ortaş et al. 2006; Yılmaz and Gül 2009; Özdemir et al. 2010). VAM fungi have been reported to be effective in the uptake of Zn, Cu, Mn, Fe, Ca, K, and N, in addition to playing a significant role in phosphorus uptake (Smith et al. 1992; Aguilera-Gomez et al. 1999; Davies et al. 2000).

4. Conclusions

Soil alkalinity, which is one of the significant stress factors affecting agriculture, also restricts strawberry cultivation. To be able to farm in such soils, growers resort to methods such as farm manure and chemical fertilization. However, these practices are often ineffective in soils with a high lime content. In addition to these practices, the use of certain soil-borne microorganisms (such as bacteria regulating plant growth and mycorrhizae) that enhance the uptake of nutrients and minerals like water from the soil can contribute to better plant growth under stressful conditions.

Mycorrhizae can be effective against stress factors such as drought, nutrient deficiency, and salinity due to their ability to enhance the uptake of plant nutrients and water from the soil and prevent the proliferation of soil-borne pathogens through their colonization. Taking these aspects into consideration, it is believed that mycorrhizae could have positive effects on strawberry cultivation in high lime alkaline soils.

Author Contributions: The authors have made an equal contribution. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the Scientific Research Projects Coordination Unit of S.U. under project number 16401016.

Conflicts of Interest: The authors declare no conflicts of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 337-353 DOI:10.15316/SJAFS.2023.033 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Investigation of the Effect of Urban Identity on Urban Landscape Design with Eye Tracking Technique in the Case of Konya City

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HIGHLIGHTS

- The effect of Konya urban identity on the urban landscape design of Konya city was investigated with eye tracking technique (method).
- Urban identity and eye tracking method have been the subject of a study together for the first time.

Abstract

The aim of this study is to examine the effect of Konya urban identity on the urban landscape design of Konya city through eye tracking technique (method) through individuals. Within the scope of the research, first of all, a literature review on the subject was made. Afterwards, urban landscape areas with dense urban identity components determined in the light of literature resources were visited and photographs were obtained from these areas. Interviews were held with experts in the field of Konya urban identity, and as a result of these interviews, the photographs to be used in eye tracking analysis were determined. The photographs were uploaded to the eye tracking program and heat maps of the eye movements of the volunteer participants were created using the eye tracking device, and the numerical data (fixation numbers and fixation times) of the eye tracking analysis were reached. In addition, questionnaires were applied to the participants after the eye tracking analysis. As a result of the research, it was revealed that heat maps and eye tracking numerical data supported the questionnaires. Based on this, the conclusion that Konya's urban identity has an effect on Konya's urban landscape design was reached through the people who participated in the study.

Keywords: Eye tracking technique; Konya; urban identity; urban landscape design

1. Introduction

Urban identity is all the features that distinguish a city from other cities. These features are called urban identity components. In the formation of urban identity components, natural and artificial environmental features, historical, cultural, institutional and demographic characteristics, as well as socio-economic features, sensory and psychological features are also effective.

Citation: Gemici RO, Polat AT (2023). Investigation of the Effect of Urban Identity on Urban Landscape Design with Eye Tracking Technique in the Case of Konya City. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 337-353. https://doi.org/10.15316/SJAFS.2023.033

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Received date: 21/01/2023

Accepted date: 05/06/2023

The identity of the city becomes clear and can be perceived through urban design and urban landscape design. In this way, the natural and artificial environment of the city and the meaning that socio-cultural and socio-economic formation adds to this environment can be revealed (Çakmaklı, 1992).

Eyes, one of the most important sense organs, are the windows of the mind and have the most important place in our perception of the world. For this reason, eye tracking analysis, tracking and recording eye movements is one of the effective methods used to understand the processes taking place in the mind. Eye movement data provides information about where people pay attention, what information they ignore, and what bothers them most (Çağıltay, 2011).

In the scientific studies in the field of landscape architecture, especially visual landscape perception, visual landscape quality, etc. In order to measure people's preferences and perceptions on the subject, photo-surveys are generally applied to the participants. It has been observed that the people who were asked questions by the survey method gave the answers they wanted to the people who made the survey by using the cognitive sides of their brains. For this reason, it can be said that a "real" analysis of people's preferences and perceptions can be made, especially with neuromarketing methods. The reason for this is that neuroscientific methods give more accurate and detailed information (Stipp, 2015). In addition, it is possible to reach accurate results even with studies with a small number of samples by using neuroimaging techniques (Emul and Yücel, 2021).

In the research, the use of urban identity and eye tracking method together for the first time shows that the study is an original study. The fact that the eye tracking method, which is an up-to-date method, will shed light on national/international scientific studies in the field of landscape architecture once again reveals the importance of the study.

2. Materials and Methods

2.1. Materials

The main material of the research consists of some objects containing the components of Konya's urban identity. These objects; rose, tulip, cascade ornamental pool, fountain, double-headed eagle, tile, green dome and butterfly. These objects are located in the landscape areas in the city center of Konya. In Table 1, the codes given to the objects containing the urban identity components, the locations of the objects and the urban identity component categories including the objects are given.

Table 1. Codes, locations and categories of objects containing urban identity components

Object Name	Code	Location	Urban Identity Component Category
Rose	D1	Kelebekler Vadisi Park	Environmental Identity-Natural Environmental Features
Tulip	D2	Kelebekler Vadisi Park	Environmental Identity-Natural Environmental Features
Cascade ornamental pool	Y1	Kültürpark	Environmental Identity-Artificial Environment Features
Fountain	Y2	Alaeddin Hill Park	Environmental Identity-Artificial Environment Features
Double-headed eagle	SK1	Selcuk Unıversity Alaeddin Keykubat Campus	Social Identity-Socio-Cultural Identity Features
Tile	SK2	Kalehan-Ecdad Garden	Social Identity-Socio-Cultural Identity Features
Green Dome	SE1	Kalehan-Ecdad Garden	Social Identity-Socio-Economic Identity Features
Butterfly	SE2	Alaeddin Hill Park	Social Identity-Socio-Economic Identity Features

Other materials used in the study are; eye tracking device, eye tracking software program, computer, 6.1 inch, 828x1792 pixel screen, 4 gb ram, 64 gb phone, master's theses, doctoral theses, national and international scientific articles, papers, books, original photographs obtained from research areas, a questionnaire prepared with Google Forms, Microsoft Office 365 and Autocad 2023 program.

2.2. Method

The method consists of 3 stages. The first stage is the preliminary stage, the second stage is the data collection and analysis stage, and the third stage is the evaluation stage.

2.2.1 Preliminary stage

At this stage, the subject, purpose and scope of the study were determined, literature and field studies were conducted. While conducting the literature research, national and international master's theses, doctoral theses, scientific articles, papers, books and other materials were used.

While conducting the field research, first of all, all areas that are thought to have an effect on the urban landscape design of Konya city were determined in line with the literature resources and these areas were visited. As a result of the visits, urban landscape areas with the densest of Konya urban identity components were determined and work was continued in line with the visuals obtained from these areas. These areas within the scope of the study; Alaeddin Hill Park, Kültürpark, Kelebekler Vadisi Park, Kalehan-Ecdad Garden, Selcuk UniversityAlaeddin Keykubat Campus.

2.2.2. Data collection and analysis stage

At this stage, by going to the study areas, 96 photographs, which are thought to contain the urban identity components of Konya, were obtained from the areas. The photographs obtained from the areas were taken in a way that does not allow manipulation and on clear days. Attention was paid to the equal number of photographs. These photographs, which include the components of Konya's urban identity; Images containing natural environment features as an environmental identity component, images containing artificial environment features as an environmental identity component, images containing socio-cultural identity features as a social identity component, and images containing socio-economic identity features as a social identity component were obtained from areas in 4 categories.

Secondly, interviews were conducted with experts on Konya's urban identity. First of all, each expert evaluated Konya's urban identity and its components according to their field of expertise. Afterwards, 96 photographs obtained from the fields were shared with experts. Photographs with similar urban identity components were eliminated. It was decided by experts that there are 8 objects containing the components of Konya's urban identity, and 8 photographs of these 8 objects were selected for use in eye tracking analyses.

Finally, eye tracking analyzes were performed at this stage. It is very important to determine the optimum sample size before academic researches are carried out with the eye tracking device in order to reach qualified data. For this reason, power analysis is required for the study to be successful. It is necessary to use research resources efficiently due to reasons such as the eye tracking device used in the studies is expensive, the people who will use the device will use the device one by one and sequentially, and the analysis process takes time. Because of these situations, basic standards have been determined in studies using eye tracking devices on how many people should be in the minimum sample group required to reach the desired power (Bojko, 2013). Looking at these standards; At least 14 data is required in a research with 80% power effect without movement using an eye tracking device, while at least 21 data is needed in the sample group in a research with 90% power effect. In a research with 80% power effect, at least 21 data is required, while in a research with 90% power, at least 34 data needs to be in the sample group (Şenduran, 2019). While non-motion research is done with screen-based eye tracking devices, research involving motion is done with wearable eye tracking devices.

In experimental studies, it was determined that groups between 30-40 people were the most optimal and consistent sample size with an error margin of less than 1% (Sands, 2009). Therefore, the number of samples in this study was determined as 36. Eye tracking analyzes conducted at Selcuk University, Faculty of Architecture and Design, Department of Landscape Architecture, were carried out with 36 volunteer participants, consisting of different demographic characteristics such as age, gender, marital status, and educational status.

Participants in the study voluntarily participated in the analysis. Before the eye tracking analyses, the participants were given information about how the analyzes would be carried out. Permission for the study was obtained from the Ethics Committee of the Faculty of Architecture and Design of Selcuk University. The participants filled the Voluntary Consent Form before the analysis.

Before the participants were included in the study, the visuals of the urban landscape areas in the city of Konya were uploaded to the eye tracking analysis program. First, areas of interest (AOI) were determined on these images uploaded to the program. These areas of interest consist of objects/objects containing urban identity components and were created separately for each image. It was decided with experts which object/objects would be the areas of interest. Areas of interest must be created to receive numerical data from the eye tracking analysis program. Without these areas of interest it is impossible to get numerical data from the eye tracking program. Thanks to these areas of interest, it can be easily determined how many times the participants look at the objects and for how long.

Before the eye-tracking analysis, the volunteers were told, "Consider the features that come to your mind when the city of Konya is mentioned, and examine the photos." and then eye tracking analyzes were started. Thus, the calibration process, which is the first step of eye tracking analysis, was started. Participants were first seated in front of the computer where the eye tracking device was pre-installed. The optimum distance between the participants and the computer is 65 cm. After this distance was achieved, the required calibration process was applied. Calibration procedures were repeated until the calibration result was successful. Validation degree must be below 0.50 for the calibration process to be successful. In order for this value to be below 0.50 and for the calibration process to be successful, the participants were asked not to wear make-up. In addition, people with high vision problems were asked to use glasses or contact lenses during the analysis. Despite glasses and lenses, analyzes could not be performed with people with a Validation degree higher than 0.50. Therefore, these individuals were excluded from the analysis. The analyzes were continued with the participants obtained as a result of successful calibration, and 8 images of 5 seconds each related to the urban landscape areas in the city of Konya were shown to the participants in the form of slides. The visuals were shown to the participants with a computer with a 15.6 inch screen. In order for the analyzes to be successful, the working environment was purified from external stimuli before the analysis and care was taken not to have too much ambient light. Only eye tracking specialist and participant were found in this setting.

After the eye tracking analysis, the participants were informed about the components of urban identity and questionnaires were applied. In the survey, 2 questions were asked by showing the photos on the eye tracking slide again.

As a result of this stage, heat maps were drawn separately for each image, the number of fixations in the areas of interest and the fixation times in the areas of interest were calculated, and charts were obtained and graphs of the survey results were created.

2.2.3. Evaluation stage

The heat maps obtained as a result of the eye tracking analysis, the numerical data of the eye tracking analysis and the survey results applied after the analyzes were evaluated at this stage. Since this method is applied through visuals, the issue of sensory and psychological identity components could not be evaluated in this context. Finally, recommendations were made as a result of the evaluations.

3. Results

3.1. Demographic characteristics of people participating in eye tracking analysis

A total of 36 people participated in the research. Of the volunteer participants participating in the analysis, 20 were female and 16 were male. 27 of the participants are between the ages of 18-25, 3 of them are between the ages of 26-35, 2 of them are between the ages of 36-45, and 4 of them are between the ages of 46-55. 6 of the participants are married and 30 are single. Twenty of the participants were high school graduates, 9 were university graduates, and 7 were graduate students. While 16 of the participants are from Konya, 20 of them are not.

3.2. Heat maps, eye tracking analysis numerical data and survey results

3.2.1. Heat maps, eye tracking numerical data and survey results obtained from visuals related to natural environmental features, which are environmental identity components

There are 2 visuals related to natural environmental features, which are environmental identity components. The first image is the image with the rose object. The code for this image is D1. The areas of interest in this image are roses. This image is an image of the Butterfly Valley park. When the heat map of this image is examined (Figure 1), it is seen that the participants are mostly fixed on roses.

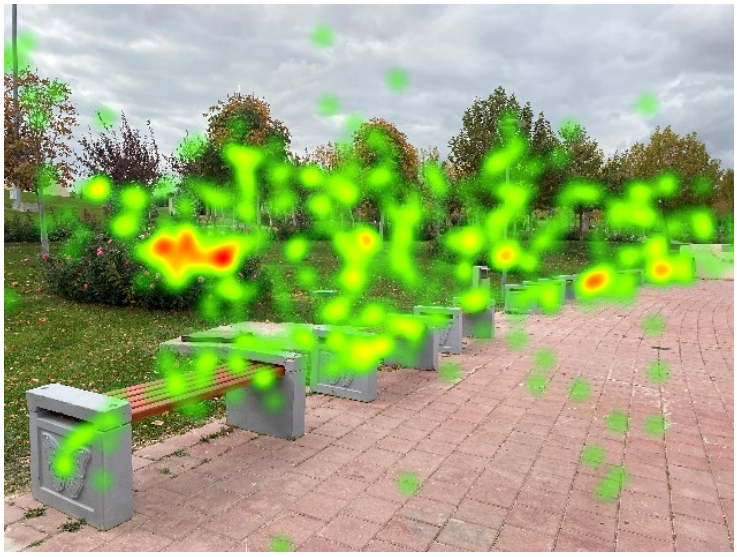

Figure 1. Heat map obtained from participants of D1 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the averages of how many times all participants were fixed on two areas of interest (roses1 2.63 times and roses2 1.41 times) and the average of how many times all participants fixed on two areas of interest (2.26 times) are given. In the second chart, the average of how long all participants were fixed on two areas of interest (roses1 0.92s and roses2 0.42s) and the average of how many times all participants were fixed on two areas of interest (0.78s) were given. The time is given in seconds (Table 2 and Table 3).

Table 2. Averages of fixation numbers within the areas of interest for the D1 image

Participants	Roses 1	Roses 2	Average	Median	Sum	Total Recording Duration
Average	**2,63**	**1,41**	**2,26**	2,26	3,27	161,44
Percentage Fixated (%)	94,12	50,00				
Variance	1,85	0,26	0,86	0,86	2,64	741,43
Standard Deviation (n-1)	1,36	0,51	0,93	0,93	1,63	27,23

Table 3. Averages of fixation times (s) within the areas of interest for the D1 image

Participants	Roses 1	Roses 2	Average	Median	Sum	Total Recording Duration
Average	**0,92**	**0,42**	**0,78**	0,78	1,11	161,44
Share of Total Time (%)	80,30	19,70				
Percentage Fixated (%)	94,12	50,00				
Variance	0,43	0,07	0,35	0,35	0,51	741,43
Standard Deviation (n-1)	0,66	0,26	0,59	0,59	0,72	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. 14 of the participants answered "Yes" and 22 of them answered "No". Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered “roses” to the question.

Another visual related to natural environmental features, which is an environmental identity component, is the tulip object. The code for this image is D2. The areas of interest in this image are tulips. This image is an image of the Butterfly Valley park. When the heat map of this image is examined (Figure 2), it is seen that the participants are mostly fixed on tulips.

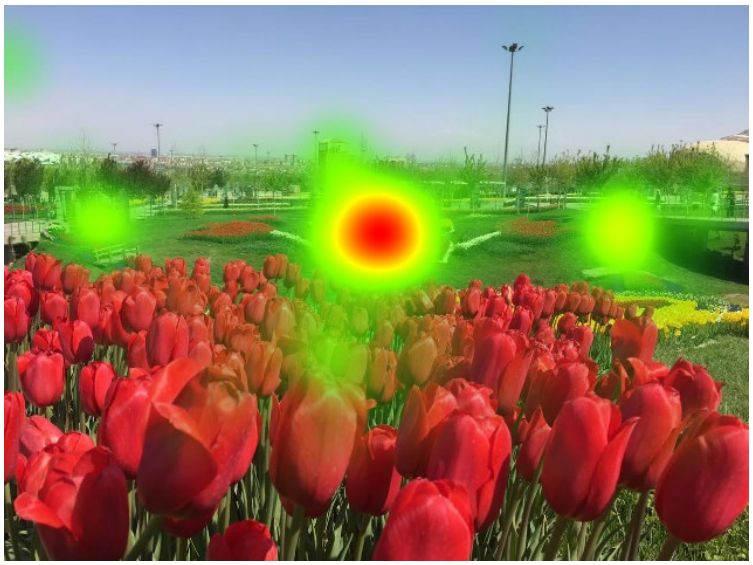

Figure 2. Heat map obtained from participants of D2 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the average of how many times all participants were fixed on two areas of interest (3.94 times for tulips on a butterfly pattern and 3.35 times for other tulips) and the average of how many times all participants were fixed on two areas of interest (3.65 times) are given. In the second chart, the average of how long all participants were fixed on two areas of interest (1.41s for tulips on a butterfly pattern and 0.79s for other tulips) and the average of how many times all participants were fixed on two areas of interest (1.10s) were given. The duration is given in seconds (Table 4 and Table 5).

Table 4. Averages of fixation numbers within the areas of interest for the D2 image

Participants	Tulips on a butterfly pattern	Other tulips	Average	Median	Sum	Total Recording Duration
Average	**3,94**	**3,35**	**3,65**	3,65	7,29	161,44
Percentage Fixated (%)	100,00	100,00				
Variance	5,33	5,69	2,92	2,92	11,67	741,43
Standard Deviation (n-1)	2,31	2,39	1,71	1,71	3,42	27,23

Table 5. Averages of fixation times (s) within the areas of interest for the D2 image

Participants	Tulips on a butterfly pattern	Other tulips	Average	Median	Sum	Total Recording Duration
Average	**1,41**	**0,79**	**1,10**	1,10	2,19	161,44
Share of Total Time (%)	64,10	35,90				
Percentage Fixated (%)	100,00	100,00				
Variance	1,12	0,23	0,27	0,27	1,10	741,43
Standard Deviation (n-1)	1,06	0,48	0,52	0,52	1,05	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. Twenty-six of the participants answered "Yes" and 10 answered "No". Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered the question as “tulips”.

3.2.2. Heat maps, eye tracking numerical data and survey results obtained from visuals related to artificial environmental features, which are environmental identity components

There are 2 visuals related to the artificial environment features, which are the environmental identity component. The first image is the one with the cascade ornamental pool reinforcement element. The code of this image is Y1. The area of interest in the image is the cascade ornamental pool. This image belongs to Kültürpark. When the heat map of this image is examined (Figure 3), it is seen that the participants are mostly fixed on the cascade ornamental pond.

Figure 3. Heat map obtained from participants of Y1 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the average number of times all participants were fixed on the area of interest (cascaded ornamental pond 2 times) is given. In the second table, the average of how long all participants were fixed on the area of interest (cascaded ornamental pool 1.02s) is given. The time is given in seconds (Table 6 and Table 7).

Table 6. Averages of fixation numbers within the areas of interest for the Y1 image

Participants	Cascade ornamental pool	Average	Median	Sum	Total Recording Duration
Average	**2,00**	**2,00**	2,00	2,00	161,44
Percentage Fixated (%)	76,47				
Variance	1,20	1,20	1,20	1,20	741,43
Standard Deviation (n-1)	1,10	1,10	1,10	1,10	27,23

Table 7. Averages of fixation times (s) within the areas of interest for the Y1 image

Participants	Cascade ornamental pool	Average	Median	Sum	Total Recording Duration
Average	**1,02**	**1,02**	1,02	1,02	161,44
Share of Total Time (%)	100,00				
Percentage Fixated (%)	76,47				
Variance	0,70	0,70	0,70	0,70	741,43
Standard Deviation (n-1)	0,84	0,84	0,84	0,84	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. Fifteen of the participants answered "Yes" and 21 answered "No". Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered the question as "cascaded ornamental pool".

Another one of the visuals related to the artificial environmental features, which is an environmental identity component, is the image in which the fountain reinforcement element is located. The code for this image is Y2. The area of interest in the image is the fountain. This image is an image of Alaeddin Hill park. When the heat map of this image is examined (Figure 4), it is seen that the participants mostly focus on fountain.

Figure 4. Heat map obtained from participants of Y2 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the average number of times all participants were fixed on the area of interest (5.58 times of fountain) is given. In the second chart, the average of how long all participants were fixed on the area of interest (fountain 2.18s) is given. The time is given in seconds (Table 8 and Table 9).

Table 8. Averages of fixation numbers within the areas of interest for the Y2 image

Participants	Fountain	Average	Median	Sum	Total Recording Duration
Average	**5,58**	**5,58**	5,58	5,58	161,44
Percentage Fixated (%)	100,00				
Variance	7,56	7,56	7,56	7,56	741,43
Standard Deviation (n-1)	2,75	2,75	2,75	2,75	27,23

Table 9. Averages of fixation times (s) within the areas of interest for the Y2 image

Participants	Fountain	Average	Median	Sum	Total Recording Duration
Average	**2,18**	**2,18**	2,18	2,18	161,44
Share of Total Time (%)	100,00				
Percentage Fixated (%)	100,00				
Variance	1,40	1,40	1,40	1,40	741,43
Standard Deviation (n-1)	1,18	1,18	1,18	1,18	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. Eighteen of the participants answered "Yes" and 18 answered "No". Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered “yes” to the question “fountain”.

3.2.3. Heat maps, eye tracking numerical data and survey results obtained from images related to socio-cultural identity, which is a social identity component

There are 2 images related to socio-cultural identity, which is a social identity component. The first of these images is the image containing the double-headed eagle object. The area of interest in the image is the double-headed eagle sculpture. The code for this image is Y2. This image is located in Selcuk University Alaeddin Keykubat Campus. When the heat map of this image is examined (Figure 5), it is seen that the participants are mostly fixed on the double-headed eagle statue.

Figure 5. Heat map obtained from participants of SK1 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the average number of times all participants were fixed on the area of interest (double-headed eagle statue 2.53 times) is given. In the second chart, the average of how long all participants were fixed on the area of interest (double-headed eagle statue 1.80s) is given. The time is given in seconds (Table 10 and Table 11).

Table 10. Averages of fixation numbers within the areas of interest for the SK1 image

Participants	Double headed eagle	Average	Median	Sum	Total Recording Duration
Average	**2,53**	**2,53**	2,53	2,53	161,44
Percentage Fixated (%)	83,33				
Variance	2,19	2,19	2,19	2,19	741,43
Standard Deviation (n-1)	1,48	1,48	1,48	1,48	27,23

Table 11. Averages of fixation times (s) within the areas of interest for the SK1 image

Participants	Double headed eagle	Average	Median	Sum	Total Recording Duration
Average	**1,80**	**1,80**	1,80	1,80	161,44
Share of Total Time (%)	100,00				
Percentage Fixated (%)	83,33				
Variance	1,87	1,87	1,87	1,87	741,43
Standard Deviation (n-1)	1,37	1,37	1,37	1,37	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. All of the participants answered “Yes”. Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered the question as “double-headed eagle”.

The last image related to socio-cultural identity, which is a component of social identity, is the one with the tile object. The areas of interest in the image are the tile motifs on the building. The code of this image is SK1. This image is an image of Kalehan-Ecdad garden. When the heat map of this image is examined (Figure 6), it is seen that the participants are generally fixed on the tile motifs on the building.

Figure 6. Heat map obtained from participants of SK2 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the averages of how many times all participants were pinned to two areas of interest (tile motif1 1.42 times, tile motif2 3.16, tile motif3 3.94, and tile motif4 1.20 times) and the average of the total number of times all participants were fixed to two areas of interest (2.77 times). In the second chart, the average of how long all participants were fixed on two areas of interest (tile motif1 0.52s, tile motif2 1.05s, tile motif3 1.18s, and tile motif4 0.38s) and the average of how many times all participants were fixed on two areas of interest (0.93s) is given. The time is given in seconds (Table 12 and Table 13).

Table 12. Averages of fixation numbers within the areas of interest for the SK2 image

Participants	Tile motif 1	Tile motif 2	Tile motif 3	Tile motif 4	Average	Median	Sum	Total Recording Duration
Average	**1,42**	**3,16**	**3,94**	**1,20**	**2,77**	2,50	7,56	161,44
Percentage Fixated (%)	52,78	69,44	100,00	55,56				
Variance	0,37	3,64	3,25	0,38	0,91	1,34	9,17	741,43
Standard Deviation (n-1)	0,61	1,91	1,80	0,62	0,95	1,16	3,03	27,23

Table 13. Averages of fixation times (s) within the areas of interest for the SK2 image

Participants	Tile motif 1	Tile motif 2	Tile motif 3	Tile motif 4	Average	Median	Sum	Total Recording Duration
Average	**0,52**	**1,05**	**1,18**	**0,38**	**0,93**	0,88	2,40	161,44
Share of Total Time (%)	11,41	30,37	49,33	8,89				
Percentage Fixated (%)	52,78	69,44	100,00	55,56				
Variance	0,14	0,94	0,49	0,06	0,33	0,38	1,04	741,43
Standard Deviation (n-1)	0,37	0,97	0,70	0,24	0,57	0,62	1,02	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. Thirty of the participants answered "Yes" and 6 of them answered "No". Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered the question as "tile".

3.2.4. Heat maps, eye tracking numerical data and survey results obtained from the image related to socio-economic identity, which is a social identity component

There are 2 images related to socio-economic identity, which is a social identity component. The first of these images is the Mevlana Museum model containing the green dome object. The code for this image is SK2. The area of interest in the image is the Mevlana Museum model. This image is an image of Kalehan-Ecdad garden. The code for this image is SE1. When the heat map of this image is examined (Figure 7), it is seen that the participants are mostly fixed on the green dome.

Figure 7. Heat map obtained from participants of SE1 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the average number of times all participants were fixed on the area of interest (5,72 times for the Mevlana Museum model) is given. In the second table, the average of how long all participants were fixed on the area of interest (Mevlana Museum model 2.37s) is given. The time is given in seconds (Table 14 and Table 15).

Table 14. Averages of fixation numbers within the areas of interest for the SE1 image

Participants	Mevlana Museum model	Average	Median	Sum	Total Recording Duration
Average	**5,72**	**5,72**	5,72	5,72	161,44
Percentage Fixated (%)	100,00				
Variance	7,06	7,06	7,06	7,06	741,43
Standard Deviation (n-1)	2,66	2,66	2,66	2,66	27,23

Table 15. Averages of fixation times (s) within the areas of interest for the SE1 image

Participants	Mevlana Museum model	Average	Median	Sum	Total Recording Duration
Average	**2,37**	**2,37**	2,37	2,37	161,44
Share of Total Time (%)	100,00				
Percentage Fixated (%)	100,00				
Variance	1,82	1,82	1,82	1,82	741,43
Standard Deviation (n-1)	1,35	1,35	1,35	1,35	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. All of the participants answered “Yes”. Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered the question as “green dome”.

The last image related to socio-economic identity, which is a component of social identity, is the image of the butterfly object. The code for this image is SE2. The area of interest in the image is the butterfly pattern. This image is an image of Alaeddin Hill park. When the heat map of this image is examined (Figure 8), it is seen that the participants are mostly fixed on the butterfly pattern.

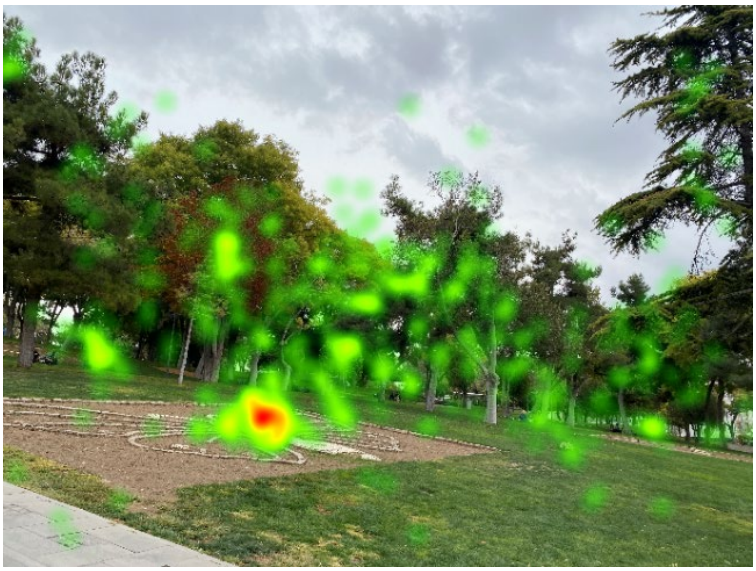

Figure 8. Heat map obtained from participants of SE2 image (Original, 2022)

Below are the charts with the eye tracking analysis numerical data of the image. In the first chart, the average number of times all participants were fixed on the area of interest (butterfly pattern 2.56 times) is given. In the second chart, the average of how long all participants were fixed on the area of interest (butterfly pattern 1.04 s) is given. The time is given in seconds (Table 16 and Table 17).

Table 16. Averages of fixation numbers within the areas of interest for the SE2 image

Participants	Butterfly pattern	Average	Median	Sum	Total Recording Duration
Average	**2,56**	**2,56**	2,56	2,56	161,44
Percentage Fixated (%)	94,12				
Variance	2,00	2,00	2,00	2,00	741,43
Standard Deviation (n-1)	1,41	1,41	1,41	1,41	27,23

Table 17. Averages of fixation times (s) within the areas of interest for the SE2 image

Participants	Butterfly pattern	Average	Median	Sum	Total Recording Duration
Average	**1,04**	**1,04**	1,04	1,04	161,44
Share of Total Time (%)	100,00				
Percentage Fixated (%)	94,12				
Variance	0,31	0,31	0,31	0,31	741,43
Standard Deviation (n-1)	0,55	0,55	0,55	0,55	27,23

After the eye tracking analysis, the participants were asked, "Are there any objects/objects in the photograph that reflect the urban identity components?" question has been asked. Eleven of the participants answered "Yes" and 25 answered "No". Another question is "If your answer is "Yes", can you write the objects/objects that reflect the urban identity components?" 100% of the participants answered the question as “butterfly”.

4. Conclusions

Eye tracking technique is used in many fields such as education, health, web design, marketing and advertising. In order to examine the purchasing behavior of consumers in the field of this technique, marketing and advertising; to investigate neuropsychiatric disorders in the field of health; In the field of web design, in order to enable people to easily access the information they seek in the virtual environment; In the field of education, it is used to examine how students solve problems, especially in numerical lessons.

When some international scientific studies in the field of landscape architecture are examined, it is seen that the eye tracking technique is used to determine the perceptions and preferences of people. These data, which were previously tried to be obtained only through questionnaires, can be measured more accurately and more accurately when obtained by eye tracking technique. In addition, when these data obtained from eye tracking analysis are supported by questionnaires, it is possible to reach more specific data. The eye tracking technique, which is a current technique, can determine where people focus the most, how long they focus, how many times they focus on the same point, and many other data by examining the eye movements of people. It is therefore advantageous to obtain these data using this technique. In other methods, people are sometimes hesitant to express their true views while expressing their own opinions. This technique largely eliminates such manipulation situations. In addition, the eye tracking method has some limitations. For example, this technique cannot be applied to people with high eye disorders and elderly people with poor eyesight. Other constraints encountered are that suitable environmental conditions for eye tracking analysis cannot be easily provided each time, and people of the same age group generally want to voluntarily participate in eye tracking analysis studies. It is possible to reach more objective results when such situations are eliminated.

Within the scope of the research, the effect of Konya urban identity on the urban landscape design of Konya city was examined through the volunteer participants who participated in the research. In this study, which was carried out using the eye tracking technique, people's perceptions of the subject were measured. In line with the measurements made, it was observed that the areas where the participants were fixed in the analyzes were generally areas containing the components of urban identity. Starting from here; The conclusion that Konya's urban identity has an effect on Konya's urban landscape design was reached through the people who participated in the study.

Urban identity is a combination of features that help distinguish and differentiate a city from other cities, and elements specific to that city (Lynch, 1960). For this reason, using urban identity components more prominently in urban landscape design can make the city more unique. The identity of that city can be made more evident by using objects containing these components in all landscape design works carried out on a large or small scale, from the design of the reinforcement elements to the urban design.

As a result of the study, it is seen that most of the objects reflecting Konya's urban identity (rose, tulip, cascaded ornamental pool, fountain, double-headed eagle, tile, green dome and butterfly) were seen as a part of Konya's urban identity by the people who participated in the study. For this reason, the use of these objects in urban landscape areas in the form of different designs in the landscape design works to be carried out in the city of Konya can make the city of Konya a unique city.

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Selcuk University Scientific Research Projects Coordinator, grant number 20301029.

Acknowledgments: This study was produced from the doctoral thesis created in 2023 at the Graduate School of Natural and Applied Science of Selcuk University under the advisor of Prof. Dr. Ahmet Tuğrul Polat.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 354-362 DOI:10.15316/SJAFS.2023.034 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

The Contribution of Improving Phosphorous Use Efficiency to Agricultural Economics: A Case Study in Türkiye

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HIGHLIGHTS

- Important economic benefit can be gained by improving phosphorous use efficiency
- The economic benefit is gained for all regions in Türkiye by decreasing P mineral fertilizer usage

Abstract

The contribution of improving phosphorous (P) use efficiency (PUE) in agricultural areas of Türkiye to agricultural economics has been measured regionally for the years of 2007-2011 within this study. For this purpose, the economic benefit gained from use of P mineral fertilizers has been presented when improving PUE from 5% to maximum PUE in agricultural areas. PUE values used in this study were estimated by using hyperbolic regression model, which states the relationship between phosphorous input and output in agricultural areas of Türkiye. The results showed that important economic benefit would be gained by improving PUE, even when PUE was improved to maximum level, this benefit would be almost the half of the expenses for purchasing P mineral fertilizers. Yearly average economic benefits gained from purchasing P mineral fertilizers would be 0.22 ($0.15 billion) and 0.82 billion TL ($0.56 billion) by 5% improving of PUE and reaching maximum PUE, respectively over the five years 2007-2011.

Keywords: Agricultural economics; economic benefit; phosphorous mineral fertilizers; phosphorous use efficiency

1. Introduction

Phosphorus (P), a crucial macronutrient for all living cells (Johnston and Dawson 2005; White et al. 2010, Zeng et al. 2022), can limit plant growth if not provided in sufficient quantities by the soil or external sources (MacDonald et al. 2011; Chien et al. 2012; Dhuldhaj and Malik 2022). For this reason, P mineral fertilizer is commonly used in agricultural production in Türkiye as in the world. The application of P mineral fertilizer to agricultural soils increased by 3.2 % annually from 2002 to 2010 in the world (Lun et al. 2018); and increased to 4.4 million tonnes in 2017 from 3.4 million tonnes in 2009 in Türkiye (Turkstat 2018). However, surplus use of P in soil has increased the r isk of P movement from agricultural fields to adjacent water bodies (e.g. Djodjic et al. 2005, Sims et al. 2000). This affects water quality with negative effects on biodiversity, eutrophication, and low oxygen level in waters (Sharpley et al. 1994; Smith 1998; Hansen et al. 2002).

The other negative effects of surplus use of P are specified by Withers et al. (2018) that high global consumption rates of P fertilizer are depleting the finite reserves of good quality rock phosphate, phosphorus

Citation: Özbek FŞ (2023). The Contribution of Improving Phosphorous Use Efficiency to Agricultural Economics: A Case Study in Türkiye. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 354-362. https://doi.org/10. 15316/SJAFS.2023.034
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Received date: 24/01/2023
Accepted date: 10/06/2023

fertilizers are also a source of harmful inputs of metals, especially cadmium and uranium, to agricultural soils, the manufacturing process leaves large stockpiles of radioactive phosphogypsum, heavily fertilized soils are ecologically less diverse with loss of soil function (Vries et al. 2013), and excess P in the human diet resulting from increasing meat consumption and use of food additives may be compromising human health (Ellam et al. 2012). It was also emphasized that the manufacture and use of P fertilizers is extremely wasteful and inefficient, and this inefficiency is existing along all parts of the P supply chain, including the field application of the manufactured products (Withers et al. 2018; Cordell and White 2013).

Improving P use efficiency (PUE) is essential because of the above-mentioned negative and positive effects of the use of P in agricultural soils. To improve PUE, it is crucial to quantify PUE accurately. Ozbek et al. (2016) developed a method that allows estimating PUE under conditions of changes in soil P stock (SSC-P). This method ensured to quantify PUE more accurately compared to P budget method estimating PUE by not taking account of the SSC-P. The results of Ozbek et al. (2016) gave a range of regional PUE of 56% and 93% with a mean national PUE of 74% at the level of administrative regions for the period 2007-2011. This indicates that 26% of P is not taken by plants in Türkiye. This percentage is almost 44 % for some regions. To this end, improving PUE in Türkiye agriculture, in other words improving agricultural production by using less P mineral fertilizer is also essential for Türkiye.

Using recycled and recovered P, appropriate fertilizer placement, application time and rate of fertilizer, soil testing, erosion reduction, microbial inoculants, plant selection, utilizing legacy soil P, and improving soil characteristics are the options to improve PUE in agricultural soils (Cordell and White 2013; Withers et al. 2018). By using these methods, the usage of P mineral fertilizers decreases, so significant economic benefits can be gained.

P mineral fertilizer is intensively used for more agricultural production around the world. Above-mentioned studies show that this has a cost both environmentally and economically. However, more agricultural production is required for the food chain to meet better the needs of increasing population. At this point, the crucial question is that "how can we ensure more agricultural production by using less P mineral fertilizer". The answer of this question is to improve PUE (Powers and Thavarajah 2019) by taking above-mentioned necessary measures. Improving PUE reduces the cost of P mineral fertilizer usage both environmentally and economically. To quantify the contribution of improving PUE to agricultural economics is required to evaluate the economic effect of it deeply.

The purpose of this study is to evaluate the contribution of improving PUE to agricultural economics in Türkiye at the regional level for the period from 2007 to 2011. For this purpose, the economic benefit gained from use of P mineral fertilizers has been evaluated when improving PUE from 5% to maximum PUE in agricultural areas.

2. Materials and Methods

Ozbek et al. (2016) presented relationship between P input and P output by developing a model that uses a hyperbolic regression model for Turkish regions for the years of 2007-2011 (Equation 1), where ◎ and ◎ are model parameters. And, they calculated PUE by using this model (Equation 2). In this model, P inputs comprise P from mineral fertilizer, manure production, net manure imports/ exports, withdrawals, stocks, other organic fertilizer, atmospheric deposition, and seed and planting materials. P outputs comprise P from crop and fodder production, crop residues removed, and stock changes of P in soil.

$$P\_output=(\alpha \cdot P\_input)/(\beta+P\_input) \quad (1)$$

$$PUE=P\_output/P\_input \quad (2)$$

Table 1. The average values of P input, output, mineral fertilizer use and change, P use efficiency initial and change values, 2007-2011

Regions	P_{input} (kgP ha^{-1})	P_{output} (kgP ha^{-1})	P_{minfer} (kgP ha^{-1})	$PUE_{initial}$ (%)	ΔP_{minfer} (kgP ha^{-1})							
					ΔPUE=5	ΔPUE=10	ΔPUE=15	ΔPUE=20	ΔPUE=25	ΔPUE=30	ΔPUE=35	ΔPUE=PUE_{max}-$PUE_{initial}$
TR10	22	14	11	61	1.7	3.2	4.5	5.6	6.6	7.4	8.2	8.9
TR21	17	11	12	68	1.2	2.2	3.0	3.8	4.5	5.1	5.4	5.4
TR22	20	13	7	63	1.5	2.8	3.9	4.9	5.8	6.6	6.8	6.8
TR31	23	14	8	60	1.8	3.3	4.6	5.7	6.7	7.6	7.9	7.9
TR32	15	11	7	70	1.0	1.9	2.7	3.4	4.0	4.6	4.6	4.6
TR33	14	10	7	72	0.9	1.7	2.5	3.1	3.7	4.0	4.0	4.0
TR41	12	9	8	75	0.8	1.4	2.0	2.6	3.1	3.1	3.1	3.1
TR42	27	15	8	56	2.2	4.1	5.7	7.1	8.2	8.2	8.2	8.2
TR51	9	7	6	82	0.5	0.9	1.3	1.5	1.5	1.5	1.5	1.5
TR52	10	8	7	79	0.6	1.2	1.6	2.1	2.2	2.2	2.2	2.2
TR61	14	10	8	72	0.9	1.7	2.5	3.1	3.7	4.0	4.0	4.0
TR62	21	13	16	62	1.6	3.0	4.2	5.2	6.1	7.0	7.7	8.2
TR63	14	10	9	72	0.9	1.7	2.4	3.1	3.6	4.0	4.0	4.0
TR71	8	6	5	84	0.4	0.8	1.1	1.2	1.2	1.2	1.2	1.2
TR72	6	5	3	88	0.3	0.6	0.7	0.7	0.7	0.7	0.7	0.7
TR81	16	11	3	69	1.1	2.0	2.8	2.9	2.9	2.9	2.9	2.9
TR82	11	9	4	77	0.7	1.3	1.8	2.3	2.6	2.6	2.6	2.6
TR83	12	9	6	76	0.7	1.4	2.0	2.5	2.9	2.9	2.9	2.9
TR90	6	5	2	89	0.3	0.6	0.6	0.6	0.6	0.6	0.6	0.6
TRA1	4	4	1	93	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
TRA2	8	7	1	84	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8
TRB1	6	5	2	89	0.3	0.6	0.6	0.6	0.6	0.6	0.6	0.6
TRB2	8	7	1	84	0.4	0.8	1.1	1.1	1.1	1.1	1.1	1.1
TRC1	9	8	6	81	0.5	1.0	1.5	1.8	1.8	1.8	1.8	1.8
TRC2	13	10	9	73	0.9	1.6	2.3	2.9	3.4	3.6	3.6	3.6
TRC3	15	11	9	70	1.0	1.9	2.7	3.4	4.0	4.6	4.6	4.6

In this study, the relationship between P mineral fertilizer (P_minfer) and PUE was developed by using Equation 2 in order to evaluate the contribution of improving PUE to agricultural economics in Türkiye for the period from 2007 to 2011 (Equation 3). In this formula, P_(other-input) represents other inputs except for P_minfer.

$$P\_minfer=(P\_output*100)/PUE-P\_(other\text{-}input) \quad (3)$$

Change in P_minfer(〖ΔP〗_minfer) was calculated depending on change in PUE (ΔPUE) as follows (Equation 4):

$$〖\Delta P〗\_minfer=(\Delta PUE*P\_output*100)/(〖PUE〗\_initial*〖PUE〗\_final) \quad (4)$$

Economic benefit (EB) when increasing PUE from 5% to maximum PUE (100%) was calculated according to Equation 5. The values of P input, P output, P_minfer, 〖ΔP〗_minfer, 〖PUE〗_initial, 〖PUE〗_final used in the calculations are given in Table 1.

$$EB=〖\Delta P〗\_minfer*p\_minfer \quad (5)$$

Where p_minfer is the average unit price of P mineral fertilizer in TL kgP-1 ha-1. p_minfer was calculated as weighted average of the prices of P mineral fertilizer types according to the amount of P use (Table 2). These types are diammonium phosphate (DAP) (20.1% P), composite fertilizer 20.20.0 (8.7% P), composite fertilizer 20.20.0+Zn (8.7% P), composite fertilizer 15.15.15 (6.5%), and other P mineral fertilizers. Purchasing prices of farmers for these fertilizer types were calculated by increasing average producer and importer prices by 7.5% (BUGEM, 2018a).

Table 2. The amount of P mineral fertilizer and farmer purchaser price, 2007-2011

	2007			2008			2009			2010			2011		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Diammonium phosp. (20.1% P)	428012	779	3882	149098	1797	8954	665435	741	3690	495465	988	4921	386467	1464	7294
Composite fertilizer 20.20.0 (8.7% P)	718200	530	6072	542192	1193	13672	703818	559	6405	701586	663	7599	679739	1036	11873
Composite fertilizer 20.20.0+Zn (8.7% P)	296758	571	6539	247399	1285	14723	241076	602	6897	322864	714	8184	347383	1116	12787
Composite fertilizer 15.15.15 (6.5%)	260201	571	8719	226981	1285	19631	168841	602	9197	189646	714	10912	205891	1116	17049
Other	352721	613	6303	302241	1390	14245	226858	626	6547	258976	770	7904	341353	1183	12251

Source: BUGEM 2018a

a: Fertilizer use amount (ton), b: Fertilizer unit price (TL ton^{-1}), c: P unit price (TL (ton P)$^{-1}$

Average prices of above-mentioned fertilizer types, comprising 87.4% of total P mineral fertilizer usage, were used to estimate the price of other P mineral fertilizer.

NUTS2 (Nomenclature of Territorial Units for Statistics) administrative level, developed by Turkish Statistical Institute, was used in regional analysis (see Figure 1).

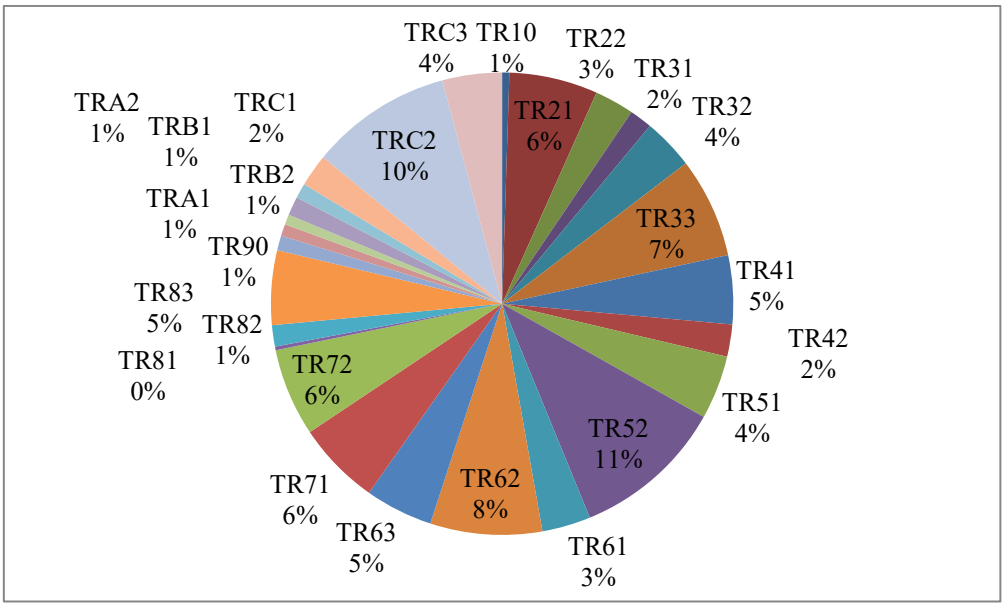

Figure 1. Yearly average expense for purchasing of phosphorous mineral fertilizer by regions, 2007-2011 (Region codes: TR10: Istanbul; TR21, TR22: West Marmara; TR31, TR32, TR33: Aegean; TR41, TR42: East Marmara; TR51, TR52: West Anatolia; TR61, TR62, TR63: Mediterranean; TR71, TR72: Central Anatolia; TR81, TR82, TR83: West Black Sea; TR90: Eastern Black Sea; TRA1, TRA2: Northeast Anatolia; TRB1, TRB2: Central-east Anatolia; TRC1, TRC2, TRC3: Southeast Anatolia)

3. Results

Yearly average expense for purchasing P mineral fertilizers is 1.76 billion TL over the five years 2007-2011. West Anatolia (TR52) has the highest share in total expense in Türkiye for purchasing P mineral fertilizers with a value of 11%. Southeast Anatolia (TRC2) and Mediterranean (TR62) follow this region with the values of 10% and 8% respectively. The lowest share was calculated in West Black Sea (TR81) with a value of 0.3% (Figure 1).

Yearly average economic benefits gained from purchasing P mineral fertilizers would be 0.22 ($0.15 billion) and 0.82 billion TL ($0.56 billion) for the 5% improving of PUE and reaching maximum PUE, respectively over the five years 2007-2011 (Figure 2).

The highest yearly average economic benefit would be in TR62 with a value of 72 million TL by reaching maximum PUE over the five years. Aegean (TR33) and TRC2 follow this region with the values of 70 million TL and 67 million TL respectively. The lowest yearly average economic benefit would be in TR81 with a value of 5 million TL. Northeast Anatolia (TRA1) and Eastern Black Sea (TR90) follow this region with the values of 6 million TL and 7 million TL respectively (Figure 3).

Over the five years 2007-2011, yearly average profit increase per employee in agriculture would be 151 TL yr-1 when PUE reaches maximum level (100%). The highest increase would be in Southeast Anatolia (TRC3) with a value of 510 TL yr-1, and the lowest increase would be in TR90 with a value of 13 TL yr-1 (Figure 4)

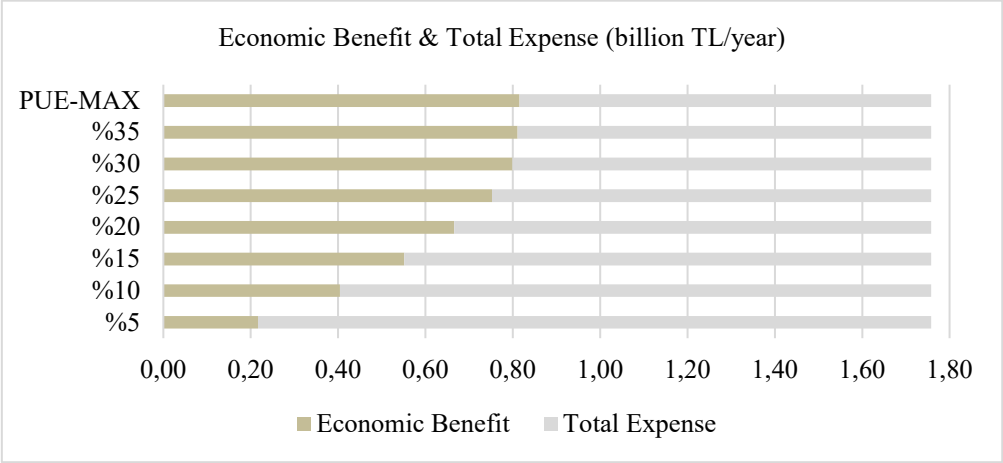

Figure 2. Yearly average economic benefit gained from expense for purchasing of phosphorous fertilizer, 2007-2011

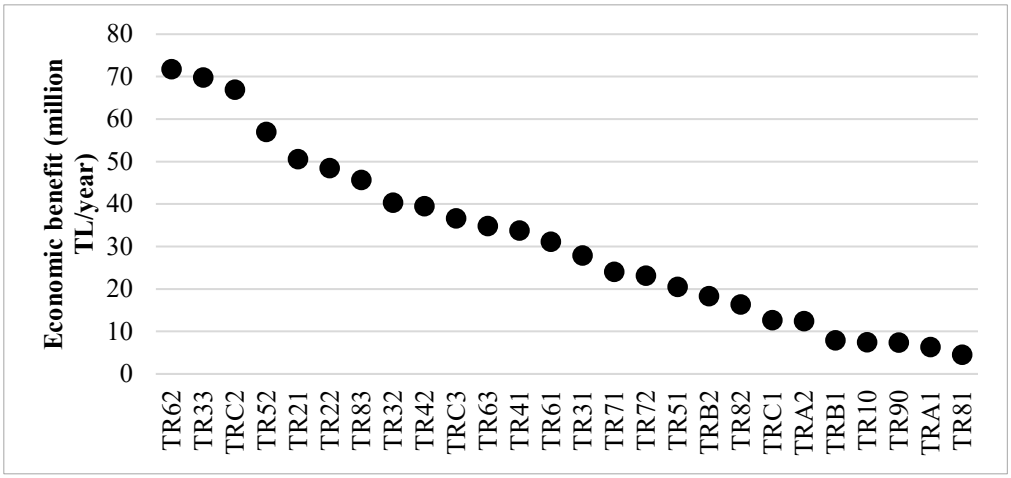

Figure 3. The yearly average economic benefit gained from the expense for purchasing of phosphorous fertilizer by regions when PUE is maximum, 2007-2011

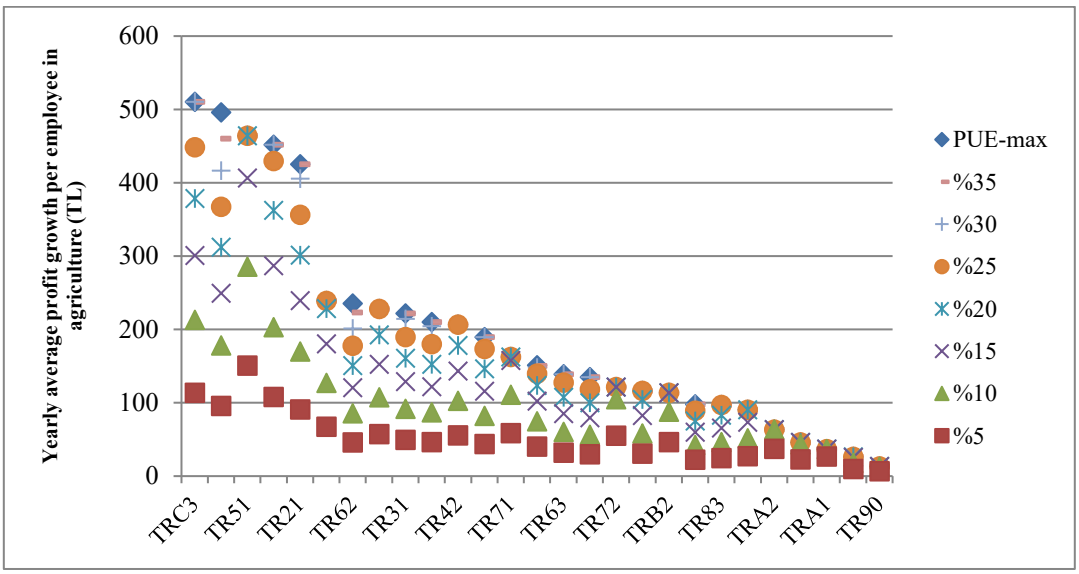

Figure 4. Yearly average profit growth per employee in agriculture by regions when PUE is maximum, 2007-2011

4. Discussion

There are important variations in PUE between regions in Türkiye, PUE vary between %56 and %93 over regions (Ozbek et al. 2016). This implies that economic benefit is gained for all regions by decreasing P mineral fertilizer usage by improving PUE. So, the options to improve PUE e.g. using recycled and recovered P, appropriate fertilizer placement, application time and rate of fertilizer, soil testing, erosion reduction, microbial inoculants, plant selection, utilizing legacy soil P, and improving soil characteristics (Cordell and White 2013; Withers et al. 2018) are crucial for Türkiye agriculture.

Higher P mineral fertilizers are required in agricultural areas because of population increases and dietary changes (Grote et al. 2005; Foley et al. 2011, Bindraban et al. 2020). So, improving PUE, which ensures more agricultural production by using less P mineral fertilizer, is required for the food chain to meet better the needs of 8.5 billion people by 2030, and 9.7 billion people by 2050 (UN 2016), and also to combat negative effects on biodiversity, eutrophication, and low oxygen level in waters.

The results showed that important economic benefit would be gained by improving PUE, even when PUE was improved to maximum level, this benefit would be almost half of the expenses for purchasing P mineral fertilizers. This implies that fertilizer usage can be decreased significantly by taking necessary measures to improve PUE.

The foreign-dependency in using P in Türkiye is high. The share of imported P in total used P in 2015 is 39% (BUGEM 2018b). Decreasing the demand of P mineral fertilizer by improving PUE will decrease foreign-dependency in using P in Türkiye. Additionally, the producers will tend to increase export in order to keep their production levels. This will ensure increase in gross domestic product by increasing net export (export-import) (Ozbek 2018).

Also, so much fossil fuel is used in the production of P mineral fertilizer. Improving PUE will contribute to increase energy efficiency, and decrease production cost of P mineral fertilizer producers. This is crucial when considering the new threat that P fertilizers will become much more expensive in the future as manufacturing (energy) costs increase (Withers et al. 2018). In addition to decreasing indirect energy use by using fewer

fertilizers in agricultural sector, direct energy use will also decrease by using less diesel fuel in fertilizing by improving PUE.

The results showed that the yearly average profit increase per employee in agriculture with a value of 151 TL yr^{-1} would be significantly high when PUE reaches the maximum level. It would be close for some regions to yearly average minimum wage per capita with a value of 747 TL yr^{-1} over the years 2007-2011.

In Türkiye, P mineral fertilizers are used for base dressing. Base dressing fertilizers also include nitrogen. When the measures for improving PUE (e.g. appropriate fertilizer placement, application time and rate of fertilizer, soil testing, erosion reduction, microbial inoculants, plant selection, utilizing legacy soil P, improving soil characteristics) are taken NUE would also increase (Ozbek, 2018). It is assumed that this would compensate for N requirements emerging because of decreasing the usage of base dressing fertilizers as the share of N in total P mineral fertilizers is low with a value of 26%. So, the farmers wouldn't make extra payments for these N requirements.

There is no estimation about economic benefit gained by improving PUE for Türkiye at the national and regional level as far as is known. However, Lun et al. (2018) estimated that if Chinese cropland PUE could be increased 20% (to the global average of 46% from 26%) China would save 60 % of its phosphate fertilizer consumption in 2010. This saving is close to saving of Türkiye with a value of 55% calculated within this study if Türkiye agricultural land PUE could be increased 26% (to 100% from 74%).

Author Contributions: The author has read and agreed to the published version of the manuscript.

Conflicts of Interest: The author declares no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 363-372 DOI:10.15316/SJAFS.2023.035 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Effect of Potassium Doses on Agricultural Characteristics of Camelina Sown in Winter and Summer Season

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HIGHLIGHTS

- Camelina oil is a valuable oil for human health.
- In this study, some effects of potassium fertilizer applied at different doses on camelina were investigated.
- In the spring sowing, an increase was observed in the seed yield value with the increase of the potassium dose, and it was determined that the potassium application in winter cultivation differs.

Abstract

This research carried out in Konya ecology, Arslanbey camelina [*Camelina sativa* (L.) Crantz] genotype which was planted in 2 different times as winter and summer, in the vegetation period of 2020, was determined at 6 different doses (0 kg da^{-1}, 10 kg da^{-1}, 15 kg da^{-1}, 20 kg da^{-1}, 25 kg da^{-1}, 30 kg da^{-1}) potassium sulphate fertilizer was applied to the soil and its effects on some agricultural properties were determined. Field trials of the study were established according to the Random Blocks trial design with 3 replications. As the results of the research in summer plantings, plant height 50.23-54.01 cm, number of branches per plant 5.60-8.80, number of capsules per plant 30.87-58.80, number of seeds per capsule 14.10-17.60, first capsule height 39.55-45.28 cm, seed yield per plant 0.28-1.27 grams, the number of seeds per plant 252.53-1166.13, thousand grain weight 0.78-1.12 grams, grain yield 63.76-77.75 kg da^{-1}, oil rate 22.54%-29.66%, oil yield between 14.05-22.25 kg da^{-1}. Additionally, the values obtained as a result of the winter planting of camelina; plant height 52.04-57.74 cm, number of branches per plant 8.33-11.70, number of capsules per plant 199.80-274.67, number of seeds in capsule 11.50-13.23, height of first capsule 41.01-47.17 cm, grain yield 1.24-1.65 grams per plant, number of seeds per plant 1754.43-2424.00 pieces, thousand grain weight 0.69-0.85 grams, grain yield 80.65-125.93 kg da^{-1}, oil rate 14.47-18.77%, oil yield 11.97-19.74 kg da^{-1}. It can be said that it is essential to carry out long-term different agronomic studies in different locations related to camelina, an important and alternative oil plant.

Keywords: Agronomy, *Camelina sativa*, Cultural practice, Potassium sulphate

1. Introduction

Agriculture is a very sensitive sector that is very important for the nutrition, employment and development of nations and is directly affected by natural conditions. At the same time, the protection and preservation of the soil is the sole basis for the continuity of future generations. In parallel with the rapidly

Citation: Sametoğlu HH, Onder M (2023). Effect of Potassium Doses on Agricultural Characteristics of Camelina Sown in Winter and Summer Season. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 363-372. https://doi.org/10. 15316/SJAFS.2023.035

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Received date: 14/12/2022

Accepted date: 12/06/2023

increasing world population, meeting the increasing nutritional and energy needs will be possible by increasing the yield and quality of agricultural products.

The increase in consumption of foodstuffs has therefore led to an increase in the demand for vegetable oils. One of the foodstuffs that have an important place in human nutrition is vegetable oils. These nutrients are extremely critical for people to perform their vital activities. In addition to having high nutritional value, oils contain free fatty acids necessary for cell structure. Vegetable oils also have a distinctive feature, such as the human body's ability to dissolve fat-soluble vitamins.

Camelina [*Camelina sativa* (L.) Crantz.] is an oil plant belonging to the Cruciferae family. It has been understood that the seed bed should be prepared quite well because the thousand grain weight is between 0.7-1.6 g. It was stated that the harvest of the camelina plant should be done when the capsule is not fully cracked and when full maturation occurs. Because in this way, it has been determined that the grain yield varies between 80-130 kg da^{-1} (İncekara, 1964). In Europe, camelina is grown mostly as a spring crop on organic farms to produce oil and press cakes for animal feed. In these harvesting systems, camelina is often mixed with legumes to prevent weed competition and increase nitrogen supply (Saucke and Ackermann, 2006; Paulsen, 2007).

It is known that camelina oil is a valuable oil for human health. It is also preferred instead of fish oil because it has similar fatty acids content (Zubr, 1997). Camelina seeds are rich in oil (30–49%) and protein (24–31%). It is rich in omega 3 and omega 6 fatty acids, as well as tocopherols, phytosterols and phenolic compounds (Mondor and Hernández-Álvarez, 2022).

In a study (Tamer et al., 2016); it has been stated that the soils of Turkey are rich in potassium at a rate of more than 90%, but because of excessive rainfall and irrigation, the potassium element can move away from the root zone of the plants and therefore the application of potassium-containing fertilizers may become mandatory. In a study on sunflower, which is also an oil plant (Yağmur and Okur 2017); it has been stated that it is inevitable to give sufficient potassium fertilizer for yield and quality increase. Researcher Yenigün (2021) stated that potassium content is high in most of Turkey's soils, but there are great debates regarding the usefulness of potassium. The researcher also stated that the climate has an important effect on potassium availability, that new studies should be established in different soil conditions by using the up-to-date climatic data on potassium for each product, and that the most appropriate potassium dose should be determined in this context. Therefore, in addition to efficiency in agronomic studies, quality work is essential to ensure food safety and sustainability in agricultural terms (Harmankaya et al., 2016; Kahraman and Onder, 2018).

It is important to investigate diversified rotation systems, including lesser-known and/or underproduced plants such as cauliflower, and to identify research priorities on quality as well as various cultural practices (adaptation, planting density, fertilization, etc.) for these crops. This research was carried out to investigate the effects of six different doses of potassium fertilizer applied to camelina [*Camelina sativa* (L.) Crantz] plant, which was cultivated in both spring and autumn periods, on some yield and quality components of camelina in Konya closed basin.

2. Materials and Methods

As material, Camelina genotype "Arslanbey" obtained from the Department of Field Crops, Faculty of Agriculture, Selcuk University was used. The research was carried out by Selcuk University Faculty of Agriculture Prof. Dr. Abdülkadir AKÇİN Experiment Field in 2020, in spring (14th March 2020) and autumn (29th October 2020) separately, according to the Random Blocks Trial Design with three replications.

It was prepared in accordance with the field method where wheat was planted in the previous year. The plots are 2.0 m long and 1.05 m wide, and 7 rows were planted on each plot. The distance between the

rows in the plots is 15 cm, the distance between the rows is 5 cm and the planting is designed at a depth of 0.5 cm.

Before planting, 15 kg da^{-1} DAP was applied to the soil, mixed with the soil with the help of a rake and leveled. 20 kg da^{-1} Ammonium Sulphate was applied as top fertilizer in the period when the plants had 4-6 leaves. Just before planting, 6 different doses (0 kg da^{-1}, 10 kg da^{-1}, 15 kg da^{-1}, 20 kg da^{-1}, 25 kg da^{-1}, 30 kg da^{-1}) of Potassium Sulphate fertilizer were applied to the soil.

The harvest date of the spring planting was realized as 24 June 2020. The harvest date of autumn sowing was 06 June 2021. While measurements and observations were taken for all the features discussed in the experiment, the necessary measurements and observations were not taken from these parts as 30 cm sections were removed from the beginning and end of the remaining rows as well as the first and last rows in each plot. Plant height, number of branches, number of capsules, number of seed per capsule, height of first capsule, thousand seed weight, seed yield, oil ratio and oil yield were detected (Çoban and Önder, 2014; Kahraman, 2017; Yıldırım and Önder, 2016).

The climate data of the period in which the field studies of the research were carried out were obtained from the website of the Regional Directorate of Meteorology and are given in Table 1.

During the vegetation period of the study, the total precipitation amount for 9 months was 168.4 mm, and it was approximately 132 mm less than the total precipitation for long years (300 mm). In the process of this study, the highest monthly precipitation value was determined as 51.8 mm in January, and extremely low precipitation was received in the other months of the study. Considering the total amount of precipitation recorded during the vegetation period in which this study took place, it was seen that the distribution of precipitation to months was much more irregular than the average of long years.

Table 1. Some climatic values of the months and long years in which the field works were carried out (data collected from: General Directorate of Meteorology)

Months	2020-2021 Vegetation Period					Long Terms (1929-2020)				
	Temperature (°C)					Temperature (°C)				
	Mean	Max.	Min.	Rain (mm)	Relative Humidity (%)	Mean	Max.	Min.	Rain (mm)	Relative Humidity (%)
October	16.3	28.7	3.6	13	56	12.6	31.6	-7.6	29.9	58
November	5.8	17.9	-8.1	25	78	6.5	25.2	-20.0	32.2	69
December	4.5	14.6	-7.5	12.6	88	1.6	20.0	-22.4	42.8	77
January	2.5	20.2	-11.2	51.8	85	-0.1	17.6	-25.8	37.9	76
February	2.9	20	-16.5	1.6	67	1.4	21.2	-25.0	28.5	70
March	5.2	31.3	-7.8	31.6	66	5.5	28.9	-15.8	28.7	62
April	12.1	30.2	-1.2	17.4	53	11	31.5	-8.6	31.9	58
May	19.1	33.7	1.7	2.4	38	15.8	33.4	-1.2	43.3	55
June	19.5	32.5	4.3	26	51	20.1	37.2	3.2	25.7	47
Average	9.7	26.9	- 4.7		60.8	10.4	34.4	-16.7		61
Total				181.4					330.8	

Considering the results of the analysis of the soil in which the field experiment was established; clay-loam, neutral pH, salt-free structure, medium organic matter level (2.34%), high amount of phosphorus, very rich in potassium, rich in calcium, sufficient in copper-zinc and manganese, deficient in iron content and very It was determined that it exhibited a calcareous structure.

Variance analysis was performed on the data obtained as a result of the study, using a computer-based statistical analysis program called "JUMP", and grouping was performed with the "Student's t test" at the 5% level to compare the mean values whose "F" test was significant (Çoban and Onder, 2014).

3. Results and Discussion

Results of variance analysis presented on Table to while the mean values of the investigated characteristics presented on Table 3.

Focus on the plant height values obtained in the study; In spring plantings, the shortest plant height was 50.23 cm at 30.0 kg da^{-1} potassium application dose, and the highest value was 54.01 cm at 0.0 kg da^{-1} application dose. In camelina planted in autumn, the highest plant height was determined as 57.74 cm,

Table 2. Results for analysis of variance

Plant Height		Spring Sowing		Autumn Sowing	
Source of Variance	**DF**	**MS**	**F**	**MS**	**F**
Total	**17**	8.24	-	20.87	-
Replication	**2**	20.54	-	27.27	-
Potassium Dose	**5**	7.48	1.21	13.60	0.59
Error	**10**	6.16	-	23.23	-
Number of Branch		**Spring Sowing**		**Autumn Sowing**	
SV		**MS**	**F**	**MS**	**F**
Total		4.79	-	3.13	-
Replication		1.50	-	4.66	-
Potassium Dose		3.98	0.68	5.29	3.08
Error		5.85	-	1.71	-
Number of Capsule per Plant		**Spring Sowing**		**Autumn Sowing**	
SV		**MS**	**F**	**MS**	**F**
Total		636.77	-	3141.29	-
Replication		3326.71	-	3091.18	-
Potassium Dose		268.99	0.95	1975.95	0.53
Error		282.67	-	3733.99	-
Number of Seed per Capsule		**Spring Sowing**		**Autumn Sowing**	
SV		**MS**	**F**	**MS**	**F**
Total		5.72	-	2.29	-
Replication		13.09	-	4.46	-
Potassium Dose		5.27	1.18	1.84	2.14
Error		4.47	-	2.08	-
Height of First Capsule		**Spring Sowing**		**Autumn Sowing**	
SV		**MS**	**F**	**MS**	**F**
Total		23.81	-	17.19	-
Replication		7.98	-	51.28	-
Potassium Dose		20.32	0.71	15.37	1.36
Error		28.71	-	11.29	-
Thousand Seed Weight		**Spring Sowing**		**Autumn Sowing**	
SV		**MS**	**F**	**MS**	**F**
Total		0.07	-	0.02	-
Replication		0.05	-	0.00	-
Potassium Dose		0.05	0.62	0.01	0.49
Error		0.08	-	0.00	-
Seed Yield		**Spring Sowing**		**Autumn Sowing**	
SV		**MS**	**F**	**MS**	**F**
Total		867.81	-	627.12	-
Replication		6793.05	-	803.92	-
Potassium Dose		72.66	0.90	818.06	1.65
Error		80.34	-	496.28	-
Oil Ratio		**Spring Sowing**		**Autumn Sowing**	
Sources of Variation		**MS**	**F**	**MS**	**F**
Total		36.89	-	9.37	-
Replication		126.83	-	12.60	-
Potassium Dose		21.05	0.78	10.61	1.31
Error		26.82	-	8.09	-
Oil Yield		**Spring Sowing**		**Autumn Sowing**	
SV		**MS**	**F**	**MS**	
Total		106.63	-	21.89	-
Replication		668.76	-	16.55	-
Potassium Dose		25.44	0.73	29.58	1.55
Error		34.79	-	19.13	-

while the smallest plant height was determined as 52.04 cm. In this study, the highest value for plant height; It was obtained from plots where potassium was not applied. The average plant height in autumn planting (54.69 cm) was taller than the average plant height in spring planting (52.26 cm).

Previous findings for plant height value in various studies on camelina; 73.91 cm (Mason, 2009b), 95.25 cm (Mason, 2010), 47.25-51.50 cm (Sadhuram et al., 2010), 60 to 110 cm (Berti et al., 2011), 103.41-67.17 cm (Katar et al., 2012), 83.24-95.28 cm (Yıldırım and Önder, 2016).

Table 3. Mean values of the investigated characteristics

	Potassium Doses (kg/da)						
	0.0	**10.0**	**15.0**	**20.0**	**25.0**	**30.0**	**Mean**
Plant Height (cm)							
Spring	54.01	53.01	53.19	52.75	50.35	50.23	**52.26**
Autumn	57.74	53.87	53.23	56.57	52.04	54.67	**54.69**
Mean	55.88	53.44	53.21	54.66	51.20	52.45	**53.48**
Number of Branch per Plant (piece)							
Spring	7.73	8.20	8.80	6.60	7.60	5.60	**7.42**
Autumn	8.33	11.70	8.93	9.13	10.80	10.80	**9.95**
Mean	8.03	9.95	8.87	7.87	9.20	8.20	**8.69**
Number of Capsule per Plant (piece)							
Spring	40.18	30.87	43.60	58.80	45.73	37.00	**42.69**
Autumn	199.80	237.20	262.27	239.27	274.67	239.93	**242.19**
Mean	119.99	134.04	152.94	149.04	160.20	138.47	**142.44**
Number of Seed per Capsule (piece)							
Spring	15.43	14.10	17.60	17.20	15.40	15.17	**15.82**
Autumn	13.23	11.57	11.90	11.67	11.50	13.07	**12.16**
Mean	14.33	12.84	14.75	14.44	13.45	14.12	**13.99**
Height of First Capsule (cm)							
Spring	45.28	40.12	39.55	44.13	45.17	41.10	**42.56**
Autumn	47.17	41.65	41.94	44.07	42.57	41.01	**43.07**
Mean	46.23	40.89	40.75	44.10	43.87	41.06	**42.82**
Thousand Seed Weight (g)							
Spring	0.94	1.12	0.99	1.03	1.11	0.78	**1.00**
Autumn	0.85	0.69	0.70	0.83	0.81	0.80	**0.78**
Mean	0.90	0.91	0.85	0.96	0.96	0.79	**0.90**
Seed Yield (kg da^{-1})							
Spring	63.96	66.76	68.10	69.68	73.22	77.75	**69.91**
Autumn	90.29	125.93	107.39	80.65	111.28	92.81	**101.39**
Mean	77.13	96.35	87.75	75.17	92.25	85.28	**85.65**
Oil Ratio (%)							
Spring	23.29	26.05	29.66	22.54	25.76	23.33	**25.10**
Autumn	18.77	16.20	17.47	14.47	15.94	13.65	**16.08**
Mean	21.03	21.13	23.57	18.51	20.85	18.49	**20.59**
Oil Yield (kg da^{-1})							
Spring	14.05	18.58	22.25	16.13	20.30	18.28	**18.27**
Autumn	16.91	19.74	18.83	11.97	17.58	13.09	**16.35**
Mean	15.48	19.16	20.54	14.05	18.94	15.69	**17.31**

The average values of the number of branches in the plant, the minimum number of branches was obtained from the plots with 5.60 pieces/plant and the most potassium applied, while the maximum number of branches was obtained from the plots with 8.80 pieces/plant and 15 kg da-1 of potassium. Considering the autumn plantings, plant height values in camelina; It varied between 8.33 per plant (0.00 kg da^{-1}) and 11.70 per plant (10.0 kg da^{-1}).

Findings of the other studies in which the number of branches in the camelina plant were determined are as follows: 2.20-12.83 units/plant (Karahoca and Kırıcı, 2005); while it was determined as 9.81 units/plant (Katar et al., 2012), it was determined that 1.00-3.60 units/plant in summer plantings and 7.15-16.75 units/plant in winter plantings (Koç, 2014) in Konya ecology.

Result of the research showed that, when the average values determined for the number of capsules in the plant are examined; it was determined in the range of 30.87 units/plant (10.0 kg da^{-1}) – 58.80 units/plant (20.0 kg da^{-1}) in spring plantings. As a result of the study, the number of capsules in camelina planted in autumn was determined as 199.80 pieces/plant and the lowest value at 0.00 kg da^{-1} dose, while the highest value was determined at 274.67 pieces/plant and 25.0 kg da^{-1} potassium application dose. In the research, a significant increase was observed in the average value of the number of capsules per plant compared to spring planting in camelina planted in autumn (autumn average: 242.19 units/plant; spring average: 42.69 units/plant).

Relative studies carried out, the number of capsules in the camelina plant; in Konya ecological conditions, it was determined in the range of 40.15-94.75 units/plant in summer plantings, 264.20-465.80 units/plant in winter plantings (Koç, 2014), and 75.33-117.17 units/plant in summer plantings (Yıldırım and Önder, 2016) in Konya ecology.

The average values determined for the number of seeds in the capsule of the camelina plant; It ranged between 14.10 pieces/capsule and 17.60 pieces/capsule in spring planting. If sown in autumn, the said value was determined in the range of 11.50 – 13.23 pieces/capsule. In this study, the highest value in autumn planting in terms of the number of seeds in the capsule; emerged from plots that were not treated with potassium.

Investigated values of the number of seeds in the capsule in various studies with the camelina plant; 11.4-12.8 pcs/capsule Sadhuram et al. (2010), 8-15 pcs/capsule Berti et al. (2011), in Konya ecology; it was determined in the range of 10.28-13.73 units/capsule (Koç, 2014), 13.83-16.67 units/capsule (Yıldırım and Önder, 2016).

When the average values obtained for the first capsule height in the camelina are examined; In the spring plantings, the lowest result was obtained with a value of 39.55 cm and 15.0 kg da^{-1} application, while the highest first pod height value was found in the control group with a value of 45.28 cm. The first capsule height of camelina planted in autumn was found to be between 41.01 cm (30.0 kg da^{-1}) – 47.17 cm (0.00 kg da^{-1}) values. Considering these results, the highest first capsule height value for both spring and autumn plantings; appeared in plots not treated with potassium.

The first capsule height is an important parameter for machine harvesting. In other studies, conducted in Konya ecology; It was determined between 50.67-83.67 cm (Çoban and Önder, 2014), 71.00-80.09 cm Yıldırım and Önder (2016), and it is seen that the findings of the studies on the subject over-lap.

Considering the average values for the thousand seed weight determined in this study; the lowest value was determined at 0.78 g and 30.0 kg da^{-1} application dose, and the highest value 1.12 g was determined at 10.0 kg da^{-1} dose. When the findings are evaluated; it is quite remarkable that the highest potassium application dose leads to the lowest thousand seed weight.

The weight of a thousand seeds in camelina planted in autumn; 0.69 g value was determined at 10.0 kg da^{-1} application, and the highest value was determined with 0.85 g value at 0.00 kg da^{-1} dose. When the autumn plantings are examined; the highest thousand seed weights occurred in the plots without potassium application and the application dose of 10.0 kg da^{-1} resulted in the highest value in spring planting and the lowest value in autumn planting; it suggests the interpretation that different results can be obtained in seasonal potassium applications.

Former studies carried out in camelina, thousand seed weight values; 1.32 g (Karahoca and Kırıcı, 2005), 1.19 g (Mason, 2009a), 0.8 - 1.8 g (Berti et al., 2011), (Katar et al., 2012), 0.85 g in spring sowing and 1.26 g in autumn sowing in Konya ecology (Koç, 2014) was determined in the range of 1.06 g (Yıldırım and Önder, 2016), and it coincides with the thousand-grain weight values obtained as a result of this study.

As a result of the research, when the values for seed yield are examined; In the plots planted in spring, the lowest value was 63.76 kg da^{-1} and 10.0 kg da^{-1} potassium application. In camelina planted in autumn, the lowest grain yield was determined with a value of 80.65 kg da^{-1} in potassium application at a dose of 20.0 kg da^{-1}, and the highest grain yield value was found in potassium application with a value of 125.93 kg da^{-1} in 10.0 kg da^{-1}. It has been observed that potassium application in camelina in autumn planting fluctuates depending on the dose in terms of grain yield. When a general evaluation is made, it has been determined that the grain yield of camelina is higher in winter plantings, regardless of the effect of potassium doses.

The results of other studies that determined the grain yield in camelina are as follows: 105-325 kg da^{-1} (Vollmann et al., 1996), 116-180 kg da^{-1} (Agegnehu and Honermeier, 1997), 260-330 kg da^{-1} (Zubr, 1997), 360-400 kg da^{-1} (Crowley and Fröhlich, 1999), 255.47 kg da^{-1} (Mason, 2009a), 235.87 kg da^{-1} (Mason, 2009b), 67–74 kg da^{-1} (Koncius and Karcauskiene, 2010), 259.05 kg da^{-1} (Mason, 2010), 120.2-150.1 kg da^{-1} (Sadhuram et al., 2010), 87.81-281.27 kg da^{-1} (Katar et al., 2012), 71.12- 97.90 kg da^{-1} (Yıldırım and Önder, 2016), 80-140 kg da^{-1} (Kurt and Göre, 2018), 37.05-55.13 kg da^{-1} (Dağ Subaş, 2022), 103.1-227.8 kg da^{-1} (Koçer, 2022). Grain yield in camelina plant; It varies greatly according to the genetic character of the cultivar grown, climatic conditions and cultivation techniques as it seen on the other field crops (Kahraman, 2022).

Considering the average values obtained for the oil rate determined in the camelina; in the spring plantings, the lowest value was found at 22.54% at the application dose of 20.0 kg da^{-1}, while the highest rate was determined with 29.66% in the plots where 15.0 kg da^{-1} of potassium fertilizer was applied. In the case of planting camelina in autumn, the lowest value of the oil rate was 14.47% at a dose of 20.0 kg da^{-1}, while the highest oil rate was 18.77% in the plots without potassium application. When the winter and summer plantings of camelina are evaluated in general; while the lowest value in terms of oil content was observed in 20.0 kg da^{-1} potassium application, it was determined that the oil ratio was higher in camelina in spring plantings.

Other research results in which the oil rate was determined in the camelina; 28%-37% (Atakişi, 91), 38.5-45.5% (Vollmann et al., 1996), 37-43% (Agegnehu and Honermeier, 1997), 42-45% (Zubr, 1997), 39.30% (Mason) , 2009a), 38.8% (Mason, 2009b), 32.6% (Mason, 2010), 25.16-37.15% (Katar et al., 2012), 22.72-37.55% (Koç, 2014), 30-49% (Berti et al., 2016, Boyle et al., 2018, Hossain et al., 2019), 24.02-29.33% (Yıldırım and Önder, 2016), 17.26-22.53% (Dağ Subaş, 2022), 24.66 – 30.62 Koçer (2022) is specified. The oil rate in the grain; it is known that it may vary depending on the variety, growing conditions, and climatic conditions, as well as the storage period (Tura et al., 2022). As a matter of fact, as seen in the research on camelina, the oil rate in the grain varies in a wide range.

In this study, when the average values of oil yield in camelina grown in summer and winter are examined; the lowest value was found – 14.05 kg da^{-1} in the plots where potassium was not applied in spring plantings, and the highest value (22.25 kg da^{-1}) was reached in the application of potassium at a dose of 15.0 kg da^{-1}. In the case of planting camelina in autumn, the lowest value of oil yield occurred at a dose of 11.97 kg da^{-1} and 20.0 kg da^{-1}, while the highest oil yield was observed in plots treated with potassium at a dose of 10.0 kg da^{-1}, reaching a value of 19.74 kg da^{-1}.

The findings related to oil yield in various studies on camelina were examined; 12.06-72.39 kg da^{-1} (Karahoca and Kırıcı, 2005), 100.91 kg da^{-1} (Mason, 2009a), 84.45 kg da^{-1} (Mason, 2010), 103.84-22.94 kg da^{-1} (Katar et al., 2012), 57.93 kg da^{-1} (Yıldırım and Önder, 2016), 30.1-66.5 kg da^{-1} (Koçer, 2022). It is stated that

many metabolic factors such as seed yield and quality in plants are affected by genetic structure and climatic conditions (Onder and Kahraman, 2016; Deng et al., 2022).

4. Conclusions

As a result of this research, regardless of the effect of potassium applications, seed yield in camelina plant; found to be higher in autumn sowings. It is very striking that the application of the highest dose of potassium in spring planting resulted in the lowest 1000 seed weight. Looking at the winter sowings; the highest value of 1000 seed weight is observed in the plots without potassium application and the application dose is 10.0 kg da^{-1}, and the highest thousand seed weight in summer cultivation and in winter cultivation; reach the lowest value; it has been suggested that the results obtained from potassium applications may vary depending on the season. In the spring sowing, an increase was observed in the seed yield value with the increase of the potassium dose, and it was determined that the potassium application in winter cultivation differs depending on the application doses in terms of grain yield. The highest oil rate in autumn planting; It was observed that the oil rate was higher in the spring plantings, while it appeared in the plots where potassium was not applied. In terms of oil yield, the lowest value was observed in the plots where potassium was not applied in summer cultivation, and the highest oil yield was reached at the potassium application dose of 15.0 kg da^{-1}, respectively.

It is important to expand the cultivation of alternative oil crops, to implement systems to encourage oilseed farming with government support, to create a product pattern suitable for the region, and to enter the rotation of alternative oil crops. To meet the need for oilseeds by evaluating fallow fields with these plants, growing second crops, supporting research projects, and making a planned and programmed study; It will pave the way for being a self-sufficient country in vegetable oil production and exporting surplus production.

Author Contributions: Conceptualization and methodology, M.O.; investigation and realization of the research H.H.S. and M.O.; resources, data curation, writing—original draft preparation, writing—review and editing, visualization and supervision H.H.S. and M.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Selcuk University Scientific Research Projects Coordinator, grant number 20201072.

Acknowledgements: This article summarized from Hasan Huseyin SAMETOGLU's MSc thesis (Thesis number: 780826).

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 371-388 DOI:10.15316/SJAFS.2023.036 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Determination of Seedling Reactions of Some Barley Cultivars, Lines, and Wild Barley (*Hordeum spontaneum*) Genotypes to *Cochliobolus* Leaf Spot Disease

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HIGHLIGHTS

- *Cochliobolus* leaf spot diseaseis an important disease of barley caused by the fungus *Cochliobolus sativus*.
- Under greenhouse conditions, seedling stage reactions of 36 barley cultivars, 35 advanced lines, and 21 wild barley (*Hordeum spontaneum*) genotypes were determined.
- Among barley cultivars and genotypes, six genotypes showed a low reaction, 29 genotypes showed moderate reactions and 36 genotypes showed a high reaction.
- Of the wild barley genotypes, two, 8, and 11 genotypes showed low, moderate, and high reactions respectively.

Abstract

*Cochliobolus*leaf spot disease, also seen in barley, is an important disease caused by the fungus, *Cochliobolus sativus*. In this study, under greenhouse conditions, seedling stagereactions of 36 barley cultivars, 35 advancedlines, and 21 wild barley (*Hordeum spontaneum*) genotypes obtained from Elazığ province of Türkiye and Güzelyurt district of the Turkish Republic of Northern Cyprus against a virulent isolate of *Cochliobolus sativus* has been determined. Among barley cultivars and genotypes, six genotypes showed a low reaction, 29 genotypes showed moderate reactions and 36 genotypes showed a high reaction. Of the wild barley genotypes, two, 8, and 11 genotypes showed low, moderate, and high reactions respectively. Barley cultivars Harman and Pınar showed low reaction responses, cultivars Akar, Bolayır, Bozlak, Burgaz, Çumra 2001, Hasat, Misket, Orza 96, Sabribey, Sinanbey, Yaprak, and Yesevi 93 exhibited intermediate reaction responses and cultivars Anka-06, Asil, Avcı 2002, Aydanhanım, Ayrancı, Başgül, Burakbey, Bülbül 89, Cacabey, Cirit, Çetin 2000, Hazar, İnce 04, Keykubat, Larende, Özdemir 05, Sayım 40, Tarm 92, Tosunpaşa, Yalın, Yüksel, and Zeynelağa showed high reaction responses. Barley cultivars exhibiting low reaction types can be used by farmers in the field, while barley lines and wild barley genotypes showing low reactions can be used in breeding studies.

Keywords: Barley; *Bipolaris sorokiniana*; *Cochliobolus sativus*; spot blotch; disease resistance

Citation: Kızıl N, Karakaya A, Çelik AO, Ergün N (2023). Determination of Seedling Reactions of Some Barley Cultivars, Lines, and Wild Barley (*Hordeum spontaneum*) Genotypes to Cochliobolus Leaf Spot Disease. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 373-388. https://doi.org/10. 15316/SJAFS.2023.036

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Received date: 02/01/2023

Accepted date: 27/06/2023

1. Introduction

Barley (*Hordeumvulgare*L.), a member of the Poaceae family, is an annual long-day plant among the cool climate cereals. Cultivated barleys are typically categorized as 2 rowed or 6 rowed based on ear structure (Geçit 2016), and they are divided into hulled or hulless (naked) according to the separation of grains and husks after harvest (Duan et al. 2015). Barley, which can be grown without irrigation in arid and semi-arid regions, shows better growth in areas with high relative humidity, and moderate climates. *Hordeum spontaneum* C. Koch, which is accepted as the ancestor of modern barley, is two-rowed and predominantly self-pollinated (Zohary and Hopf 2000).

It is estimated that the barley cultivation areas in the world are 51.7 million ha with an increase of 1% in the cultivation areas in the 2020/21 season, and the barley production is 159.7 million tons with an increase of 1.9%. Analysis of the 2019/20 USDA datashowed that the EU has the largest barley cultivation area in the world with 21.7% in the last seven production seasons. The EU is followed by Russia, Australia, Türkiye, and Canada with 16.4%, 7.9%, 7.4%, and 5.3%. These countries constitute approximately 58.7% of the world's cultivation area (Eğilmez 2021; USDA 2022).

Approximately 55-60% of the world's barley production is used for animal feeding, 30-40% in the malt industry, 2-3% in human consumption, and 5% as seed (Ullrich 2011). Barley, which is mostly cultivated under rainfed conditions and in the arid climate zone, is a grain known for its earliness, which has an escape mechanism from drought in Türkiye (Anonymous B 2020). Barley, which ranks second in Türkiye after wheat, is produced in every agro-ecological zones of Türkiye. Barley cultivation areas and production amounts for the last ten years vary between 2.4-3.0 million hectares (ha) and 6.3-8.0 million tons, respectively (Anonymous A 2020; Eğilmez 2021; Anonymous 2021).

Cochliobolus sativus (Ito and Kuribayashi) Drechs. ex Dastur (anamorph: *Bipolaris sorokiniana* (Sacc.) Shoem.) is one of the fungal diseases that affect barley production and quality. This pathogen, which causes *Cochliobolus* leaf spot and root rot diseases in the plant (Mathre 1997; Kumar et al.2002), is an important disease agent that leads to a decrease in quality and yield in barley. The disease was more common in barley than in wheat in the central Anatolian Region, and it was determined that one-third of the cultivation areas were contaminated with the pathogen (Aktaş 1982). *Cochliobolus* leaf spot disease is usually seen in humid conditions (Fetch and Steffenson 1999). On the leaves of the plant infected with this disease, the first symptoms are dark chocolate-colored spots and over time they form irregular necrotic patches on the leaf. As the infection progresses more severely, the infected leaf dries up completely (Mathre 1997).

Cochliobolus sativus passes to the next year with seeds and diseased plant residues in the soil and can cause disease in all development stages of the plant. Root and root collar disease symptoms caused by the fungus are dark and pale brown spots. Grain deaths occur due to reasons such as spots on leaves, seedling blight, and root rot; the husk and grain blight seen on the spike causes the embryo to darken (Yıldırım et al. 2016).

This disease causes 16% to 33% product loss with the effect of environmental conditions (Wilcoxson et al. 1990). Overall, the degree of resistance in modern cultivars is still insufficient (Hetzler et al. 1991; Chang et al. 1998; Mujeeb-Kazi 1998; Van Ginkel and Rajaram 1998; Kumar et al.2002).

Although fungicide applications are applied in the fight against this disease, the development and use of lines and varieties resistant to *C. sativus* stand out as an environmentally friendly control method (Kiesling1985). The reactions of the newly developed barley cultivars should be determined. The resistance status of advanced barley lines and wild barley (*Hordeum spontaneum*) genotypes which are important resistance sources should be assessed. *Hordeum spontaneum*genotypes are useful disease-resistance sources (Çelik and Karakaya 2017).

There are studies of resistance to diseases related to *Cochliobolus* leaf spot in the world and in Türkiye (Aktaş and Tunalı 1994; Clear et al. 1997; Legzdina and Buerstmayr 2004; Gerlegiz et al. 2015; Çelik Oğuz et al. 2016; Celik-Oguz and Karakaya 2017; Balcı et al. 2018). On a worldwide scale, yield losses in wheat and barley caused by *C. sativus* reveal the need to search for alternative strategies to combat the disease (Yıldırım 2016).

Several studies have identified quantitative trait loci (QTL) for resistance to *Cochliobolus* leaf spot disease on all seven barley chromosomes. To date, three resistance genes (Rcs 5, Rcs 6, Rbs 7) have been mapped in detail(Zhou and Steffenson 2013; Afanesenko et al. 2015; Novakaziet al. 2020; Visioni et al. 2020). In addition, common QTLs were detected in all barley chromosomes at seedling and adult plant stages (Visioni et al. 2020). Wild barley is an important source of genetic variation for disease resistance (Fetch et al. 2003; Yun et al. 2005). Although there are some studies on genetic resistance to *Cochliobolus* leaf spot disease, there are limited genetic studies from the wild barley host. Wild barley accession PI 466423, resistant to Fusarium head blight and *C. sativus*, was crossed with the Rasmusson cultivar, and four resistance QTLs were identified on chromosomes 1H, 2H, 4H, and 5H.These results confirm the value of using wild relatives as a source of new resistance alleles (Haas et al. 2016).

In this study, seedling stage reactions of old and new barley cultivars,advanced barley breeding materials, and wild barley (*Hordeum spontaneum*) genotypes against *C. sativus* leaf spot disease were determined.

2. Materials and Methods

In this study, seedling resistance of 36 old and newly bred barley cultivars, 35 advanced barleylines and 21 wild barley (*Hordeum spontaneum*) genotypes were evaluated under greenhouse conditions against a virulent isolate of *Cochliobolus sativus*. A highly virulent isolate obtained from Yozgat in 2015, which was stored in the culture collection of Ankara University, Faculty of Agriculture, Department of Plant Protection, Mycology laboratory, was used. Before the study, the virulence level of the isolate was tested on the susceptible variety Bülbül 89 (Celik-Oguz and Karakaya 2017; Çelik Oğuz et al. 2019), and the virulence level was again found to be high. Wild barley genotypes were obtained from Elazığ province of Türkiye (16 genotypes) and Güzelyurt district of the Turkish Republic of Northern Cyprus (TRNC) (5 genotypes). For this purpose, the methods outlined by Celik-Oguz and Karakaya (2017) were used. Reproduction of pure wild barley seeds under field conditions was carried out in the experimental field of the Central Research Institutefor Field Crops in Yenimahalle, Ankara, Türkiye. Fifteen seeds of each barley and wild barley genotype were planted in pots containing soil, sand, and organic matter (60: 20: 20, v:v:v). Conidia suspension was prepared from 10-day-old cultures grown on Potato Dextrose Agar. To prepare the inoculum, the conidia of the fungus grown in Petri dishes for 14 days were scraped with the help of a brush, filtered through cheesecloth and the density was determined using a Thoma slide as $2x10^4$ conidia/ml. 1 drop of Tween 20 was added to each 100 ml (Çelik Oğuz et al. 2016). Cultures were incubated at 20-23°C in 12 hours dark/12 hours light conditions. The plants in each pot were sprayed homogeneously with the inoculum. Inoculation was carried out at Zadoks 12-13 growth stagewhich corresponds to the 2-2.5 leaf stage (Zadoks et al. 1974). The studies were carried out under greenhouse conditions. Following inoculation, the plants were placed in boxes with transparent lids and closed with a polyethylenebag. Experiments were carried out as 3 replications. After 7 days, evaluations were made according to the 1-9 scale developed by Fetch and Steffenson (1999). This scale is divided into 3 categories. Scale values 1-3, 4-5, and 6-9 represented low, intermediate, and high infection responses, respectively.

3. Results

Seedling stage reactions of 36 barley cultivars, 35 barley lines, and 21 wild barley (*Hordeum spontaneum*) genotypes against *C. sativus* were determined (Tables 1, 2, 3 and Figures 1, 2).

Among barley cultivars and lines, six genotypes showed a low reaction, 29 genotypes showed intermediatereactions and 36 genotypes showed a high reaction. Of the wild barley genotypes, two, 8, and 11 genotypes showed low, intermediate, and high reactions, respectively. Barley cultivars Harman and Pınar showed low reaction responses; Akar, Bolayır, Bozlak, Burgaz, Çumra 2001, Hasat, Misket, Orza 96, Sabribey, Sinanbey, Yaprak, and Yesevi 93 exhibited intermediate reaction responses and cultivars Anka-06, Asil, Avcı 2002, Aydanhanım, Ayrancı, Başgül, Burakbey, Bülbül 89, Cacabey, Cirit, Çetin 2000, Hazar, İnce 04, Keykubat, Larende, Özdemir 05, Sayım 40, Tarm 92, Tosunpaşa, Yalın, Yüksel, and Zeynelağa showed high reaction responses.

Barley line IKABVD Ç-23 (IR 7.33) and wild barley genotype *H. spontaneum* 24 (IR 6.67) and barley cultivar Ayrancı (IR 7.33) showed the most susceptible reactions against *C. sativus*. The most resistant reaction against the disease was exhibited by the *H. spontaneum* 30 (IR 2) genotype (Tables 1, 2, and 3).

Out of 21 genotypes of wild barley (*H. spontaneum*), 9.52%, 38.1% and 52.38% showed low, intermediate, and high infection responses, respectively. Among the barley cultivars, 5.56%, 33.33%, and 61.11% showed low, medium, and high infection responses, respectively. 11.43% of barley lines showed low infection response, 48.57% were placed in the intermediate group and 40% exhibited high infection values. Of the 36 barley cultivars, 35 barley lines and 21 wild barley (*H. spontaneum*) genotypes, 8.70%, 40.22%, and 51.09% were placed in the low (resistant), intermediate, and high (susceptible) infection classes, respectively.

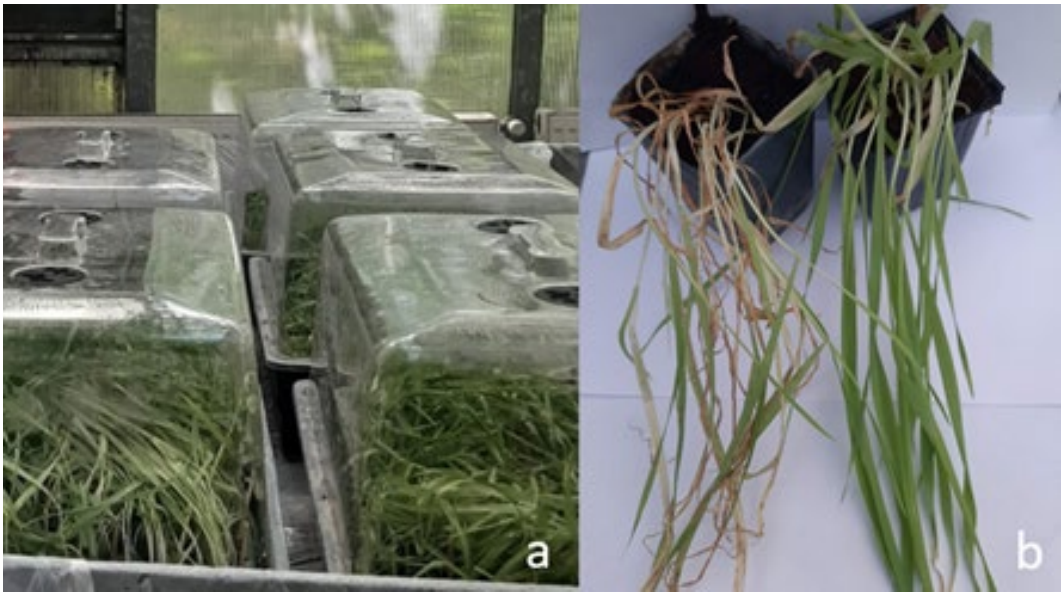

Figure 1. a) Barley genotypes after inoculation with a virulent strain of *Cochliobolus sativus* under greenhouse conditions b) Ayrancı (left) and Pınar (right) barley cultivars 7 days after inoculation

Table 1. Seedling stage reactions of 35 barley genotypes against *Cochliobolus sativus* leaf spot disease.

Barley Lines	Replications	Mean	Infection Classes
Std. Çeş.-50	3 3 4	3.33	A
Std. Çeş.-63	6 6 6	6	C
Std. Çeş.-64	3 3 3	3	A
Std. Çeş.-65	3 4 4	3.67	B
Std. Çeş.-67	6 6 5	5.67	C
Std. Çeş.-125	6 6 6	6	C
Std. Çeş.-126	5 6 5	5.33	B
Std. Çeş.-127	5 5 4	4.67	B
Std. Çeş.-128	5 5 5	5	B
Std. Çeş.-133	7 6 7	6.67	C
Std. Çeş.-145	5 5 4	4.67	B
Std. Çeş.-146	5 5 5	5	B
Std. Çeş.-147	5 5 5	5	B
Std. Çeş.-148	4 3 3	3.33	A

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

Table 1 (Continued). Seedling stage reactions of 35 barley genotypes against *Cochliobolus sativus* leaf spot disease (continued).

Barley Lines	Replications	Mean	Infection Classes
Std. Çeş.-149	5 5 5	5	B
Std. Çeş.-150	3 3 4	3.33	A
Std. Çeş.-151	5 5 6	5.33	B
Std. Çeş.-152	6 6 6	6	C
İKABVD Ç-2	7 6 6	6.33	C
İKABVD Ç-3	5 4 4	4.33	B
İKABVD Ç-4	4 4 4	4	B
İKABVD Ç-6	5 6 5	5.33	B
İKABVD Ç-7	7 7 6	6.67	C
İKABVD Ç-8	7 7 6	6.67	C
İKABVD Ç-9	6 5 6	5.67	C
İKABVD Ç-11	4 5 5	4.67	B
İKABVD Ç-12	7 6 7	6.67	C
İKABVD Ç-13	7 6 6	6.33	C

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

Table 1 (Continued). Seedling stage reactions of 35 barley genotypes against *Cochliobolus sativus* leaf spot disease (continued)

Barley Lines	Replications	Mean	Infection Classes
İKABVD Ç-14	5 5 5	5	B
İKABVD Ç-17	6 6 5	5.67	C
İKABVD Ç-18	7 6 6	6.33	C
İKABVD Ç-19	5 5 4	4.67	B
İKABVD Ç-21	5 6 5	5.33	B
İKABVD Ç-22	5 4 4	4.33	B
İKABVD Ç-23	8 7 7	7.33	C
General Mean	**5.34** **5.2** **5.09**	**5.21**	**B**

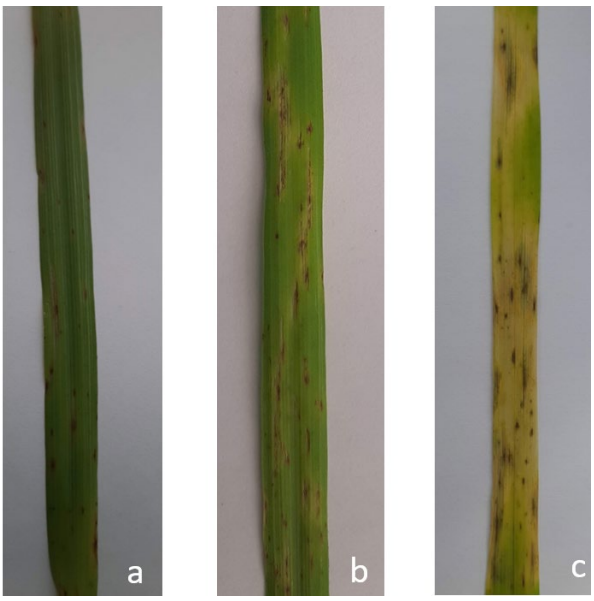

Figure 2. Infection classes showing a) low infection response b) intermediate infection response c) high infection response

Table 2. Seedling stage reactions of 36 barley cultivars against *Cochliobolus sativus* leaf spot disease

Barley Cultivars	Replications	Mean	Infection Classes
Akar	5 5 5	5	B
Anka-06	7 7 7	7	C
Asil	7 7 7	7	C
Avcı 2002	7 6 7	6.67	C
Aydanhanım	6 6 7	6.33	C
Ayrancı	7 7 8	7.33	C
Başgül	7 6 7	6.67	C
Bolayır	5 5 5	5	B
Bozlak	6 6 4	5.33	B
Burakbey	5 6 6	5.67	C
Burgaz	5 5 6	5.33	B
Bülbül-89	7 7 6	6.67	C
Cacabey	7 7 6	6.67	C
Cirit	6 6 5	5.67	C

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

Table 2 (Continued). Seedling stage reactions of 36 barley cultivars against *Cochliobolus sativus* leaf spot disease (continued)

Barley Cultivars	Replications	Mean	Infection Classes
Çetin 2000	7 6 6	6.33	C
Çumra 2001	4 5 5	4.67	B
Harman	4 3 3	3.33	A
Hasat	4 5 5	4.67	B
Hazar	6 5 6	5.67	C
İnce 04	6 6 6	6	C
Keykubat	6 6 6	6	C
Larende	6 5 6	5.67	C
Misket	5 5 5	5	B
Orza-96	5 4 4	4.33	B
Özdemir 05	6 5 6	5.67	C
Pınar	3 2 3	2.67	A
Sabribey	4 5 5	4.67	B
Sayım 40	6 6 6	6	C

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

Table 2 (Continued). Seedling stage reactions of 36 barley cultivars against *Cochliobolus sativus* leaf spot disease (continued)

Barley Cultivars	Replications	Mean	Infection Classes
Sinanbey	5 5 5	5	B
Tarm 92	7 7 7	7	C
Tosunpaşa	6 6 6	6	C
Yalın	7 6 6	6.33	C
Yaprak	5 5 4	4.67	B
Yesevi 93	5 5 6	5.33	B
Yüksel	7 6 6	6.33	C
Zeynelağa	6 6 5	5.67	C
General Mean	**5.75** **5.56** **5.64**	**5.65**	**C**

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

Table 3. Seedling stage reactions of 21 wild barley (*Hordeum spontaneum*) genotypes against *Cochliobolus sativus* leaf spot disease

***Hordeum spontaneum* genotypes**	**Replications**	**Mean**	**Infection Classes**
TRNC 1	4 5 5	4.67	B
TRNC 2	7 7 7	7	C
TRNC 3	7 7 7	7	C
TRNC 4	5 5 5	5	B

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

Table 3 (Continued). Seedling stage reactions of 21 wild barley (*Hordeum spontaneum*) genotypes against *Cochliobolus sativus* leaf spot disease (continued)

Hordeum spontaneum genotypes	Replications	Mean	Infection Classes
TRNC 5	5 5 5	5	B
1	6 7 7	6.67	C
2	6 6 5	5.67	C
3	4 5 5	4.67	B
9	5 5 5	5	B
21	6 6 6	6	C
22	6 5 5	5.33	B
23	3 3 4	3.33	A
24	7 7 6	6.67	C
26	3 4 4	3.67	B
27	7 6 6	6.33	C
28	7 6 6	6.33	C
29	7 7 6	6.67	C
30	2 2 2	2	A

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

Table 3 (Continued). Seedling stage reactions of 21 wild barley (*Hordeum spontaneum*) genotypes against *Cochliobolus sativus* leaf spot disease (continued)

Hordeum spontaneum genotypes	Replications	Mean	Infection Classes
31	6 6 5	5.67	C
32	5 5 5	5	B
33	6 6 7	6.33	C
General Mean	**5.43** **5.48** **5.38**	**5.43**	**B**

(1-9 scale, Fetch and Steffenson, 1999; scale values; a: 1-3 low, b: 4-5 intermediate, c: 6-9 high)

4. Discussion

In different studies, the resistance status of barley genotypes and the virulence status of the isolates used were investigated. Aktaş and Tunalı (1994) investigated the leaf spot resistance status of barley genotypes against the S96 strain of *C. sativus*. The barley cultivars and lines used in this study showed very susceptible, susceptible, moderately susceptible, and moderately resistant reactions.

Jana and Bailey (1995) evaluated the responses of wild and cultivated barleys obtained from Türkiye and Jordan against three leaf pathogens, including *C. sativus*. They found that 4.5% of wild barleys and 0.3% of cultured barleys were resistant to *C. sativus*. Fetch et al. (2003) determined the reactions of a total of 116 *H. spontaneum* genotypes obtained from Israel and Jordan against 6 fungal pathogens, including leaf spot disease caused by *C. sativus*. As a result of their study, they found the resistance frequency against *Cochliobolus* leaf spot as 53% and 46% from Israel and Jordan genotypes. In our study, 5.56% of 36 barley cultivars, 11.43% of 35 barley lines, and 9.52% of 21 wild barley genotypes were found to be resistant (showing low infection response). Arabi and Jawhar (2004) investigated the infection responses of 10 barley genotypes against 12 *C. sativus* isolates obtained from different regions of Syria and determined that the reactions of the genotypes ranged from susceptible to moderately resistant. In this study, no genotype was immune to the disease Bonman et al. (2005) evaluated the resistance of barley genotypes obtained from the National Small Grains Collection (USA) against *Cochliobolus* leaf spot disease and found 3 of 48 genotypes to be resistant. Ghazvini and Tekauz (2007) evaluated 160 barley cultivars from Iran in order to determine their responses to head blight, leaf spot, and net blotch diseases. As a result of the study, no resistant barley cultivars were found against leaf spot and head blight. In our study, we found resistant cultivars, lines, and wild barley genotypes using a virulent strain of *C. sativus*.

Çelik Oğuz et al. (2016) determined the seedling reactions of 25 barley lines against 5 single spore isolates of *C. sativus*. Statistically significant differences ($P<0.01$) were observed among the isolates, and no barley line showed a low infection response. Two barley genotypes exhibited a moderate infection response to all 5 isolates. Six genotypes used in this current study showed low infection response against *C. sativus* isolate. Singh et al. (2017), under natural conditions, determined the responses of 342 barley genotypes to *Cochliobolus* leaf spot disease in their study and found 97 genotypes to be moderately resistant and one

genotype to be resistant. In our study, 8 of 92 barley cultivars, lines, and barley genotypes were resistant and 37 of them gave intermediate reactions.

Celik-Oguz and Karakaya (2017), under greenhouse conditions, determined the seedling stage responses of 39 barley cultivars widely grown in Türkiye against three isolates of *C. sativus*. As a result of the research, differences were observed in the responses of different barley cultivars to pathogen isolates, and Cs1 was the most virulent isolate. Avcı 2002 cultivar showed moderate infection response to Cs3 isolate and high infection response to Cs1 and Cs2isolates. Akar, Aydanhanım, Bolayır, Burakbey, Bülbül 89, Çetin 2000, İnce 04, Orza 96, Özdemir 05, Tarm 92, Yesevi 93, and Zeynelağa cultivars showed high infection response to all three isolates.In this current study, cultivars Akar, Bolayır, Orza 96, and Yesevi 93 showed moderate infection response against *C. sativus* isolatewhile Avcı 2002, Aydanhanım, Burakbey, Bülbül 89 Çetin 2000, İnce 04, Özdemir 05, Tarm 92 and Zeynelağa cultivars showed high infection response.

Balcı et al. (2018) evaluated the seedling stage infection responses of one hulless barley cultivar candidate, 2 hulless barley cultivars, and 19 hulless barley genotypes against two isolates of *C. sativus* under greenhouse conditions. Differences in virulence were detected between the isolates. Hulless barley cultivars Yalın and Özen showed moderate infection response to both isolates. A high infection response of cultivar Yalın was observed against *C. sativus* isolate used in this current study.

Çelik Oğuz et al. (2019) determined the seedling stage reactions of 28 six-row barley landraces, as well as Avcı 2002 and Bülbül 89 cultivars, against two *C. sativus* isolates. Avcı 2002 cultivar showed moderate infection response against Kastamonu isolate and low infection response against Hatay isolate; Bülbül 89 cultivar exhibited high and moderate infection responses against Kastamonu and Hatay isolates, respectively. In this current study, Avcı 2002 and Bülbül 89 cultivars showed a high infection response against the *C. sativus* isolate used.

5. Conclusions

Barley, which is one of the main field crops in Türkiye and the World, has an important place in terms of cultivation area and production amount. Breeding studies are important in order to obtain new cultivarsthat can tolerate diseases and pests well and have high adaptability.

Cochliobolus leaf spot disease in barley is an important disease that reduces yield and quality. In this study, barley lines and varieties and wild barley (*Hordeum spontaneum*) genotypes resistant to *Cochliobolus* leaf spot disease caused by *C. sativus* were determined. These resistant barley lines and varieties and wild barley genotypes are among the gene sources that can be used in breeding work. Further studies should be conducted on the resistance of barley against diseases and breeding studies should be carried out in order to develop disease-resistant varieties.

Author Contributions: Conceptualization, A. K.; methodology, A. K., A. Ç. O., N. E; validation, N. K., A. K.; formal analysis, N. K., A. K., A. Ç. O.; investigation, N. K., A. K., A. Ç. O. and N. E.; data curation, N. K., A. K., A. Ç. O., writing—original draft preparation, A. K.; writing—review and editing, A. K., N. K., A. Ç. O., N. E.; supervision, A. K.; All authors have read and agreed to the published version of the manuscript.

Acknowledgments: We would like to thank İsmail Sayim for providing *Hordeum spontaneum* genotypes from the Turkish Republic of Northern Cyprus and Işıl Saraç Sivrikaya for helping to obtain *Hordeum spontaneum* genotypes from Elazığ province of Türkiye.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 389-397 DOI:10.15316/SJAFS.2023.037 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Effects of Different Boron Doses on Germination, Seedling Growth and Relative Water Content of Linseed (*Linum usitatissimum* L.)

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HIGHLIGHTS

- In the study was to determine the effects of boron doses on linseed cultivars.
- Many parameters have been studied and the results are important.
- Boron applications decreased germination, seedling growth and relative water content.
- It was determined that 8 ml L^{-1} of the applied boron doses had a toxic effect.

Abstract

Boron is one of the most important nutrients required for the growth and development of plants. However, boron deficiency or excess also affects the physiological development of plants such as germination and seedling development. In this study, the effects of boron applications of 0-8 ml L^{-1} (4 concentrations) in 2 linseed cultivars [Beyaz Gelin (C1) and Sarı Dane (C2)] were investigated under laboratory conditions. In the study; germination percentage (GP), mean germination time (MGT), seeding length (SL), root length (RL), seedling fresh weight (SFW), seedling dry weight (SDW), root fresh weight (RFW), root dry weight (RDW) and relative water content (RWC) parameters were examined. As a result of the study, it has been determined that there are decreases in the properties of the cultivars in terms of the parameters examined with boron applications. It has been determined that especially 8 mg L^{-1} application has a toxic effect and prevents seedling and root development.

Keywords: boron, linseed, *linum usitatissimum* L., plant tolerance mechanism, RWC

1. Introduction

Plant nutrients are the elements that are absolutely necessary for the development of plants (Gezgin and Hamurcu 2006). Nutrient elements are divided into two as macro and micro elements according to the needs of plants, and macro nutrients are elements that are needed more than micro elements. Micronutrients are also called trace elements because plants need small amounts. Macro nutrient elements are carbon, hydrogen, oxygen, nitrogen, potassium, calcium, phosphorus, magnesium and sulfur, and micronutrients are iron, chlorine, copper, manganese, zinc, molybdenum, boron and nickel (Bolat and Kara 2017).

Citation: Culpan E, Gürsoy M (2023). Effects of Different Boron Doses on Germination, Seedling Growth and Relative Water Content of Linseed (*Linum usitatissimum* L.). *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 389-397. https://doi.org/10. 15316/SJAFS.2023.037
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Received date: 13/01/2023
Accepted date: 31/06/2023

Boron is a micro nutrient element that is absolutely essential for plants (Welch and Shuman 1995; Prathima et al. 2016; Beyaz et al. 2018). In addition, boron is one of the nutrients required in different amounts for the development of all plants (Demirtaş 2005). While different concentrations of boron are excessive for some plants, they may be below the desired amount for some plants (Yolci et al. 2022). Due to these different concentrations, boron deficiency or being in a toxic state occurs in plants and affects the activities of antioxidant enzymes in various ways. However, too much or too little boron element causes oxidative stress in plants (Hamurcu et al. 2015). In plants, boron deficiency causes decreased product quality and losses, while boron excess causes toxicity (Tassi et al. 2017). In addition, excess boron slows down growth and development in plants, causes deterioration of leaf morphology and transpiration, reduction of cell division in roots and ultimately oxidative stress (Karabal et al. 2003; Kacar and Katkat 2006). It has been reported by researchers that a sufficient level of boron element plays an important role in increasing the resistance against abiotic stresses under stress conditions.

Boron element in plants is involved in the cell membrane and wall, the activity of many enzymes, and the transport of metabolites, hormones and various ions produced as a result of biochemical processes (Dordas et al. 2000). At the same time, boron is a nutrient element that has a wide range of effects on the physiological development processes of plants (Ayvaz et al. 2016). Boron is used in agriculture to increase the development of vegetation (Demirtaş 2006). Seed treatment with boron helps in improving seed germination percentage, shoot and root length, early seedling vigor etc. helps in better early crop growth (Goldberg and Glaubig 1985). Besides this seed germination and seedling development are very important and critical stages in terms of crop production (Almansouri et al. 2001).

Linseed is a plant with varieties that can be grown for its fiber and oil (Hazneci and Arslanoğlu 2021). It is one of the oldest plants grown all over the world for flax fiber (Arslanoglu et al. 2022). In addition, linseed grown for oil production is rich in alpha-linoleic acid and rich in omega-3 fatty acids (Eseceli et al. 2006; Gogus and Smith 2010; Baydar and Erbaş 2014; Gürsoy 2019; 2022).

The aim of this study was to determine the effects of boron doses on germination, seedling growth and relative water content in linseed cultivars.

2. Materials and Methods

This research was carried out in Namık Kemal University Field Crops Department Laboratories. The experiment was arranged in completely randomized design with three replications. Seeds of linseed for surface sterilization, they were kept in 5% sodium hypochlorite solution for 10 minutes and then rinsed several times in distilled water then they were dried at room temperature to their initial weight. In the study, 2 linseed cultivars [Beyaz Gelin (C1) and Sarı Dane (C2)] obtained from the Trakya Agricultural Research Institute were used, and 4 doses of boron (0, 2, 4 and 8 mg L^{-1}) were applied and deionized water was used for the control treatment. Oil content and 1000 seed weight of the linseed cultivars are between 27.8-30.6% and 5.7-6.6 g, respectively. In addition, the seed color of Beyaz Gelin cultivar are brown, the seed color of Sarı Dane cultivar is yellow. Boron is obtained from water-soluble 8% w/w Boron Ethanolamine (Boron-8, Gubretas). For each boron dose, 20 seeds were placed in sterile petri dishes on Whatman No: 1 blotting papers and 5 mL of different doses of boron concentrations were added on March 14, 2023. Only deionized (DI) water was added to the control petri dish. Filter papers were changed every 2 days and 5 mL of boron containing solutions were added. Petri dishes are wrapped with parafilm and kept at room temperature (24 ± 2 °C). Seeds were counted daily and those with a root length of 2 mm were considered germinated (ISTA 2003). In the study; germination percentage (GP), mean germination time (MGT), seedling length (SL), root length (RL), seedling fresh weight (SFW), seedling dry weight (SDW), root fresh weight (RFW), root dry weight (RDW) and relative water content (RWC) parameters were examined.

Measurements

Germination Percentage (%)

Given formula was applied to calculate germination percentage.

Germination % = (number of germinated seeds / total number of seeds) × 100 (Siddiqi et al. 2007)

Mean Germination Time (day)

MGT= Σ(Dn)/Σn

where, n is the seed number germinated on day (D), and D is the number of days from the beginning of the germination test (Orchard 1977).

Seedling Length (cm)

The seedlings and roots of the plants in each petri dish were separated from each other 10 days after germination and determined by weighing the seedling part on a precision scale.

Root Length (cm)

It was determined by weighing the roots of the plants whose seedling and root parts were separated.

Seedling and Root Fresh Weight (g)

It was determined by weighing the seedlings and roots of control and boron-treated plants on sensitive scales.

Seedling and Root Dry Weight (g)

Seedling and root dry weights were recorded after oven drying for 48 h at 55 ^{o}C (Ateş and Tekeli 2007).

Relative Water Content (%)

Leaf samples taken from the plants in the control and stress groups were weighed and their fresh weights were determined, and placed in glass tubes containing 5 mL of deionized water and left in the light for 24 hours. At the end of this period, the hydrated leaf samples were weighed again and their turgor weights were determined, and then these leaf samples were dried in an oven at 80 ^{o}C for 48 hours and their dry weights were determined again. Finally, the relative water contents were calculated according to the following formula (Ritchie et al. 1990).

RWC (%) = (FW − DW) / (TW − DW) × 100

FW: fresh weight, TW: turgor weight, DW: dry weight

Results was analyzed using TARIST and MSTAT-C (MSTAT 1989) statistical software for analysis of variance. Least Significant Difference (LSD) test was used to compare the means of the obtained results in this research (p<0.05).

3. Results and Discussion

The variance analysis results of this study, which was conducted to determine the effects of boron doses on the germination parameters, seedling and root growth, relative water content of linseed cultivars is given in Table 1. When Table 1 is examined, it is seen that the doses in the GP, MGT, RFW and RWC parameters, the doses and cultivars in the SL, RL, SFW, SDW parameters, and the cultivars in the RDW feature made a statistically significant difference by 5%. SL, RL, SFW, SDW, RFW, RDW and RWC parameters were not included in the statistical calculation and 0 was accepted as there was not sufficient germination and seedling growth in both cultivars at the 4th dose of boron applications.

Table 1. Average values the effect of boron at different concentrations applied to linseed cultivars

Parameters	Cultivars	Doses				Means
		0 mg L^{-1}	2mg L^{-1}	4 mg L^{-1}	8 mg L^{-1}	
GP (%)	C1	98,33	68,33	28,33	8,33	50,83
	C2	96,67	61,67	16,67	8,33	45,83
	Means	97,50 **a**	65,00 **b**	22,50 **c**	8,33 **d**	
	$LSD_{0,05}$:	Dose: 4,973				
MGT (day)	C1	2,63	4,83	6,73	8,00	5,55
	C2	2,77	5,27	7,00	7,33	5,59
	Means	2,70 **d**	5,05 **c**	6,87 **b**	7,67 **a**	
	$LSD_{0,05}$:	Dose: 0,623				
SL (cm)	C1	5,13	5,03	3,20	0	4,45 **a**
	C2	4,27	4,03	2,60	0	3,63 **b**
	Means	4,70 **a**	4,53 **a**	2,90 **b**	0 **c**	
	$LSD_{0,05}$:	Cultivar: 0,619	Dose: 0,443			
RL (cm)	C1	8,40	7,20	5,03	0	6,88 **a**
	C2	5,20	5,30	2,93	0	4,48 **b**
	Means	6,80 **a**	6,25 **a**	3,98 **b**	0 **c**	
	$LSD_{0,05}$:	Cultivar: 0,562	Dose: 1,008			
SFW (g)	C1	0,047	0,042	0,038	0	0,042 **a**
	C2	0,033	0,027	0,026	0	0,029 **b**
	Means	0,040 **a**	0,034 **b**	0,032 **c**	0 **d**	
	$LSD_{0,05}$:	Cultivar: 0,003	Dose: 0,002			
SDW (g)	C1	0,022	0,019	0,016	0	0,019 **a**
	C2	0,016	0,012	0,011	0	0,013 **b**
	Means	0,019 **a**	0,016 **b**	0,013 **b**	0 **c**	
	$LSD_{0,05}$:	Cultivar: 0,002	Dose: 0,003			
RFW (g)	C1	0,018	0,014	0,010	0	0,014
	C2	0,013	0,012	0,012	0	0,012
	Means	0,015 **a**	0,013 **ab**	0,011 **b**	0 **c**	
	$LSD_{0,05}$:	Cultivar: 0,002				
RDW (g)	C1	0,007	0,006	0,006	0	0,006 **a**
	C2	0,003	0,004	0,002	0	0,003 **b**
	Means	0,005	0,005	0,004	0	
	$LSD_{0,05}$:	Cultivar: 0,001				
RWC (%)	C1	68,50	63,97	60,13	0	64,20
	C2	67,67	63,67	60,67	0	64,00
	Means	68,08 **a**	63,82 **b**	60,40 **c**	0 **d**	
	$LSD_{0,05}$:	Dose: 1,230				

*: Dissimilar letters in the column show different group

When Table 1 is examined, it was determined that the most germination in the GP feature was determined in the control application, and it was determined that the germination decreased as the application doses increased. It is observed that this decrease occurred at the rate of 90 and 88% in C1 and C2 cultivars, respectively. However, it was determined that the highest decrease was in the 3rd dose. Taban and Erdal (2000) reported that durum wheat cultivars were more affected by boron than bread cultivars in wheat cultivars to which boron was applied. Ashagre et al. (2014) reported that in safflower a significant decrease was observed on germination percentage as boron concentrations increased beyond 2 mg l^{-1} concentration. Gökkaya and Arslan (2023) reported that low dose boron applications caused an increase in germination and seedling growth parameters in their study where they applied boron to the seeds of sorghum plant under drought stress conditions.

In Table 1, which includes the averages of the MGT parameter, is examined, the highest average germination time was determined 4. dose. The lowest MGT was obtained from control application. It was determined that MGT decreased of boron applications, however, it was observed that MGT increased with increasing boron doses. Culpan et al. (2019) reported that as boron doses increased, the number of germination days increased as well, in their study where they applied boron doses to safflower cultivars. Gökkaya and Arslan (2023), in their study in which they applied boron to sorghum seeds under drought conditions, reported that MGT (3.66, 3.62, 3.67, 3.85 days) with increasing boron doses (0, 5, 10, 15 mM) increased in general even though it decreased slightly at the 5 mM dose.

When Table 1 was examined in terms of SL, it was determined that the seedling length was shortened with increasing boron doses, and the seedling height could not be measured at the 4th dose. However, after the second dose, the shortening of the seedling appeared more clearly. Culpan et al. (2019) used doses of (0, 0.5, 1, 1.5 mg L^{-1}) in their study where they applied boron doses to safflower cultivars. They reported that the seedling length was determined as (4.13, 4.25, 3.49, 4.80 cm), respectively. The results of the researchers differ from the results obtained in this study. The reason for this is the diversity of species, lower doses applied, etc. considered to be due to reasons such as Donbaloğlu Bozca and Leblebici (2022) applied boron to sunflower plant under heat stress conditions. As a result of the study, boric acid and heat stress increased the negative effect seedling length, while, a positive effect of boric acid application at low temperature on the seedling length of the plant. They reported that boron application at low temperature caused the seedling length to grow.

When Table 1 was examined in terms of RL, it was determined that RL decreased as the boron doses increased in the C1 cultivar, and in C2, although it increased a little in the 2nd dose compared to the control, it decreased again in the 3rd dose. In the 4th dose of boron application, there was no root development and root length could not be determined. With these results, it was determined that the root length shortened as the doses of boron applications increased. C2 cultivar was more affected by boron applications and root length was shorter than C1 cultivar. Akçam-Oluk and Demiray (2004) reported that root length increased in excess of boron in their study in which they applied boron in sunflower cultivar. Eroğlu and Topal (2022) reported that increasing concentrations of solutions negatively affect the stem and root length values and fresh-dry weight of plants as a result of a study in which they grew barley using solutions prepared from wastes with high boron content, and this negative effect is more pronounced when waste with higher boron content is used.

As seen in Table 1, SFW decreased as boron doses increased in both cultivars. However, it was determined that this effect was higher in C2 cultivar than in C1. However, it is seen that there is no plant growth and SFW cannot be determined at the 4th dose of boron applications. It is thought that the decrease in SFW is due to the fact that B doses reach toxic levels and accordingly plant growth is negatively affected. Similar reduction in shoot fresh weight with the increasing level of B was also observed in tomato and pepper (Eraslan et al. 2007). Seferoğlu and Kaptan (2020) reported that the fresh and dry weights and % dry matter values of barley and wheat plants grown with irrigation water containing different levels of boron decreased compared to the control as the boron concentration increased, and they determined the lowest at the highest dose (5 mg L^{-1}).

In terms of SDW (Table 1), there is a situation similar to SFW. It was determined that SDW decreased as boron doses increased, it could not be determined at all in the 4th application dose, and C2 cultivar was affected more than C1 by this decrease. This situation emerged as a decrease in SDW in parallel with the decrease in SFW with the increase of boron doses. Arslan et al. (2022) investigated the effects of salt pre-treatments on boron toxicity in safflower cultivars. The fresh and dry weight of shoot (14-53% and 34-61%, respectively) decreased at 4 mM and higher B treatments. It is thought that this decrease is due to the toxic effect that occurs with the increase in boron applications.

When Table 1 is examined in terms of RFW, it is seen that RFW decreases as the boron doses increase compared to the control, and it cannot be determined at all at the highest boron dose of 8 mg L^{-1}. Therefore, root development did not occur in the plant after a certain dose of boron. Muhammad et al. (2013) reported that root fresh and dry weight of maize plant decreased with increasing boron doses. Similarly, Turan et al. (2009) reported that root fresh and dry weights wheat decreased with the increase in concentrations of boron. Culpan et al. (2019) applied boron doses to safflower cultivars and similarly reported that RFW decreased as boron doses increased. In the study of Donbaloğlu Bozca and Leblebici (2022) in which they applied boron to sunflower plant under temperature stress conditions, it was determined that high temperature significantly reduced root biomass.

In terms of RDW (Table 1), although there was a decrease in C1 cultivar compared to the control, boron doses were determined to be the same in the 2nd and 3rd application doses (2 and 4 mg L^{-1}), and RDW could not be determined in 8 mg L^{-1} application in both cultivars. In the C2 cultivar, although there was a slight increase in the 2 mg L^{-1} dose compared to the control, it was determined that RDW decreased again at the 4 mg L^{-1} dose. A negative impact of high B was explained as the result of prevented plant growth, which might be because of the toxic effects on root cell division (Çelik et al. 2019). Culpan et al. (2019) and Arslan et al. (2022) reported that RDW decreased with increasing boron doses in their study on safflower.

When Table 1 was examined in terms of RWC, it was determined that the relative water content of plants decreased with increasing boron doses compared to the control. However, similar results were obtained in both cultivars. It is seen that the cultivars are affected by boron doses at almost the same level in terms of RWC. Arslan et al. (2022) reported that RWC decreased with the applied boron doses in their study where they performed salt pre-application in safflower cultivars.

4. Conclusions

In this study, the effects of different doses of boron applications on linseed cultivars seeds were determined. As a result of the study, it was determined that boron applications had negative effects on the germination parameters, early seedling growth, relative water content of linseed. It was determined that with the increase of boron dose, seedling and root development did not occur in both cultivars. In terms of other parameters examined, it was determined that the properties of the cultivars decreased with increasing boron doses. Besides, applications should be made in other plants and their results should be evaluated.

Author Contributions: Conceptualization, E.C. and M.G.; methodology, E.C. and M.G.; software, E.C.; validation, E.C. and M.G.; formal analysis, E.C.; investigation, M.G.; resources, M.G.; data curation, E.C. and M.G.; writing-original draft preparation, M.G.; writing-review and editing, E.C. and M.G. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 398-408 DOI:10.15316/SJAFS.2023.038 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Determination of Yield and Quality Characteristics of Sunflower Genotypes Newly Developed

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HIGHLIGHTS

- Sunflower is the most important oil plant for Türkiye.
- Improving sunflowers is an agricultural study and development process to enhance the genetic characteristics of the sunflower plant and to develop new varieties with desired characteristics.

Abstract

This research was conducted to determine the yield and quality characteristics of oil sunflower genotypes as candidates for registration under Konya and Karaman conditions, in four replications according to the "Random Blocks Trial Design". The differences between the cultivars used in both locations of the study in terms of the number of days to bloom, the number of days to physiological maturity, plant height, the diameter of the head, the thousand seed weight, seed moisture, seed yield, oil rate, and oil yield were found to be statistically significant. The number of flowering days of the genotypes was found to be 65.6-60.6 days (H194; P63MM54), the number of days to physiological maturity was 116.9-109.0 days (Tunca; P63MM54), plant height 172.0-143.3 cm (Tunca; H249), head diameter 18.8-15.9 cm (H250; P63MM64), thousand-seed weight 43.4-54.2 g (H250; Gibraltar), hectoliter weight 32.3-30.3 kg (P63MM54; H194), seed moisture 7.1-8.4 % (H250; P63MM54, Gibraltar), seed yield 4.37-3.82 t ha^{-1} (H194; H249), oil rate 47.8-42.9 % (H250; H55), and oil yield 2.04-1.64 t ha^{-1} (H250; H249). According to the averages of the locations, it can be argued that the H194, H250, H55, and H5 hybrids that have high seed and oil yield can be successfully grown in regional conditions.

Keywords: Sunflower breeding; yield; hybrid

1. Introduction

Sunflower (*Helianthus annuus*) is a plant species of the daisy family (*Asteraceae*) that originates from America. Sunflower is commonly known for its oilseeds and large yellow flowers and is an important agricultural crop on a global scale. Sunflower seeds are grown for various purposes, such as producing sunflower oil, consuming it as a snack, and using bird feed.

There has been a recent increase in vegetable oil consumption in our country. However, when the climate and soil characteristics of our country are evaluated, it is seen that although we have great potential for the production of oil plants, we cannot produce enough to meet our oil needs. We cover our vegetable oil deficit from imports. However, except for coconut and palm oil plants, other important oil plants such as sunflower,

Citation: Ada R (2023). Determination of Yield and Quality Characteristics of Sunflower Genotypes Newly Developed. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 398-408. https://doi.org/10. 15316/SJAFS.2023.038

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Received date: 26/01/2023

Accepted date: 04/07/2023

soybean, cottonseed, peanut, poppy, safflower, rapeseed, sesame, flax, and hemp can be grown easily in our country. Sunflower meets approximately 70% of our country's vegetable oil consumption among the oil crops and ranks first in this ratio (Top and Ilkay 2012).

Approximately 80-90% of the oil production need of the world is covered by plant-based sources (Arıoğlu 2007). The production of oil plants is cotton, sunflower, and soybean in our country. Sunflower alone covers 49% of our vegetable oil production (Durmaz 2012). As well as being the raw material of the vegetable oil sector, oil plants are also the raw material of many different sectors. Oilseed meal is used in animal nutrition because it has high protein content (Ilkdogan 2008). Vegetable-derived oils are also used extensively in the energy, chemistry, and food sectors (Top and Ilkay 2012).

Improving sunflowers is an agricultural study and development process to enhance the genetic characteristics of the sunflower plant and to develop new varieties with desired characteristics. Such studies are generally conducted by selecting plant populations with superior characteristics, crossing them, using the plants obtained as a result of the cross, and identifying plants with the desired characteristics.

Studies conducted to improve sunflowers are also conducted to enhance the sunflower plants' genetic structure and develop the desired characteristics. Sunflower cultivation is important because it has many economic and agricultural benefits. Among the objectives of sunflower cultivation, is the development of high-yielding, high oil content, and better-quality sunflower varieties that are more resistant to diseases and pests. Newly developed cultivar candidates must be tested for environmental compatibility, quality, and safety. The present study determined the yield and some agricultural characteristics of the candidate oil sunflower cultivars in different locations.

2. Materials and Methods

The present study was conducted in two separate trials in Konya-Altinekin and Karaman in 2022. Commercial hybrid sunflower varieties (P63MM54, Gibraltar and Tunca), and the H194, H249, H250, H253,H5 and H55 hybrids developed by Assoc. Prof. Rahim ADA in Selcuk University Faculty of Agriculture was used in the study. The study was conducted in four replications according to the "Randomized Blocks Trial Design" at each location (Düzgüneş et al. 1987).

The trial fields, where the front crop was wheat, were ploughed deeply with a socket in the autumn following the preliminary crop harvest and left for the winter. The disc harrow and the field were raked several times and made ready for planting before planting in the spring.

The study plots were 2.8 mx 7.5 m = 21.0 m^2 and each plot was arranged in a way that there were 70 cm in 4 rows in the row spacing and 120 kg ha^{-1} and 80 kg ha^{-1} P_2O_5 were applied to all trial plots, all together with sowing.

3. Results and Discussion

3.1. Number of 50% Flowering Days

The difference between the locations where the study was conducted and the varieties was found to be statistically significant at the level of 1% in terms of 50% flowering days of sunflower cultivars and the location x variety interaction was found to be statistically insignificant (Table 1).

Average values for 50% flowering days of sunflower varieties are given in Table 2. As seen in Table 2, 50% flowering days of the cultivars varied between 60.6 and 65.6 days according to the averages of the two locations. The 50% flowering days of the longest cultivars were determined in H194 and the 50% flowering days of the shortest cultivars were determined in P63MM54. When the locations of the varieties were

compared in terms of 50% flowering day durations, it was seen that there were different results, which shows that although 50% of flowering days was a cultivar characteristic, it was also associated with environmental changes because of differences in climate and soil conditions among years.

3.2. Physiological Maturity Days

Regarding physiological maturity days, the difference between the cultivars in which the study was conducted was found to be statistically significant at the 1% level and the locations and location x cultivar interaction were found to be statistically insignificant (Table 1).

As seen in Table 2, the physiological maturity durations of the cultivars varied between 109.0 and 116.9 days, according to the averages of the two locations. The physiological maturity days of the longest cultivars were determined in Tunca, and the physiological maturity days of the shortest cultivars were determined in the P63MM54 cultivar. It was also found that the cultivars did not produce different results when compared in terms of physiological maturity durations in locations, which shows that physiological maturity durations have a variety of characteristics.

3.3. Plant Height

As understood in Table 1, the difference between the locations where the study was conducted in terms of plant height values, the difference between the varieties, and the location x variety interaction were found to be statistically significant at the 1% level.

According to Table 2, the average plant height was found to be a maximum of 156.7 cm in Karaman and it was found to be 145.9 cm in Altınekin. The plant heights of the genotypes used in the study differed according to the locations. The highest average plant height was found in the Tunca variety with 173.0 cm in Karaman, and the lowest in H194 genotype in Altınekin with 120.0 cm (Table 2). These results show that plant height is also associated with environmental changes because of different climate and soil conditions over the years (Önder et al. 2001).

As the average of the locations, the highest plant height was measured in the Tunca variety with 172.6 cm, which was followed by plant heights of H253 (160.6 cm), H55 (151.3 cm), Gibraltar (148.9 cm), H250 (147.6 cm), H5 (146.5 cm), P63MM54 (145.0 cm) and H194 (145.9) genotypes, respectively. The lowest plant height at 143.3 cm in the H249 genotype (Table 2). Genetic structure is among the most defining factors in plant height (Önder et al. 2001; Akkaya 2006; Ceyhan et al. 2008; Öztürk et al. 2008; Day 2011; Tan 2014). It was reported in many previous studies that the grading status of sunflower varieties was different (Önder et al. 2001; Ceyhan et al. 2008; Gholinezhad et al. 2009; Tan 2014; Yılmaz and Kınay 2015). Önder et al. (2001) reported that plant heights varied between 96.8 cm and 110.5 cm in sunflower varieties in their study conducted on plant heights. Day (2011) reported that plant height was between 144.2 cm and 145.6 cm in sunflowers. On the other hand, Katar et al. (2012) reported in their study that plant heights varied between 101.77 cm and 127.53 cm. Yılmaz and Kınay (2015) reported that the plant height varied between 123 cm and 153 cm in sunflowers.

3.4. Head diameter

As understood in Table 1, the difference between the locations where the study was conducted in terms of tray diameter values was found to be statistically insignificant. In contrast, the difference between the cultivars and the cultivar x year interaction was statistically significant. Önder et al. (2001) and Ceyhan et al. (2008) reported that the diameter of the tray in sunflowers showed differences between cultivars.

In terms of the average of the varieties, the diameter of the tray was determined to be 17.3 cm in Altınekin and 17.8 cm in Karaman. The diameters of the trays in sunflowers generally vary in wide ranges such as 6 - 75 cm, and the size of the tray is affected by environmental factors, especially plant density, soil moisture, and productivity (Önder et al. 2001). The diameter of the head of the plant shows significant changes in sunflower

according to the genetic structure of the variety, ecological conditions, cultivation techniques, soil characteristics, and irrigation or not (Gürbüz et al. 2003; Arıoğlu 2007; Yılmaz and Kınay 2015).

In terms of the averages of the locations, the tray diameters of the cultivars varied between 15.9 (P63MM54) and 18.8 cm (H250). The H250 variety had the largest head diameter. The results of the studies conducted by Kıllı and Özdemir (2001), Önder et al. (2001), Mahar et al. (2007), Ceyhan et al. (2008), Day (2011), Ali et al. (2012) Tan (2014) and Yılmaz and Kınay (2015) regarding the head diameters agree with our study results.

3.5. Thousand Seed Weight

As seen in Table 1, the effects of locations and location x variety interaction on thousand-seed weight were statistically insignificant, and the difference between genotypes was statistically significant. In many studies, researchers reported that there were significant differences between varieties in terms of the thousand-seed weight of sunflower (Ceyhan et al. 2008; Öztürk et al. 2008; Ali et al. 2012; Tan 2014; Yılmaz and Kınay 2015).

Regarding the average of the cultivars used in the study, the highest thousand-seed weight was found to be 50.4 g in Karaman in 2017 (Table 2). It is already known that the thousand-seed weight, which is one of the most important agricultural characteristics that affect the seed yield in sunflowers, varies depending on the variety and growing conditions (Ilbaş et al. 1996).

Regarding the average of the two locations, the highest thousand-seed weight was obtained in the H250 genotype with 54.2 g, followed by Tunca (52.5 g) and H249 (52.3 g) genotypes, respectively. The lowest thousand-seed weight was found in the Gibraltar variety with 43.4 g (Table 2). The thousand-seed weights of sunflower varieties that are oily vary between 35-120 g, and those with thousand-seed weights that are higher than 120 g are known as snack foods (Atakış 1991; Turan and Göksoy 1998; Önder et al. 2001). The thousand-seed weight values obtained in this study were similar to the results reported in the studies conducted by Önder et al. (2001), Mahar et al. (2007), Ceyhan et al. (2008), Gholinezhad et al. (2009), Ali et al. (2012) on the same subject. On the other hand, the values obtained in the present study in thousand-seed weights were lower than the values reported by Öztürk et al. (2008), Katar et al. (2012), Tan (2014), Yılmaz and Kınay (2015), Çetin and Öztürk (2018), which may be because of the different materials used and environmental conditions.

3.6. Hectoliter

In terms of hectoliter values of sunflower cultivars, the locations where the study was conducted, the difference between cultivars and the location x cultivar interaction was found to be statistically insignificant (Table 1).

As seen in Table 2, hectoliters varied between 30.3 and 32.3 kg/hl according to the averages of the two locations. Although the highest hectoliter weight was determined in the H194 genotype, 50% of flowering days of the shortest genotypes were determined in P63MM54. When the locations of the cultivars were compared in terms of hectoliter weights, it was found that the values were close to each other in both locations.

3.7. Seed Moisture

In terms of seed moisture values of the sunflower cultivars, the locations where the study was conducted, the difference between cultivars and location x cultivar interaction was found to be statistically insignificant (Table 1).

As seen in Table 2, it was found that the seed moisture values of the two locations varied between 7.3 and 8.1% according to the averages. The highest seed moisture was detected in H250 and H253 genotypes, and the lowest seed moisture was found in Gibraltar and P63MM54 cultivars. When the locations of the varieties were compared in terms of seed moisture, it was found that the values were close to each other in both locations.

Table 1. Results of variance analysis in the experiment conducted in Konya-Altinekin and Karaman Locations

Source of Variation	df	Means square				
		Number of days to bloom	Number of days to physiological maturity	Plant height (cm)	Head diameter (cm)	Thousand-seed weight (g)
Location	1	84,50**	2,00	2080,13**	5,01	12,67
Replication [L]	6	5,84	1,78	19,72	1,72	9,07
Genotypes	8	22,15**	49,44**	718,06**	8,05**	94,02**
L x G	8	1,66	3,13	614,56**	6,73*	31,25
Error	48	1,76	2,60	15,32	2,38	24,93
Source of Variation	**df**	**Hectoliter weight**	**Seed moisture (%)**	**Seed yield (t ha^{-1})**	**Oil rate (%)**	**Oil yield (t ha^{-1})**
Location	1	1,18	2,26	780,13	0,03	1.15,27
Replication [L]	6	4,43	1,11	3596,59	5,28	1195,58
Genotypes	8	2,75	0,81	2581,41*	20,92**	1168,17**
L x G	8	3,47	0,62	168,25	2,68	93,75
Error	48	1,83	1,36	1178,56	2,96	302,35

[1] Tables may have a footer.

Table 2. Means of two locations for Number of days to bloom (day), Physiological maturity days (day), Plant height (cm), Head diameter (cm), Thousand seed weight (g), Hectoliter weight (kg) of 9 sunflower genotypes evaluated in Konya and Karaman Locations

	Number of days to bloom (day)			Number of days to physiological maturity (day)			Plant height (cm)		
Genotypes	**Altinekin**	**Karaman**	**Mean**	**Altinekin**	**Karaman**	**Mean**	**Altinekin**	**Karaman**	**Mean**
H194	65,0	66,3	65,6 A	117,0	114,8	115,9 A	120,0 I	171,8 A	145,9 DE
H249	62,3	63,8	63,0 BC	113,3	113,8	113,5 BC	145,0 FG	141,5 GH	143,3 E
H250	62,3	63,0	62,6 BC	113,3	113,8	113,5 BC	142,5 G	152,8 C-E	147,6 C-E
H253	63,0	65,0	64,0 AB	115,0	115,8	115,4 AB	160,3 B	161,0 B	160,6 B
H5	62,5	64,8	63,6 B	116,3	115,3	115,8 A	148,5 D-G	144,5 FG	146,5 C-E
H55	60,3	63,0	61,6 CD	110,5	112,3	111,4 C	144,3 FG	158,3 BC	151,3 C
P63MM54	59,0	62,3	60,6 D	108,3	109,8	109,0 D	134,3 H	155,8 B-D	145,0 DE
Tunca	63,8	67,3	65,5 A	116,8	117,0	116,9 A	172,3 A	173,0 A	172,6 A
Gibraltar	61,3	63,5	62,4 BC	112,8	113,8	113,3 BC	146,3 E-G	151,5 C-F	148,9 CD
Mean	62,1 B	64,3 A	63,2	113,7	114,0	113,8	145,9 B	156,7 A	151,3
		$Lsd_{genotype\ (0.01)} = 1,78$			$Lsd_{genotype\ (0.01)} = 2,16$			$Lsd_{genotype\ (0.01)} = 5,25$	
								$Lsd_{locationx\ genotype\ (0.01)} = 7,42$	
Genotypes	**Head diameter (cm)**			**Thousand-seed weight (g)**			**Hectoliter weight (kg)**		
H194	15,8 EF	19,8 A	17,8 A-C	46,8	50,8	48,8 A-C	30,3	30,2	30,3
H249	16,5 D-F	16,8 C-F	16,6 BC	51,5	53,1	52,3 AB	32,0	29,3	30,6
H250	19,0 AB	18,5 A-D	18,8 A	56,9	51,6	54,2 A	30,5	31,5	31,0
H253	17,8 A-E	18,8 A-C	18,3 AB	50,8	53,6	52,2 AB	31,1	31,0	31,0
H5	19,0 AB	17,3 B-E	18,1 AB	51,1	49,9	50,5 AB	31,6	30,6	31,1
H55	19,0 AB	17,0 B-F	18,0 AB	45,5	47,0	46,3 BC	29,9	31,9	30,9
P63MM54	15,0 F	16,8 C-F	15,9 C	46,1	54,1	50,1 AB	32,7	31,9	32,3
Tunca	17,5 B-E	18,5 A-D	18,0 AB	52,9	52,1	52,5 AB	31,5	31,6	31,6
Gibraltar	15,8 EF	16,8 C-F	16,3 BC	44,9	41,8	43,4 C	30,8	30,4	30,6
Mean	17,3	17,8	17,5	49,6	50,4	50,0	31,2	30,9	31,0
		$Lsd_{genotype\ (0.01)} = 2,07$			$Lsd_{genotype\ (0.01)} = 6,70$				
		$Lsd_{locationx\ genotype\ (0.05)} = 2,19$							

Table 3. Means of two locations Seed moisture (%), Seed yield (t ha^{-1}), Oil content (%), Oil yield (t ha^{-1}) of 9 sunflower genotypes evaluated in Konya and Karaman Locations

	Seed moisture (%)			Seed yield (t ha^{-1})		
Genotypes	**Altinekin**	**Karaman**	**Mean**	**Altinekin**	**Karaman**	**Mean**
H194	8,4	7,4	7,9	4,40	4,34	4,37 A
H249	7,9	8,1	8,0	3,85	3,78	3,82 B
H250	7,8	8,4	8,1	4,33	4,22	4,27 AB
H253	8,7	7,6	8,1	3,93	3,87	3,90B
H5	7,9	7,6	7,7	4,18	4,13	4,16AB
H55	7,8	7,5	7,7	4,25	4,15	4,20AB
P63MM54	7,5	7,1	7,3	4,10	4,24	4,17 AB
Tunca	8,3	7,7	8,0	4,01	3,94	3,98AB
Gibraltar	7,5	7,1	7,3	4,26	4,04	4,15AB
Mean	8,0	7,6	7,8	415,0	4,08	4.11
					Lsd $_{genotype\ (0.05)}$ = 4.6	

Genotypes	**Oil rate (%)**			**Oil yield (t ha^{-1})**		
H194	44,4	45,8	45,1 BC	1,95	1,99	1,97 AB
H249	41,9	44,0	43,0 C	1,61	1,67	1,64 D
H250	47,8	47,9	47,8 A	2,07	2,02	2,04 A
H253	46,1	45,3	45,7 AB	1,81	1,75	1,78 B-D
H5	44,9	45,4	45,2 BC	1,88	1,88	1,88 A-C
H55	43,2	42,5	42,9 C	1,83	1,76	1,79 B-D
P63MM54	43,5	43,0	43,2 C	1,78	1,82	1,80 B-D
Tunca	43,8	43,6	43,7 BC	1,75	1,72	1,73 CD
Gibraltar	44,7	43,1	43,9 BC	1,90	1,74	1,82 A-D
Mean	44,5	44,5	44,5	184,6	1,82	1,83
		Lsd $_{genotype\ (0.01)}$ = 2,31			Lsd $_{genotype\ (0.01)}$ = 2,3	

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3.8. Seed Yield

Although locations and location x genotype interaction were statistically insignificant regarding seed yield in sunflower cultivars, the differences between cultivars were statistically significant at the 5% level (Table 1). Similar to our study results, Önder et al. (2001), Ceyhan et al. (2008), Öztürk et al. (2008), Katar et al. (2012), Tan (2014), Yilmaz and Kinay (2015) and Çetin and Öztürk (2018) reported that there were significant differences between sunflower varieties in terms of seed yield.

The average values for the seed yield per decare of the genotypes employed in the study and the resulting groups are given in Table 3. It can be seen in Table 3 that there were no significant differences between the seed yields of the cultivars at each location. As the average of all varieties, it was found that the seed yield, which was 4.08 kg /da in Karaman, increased to 4.15 kg/da in Altınekin. Seed yields per decare of the cultivars in Altınekin varied between 3.85 (H249) – 4.40 kg (H194), and in Karaman 3.78 (H249) – 4.37 kg (H194). Although the highest seed yield was obtained in H194 genotype in both locations, the lowest seed yield was obtained in the H249 genotype. In the study, the highest seed yield per decare was determined in the H194 variety planted in Altınekin with 4.40 kg, and the lowest value was determined in the H249 variety planted in Karaman with 3.78 kg. Many characteristics create seed yield in sunflowers, as in all other plants, and many factors (e.g., ecological conditions, morphological, physiological, and agricultural characteristics) besides the genetic structure of the plant affect the yield (Bange et al. 1997; Çetin and Öztürk 2018). In other words, yield in sunflowers may differ depending on genetic structure, environment, and cultivation techniques as in other plants.

According to the average values of the locations, the highest seed yield was detected in the H250 genotype with 427.9 kg/da and the lowest in the H249 genotype with 382.3 kg/da (Table 3). Seed yields of other genotypes were followed by H250 (4.27 kg/da), H55 (4.20 kg/da), H5 (4.16 kg/da), P63MM54 (4.17 kg/da), Gibraltar (4.15 kg/da), Tunca (3.98 kg/da) and H253 (3.90 kg/da) seed yields, respectively (Table 2). Different seed yields were obtained in the studies conducted by many researchers in different varieties and regions with different ecologies. Seed yield values (3.30 – 4.25 kg/da) that were detected in the varieties included in this study were in line with those reported by Ceyhan et al. (2008), Ali et al. (2012), Yilmaz and Kinay (2015) and Çetin and Öztürk (2018). On the other hand, the seed yields that were obtained in this trial were higher than the seed yields obtained by Gözütok and Gül (1986), Önder et al. (2001), Jahangir et al. (2006), Beg et al. (2007), Mahar et al. (2007), Öztürk et al. (2008), Day (2011), Katar et al. (2012) and Pekcan and Ensendal (2015). The genetic structure of the cultivars, environment, and cultivation techniques can explain these differences in seed yield.

3.9. Oil ratio

Although locations and location x genotype interaction were statistically insignificant in terms of oil ratios in sunflower cultivars that were used in the trial, the differences between cultivars were statistically significant at the level of 1% (Table 1). Önder et al. (2001), Ceyhan et al. (2008), Öztürk et al. (2008), Yilmaz and Kinay (2015) and Çetin and Öztürk (2018), who investigated the same subject, reported that there were differences between cultivars in terms of oil contents.

The average oil content of the cultivars was 44.5% in both locations. The highest fat ratio was determined in the H250 genotype in Karaman of the trial at 47.9%, and the lowest oil rate was determined in the H249 genotype in Altınekin at 41.9%. As an average of the locations where the study was conducted, the highest fat ratio was obtained from the H250 genotype with 47.8%, followed by the H253 (45.7%), H5 (45.2%), H194 (45.1%), Gibraltar (45.9%), Tunca (43.7%), P6MM54 (53.2%), and H249 (43.0%) genotypes. The lowest value was detected in the H55 genotype with 42.9%. The high oil content occurs primarily because of the variety in sunflowers, but it can also vary with the effect of cultivation technique and ecological factors. Our study results

are similar to the results reported by Önder et al. (2001), Ceyhan et al. (2008), Öztürk et al. (2008), Katar et al. (2012), Tan (2014), Yilmaz and Kinay (2015) and Çetin and Öztürk (2018).

3.10. Oil Yield

As seen in Table 1, although the locations where the study was conducted and the location x genotype interaction were statistically insignificant in terms of oil yield, the differences between the genotypes were statistically significant.

Although the average oil yield of the cultivars used in the study was found to be 1.82 kg/da in Karaman, this was found to be 1.84 kg/da in Altınekin. The H250 genotype that was planted in Altınekin had the highest oil yield with 2.07 kg/da, and the H249 variety that was planted in Altınekin had the lowest oil yield with 1.61 kg/da. As the average of the locations where the study was conducted, the highest oil yield was obtained in the H250 genotype with 2.04 kg/da, and the lowest value was detected in the H249 genotype with 1.64 kg/da. The oil yields of other genotypes were among these values (Table 5). The most economically important yield criterion in all oil crops is oil yield. According to Ilisulu (1970), oil yields of varieties should be calculated in studies because the seed yield of a variety with low oil content in its seeds can be high and as a result, more oil can be obtained per unit area. The high oil yield in H250, H194, and H5 cultivars, depending on the oil content and seed yield, respectively, occurred because of the high oil content of the cultivars (Table 3). The oil yield of the sunflower plant varies according to the oil content of the variety and the seed yield. The varieties with high oil contents and seed yields in sunflowers must be included in the production (Tan 2014). Many researchers who previously conducted studies on this subject reported that they found results similar to ours in their studies (Ceyhan et al. 2008; Öztürk et al. 2008; Tan 2014; Yılmaz and Kınay 2015; Çetin and Öztürk, 2018).

4. Conclusions

As a result of the present study, it was determined that the H194, H250, H55, and H5 genotypes, which are in the first place among the genotypes considered candidates for registration in this study, had the highest seed yield and some agricultural characteristics. According to the test results, it was concluded that applying for registration of H194, H250, H55, and H5 genotypes is appropriate.

Author Contributions: The authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The author declares no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37 (2), 409-418 DOI:10.15316/SJAFS.2023.039 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Determination of Yield and Quality Characteristics of *Tribenuron Methyl* Group Sunflower Genotypes Newly Developed

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HIGHLIGHTS

- Sunflower is the most important oil plant for Türkiye.
- Improving sunflowers is an agricultural study and development process to enhance the genetic characteristics of the sunflower plant and to develop new varieties with desired characteristics.

Abstract

The present study was conducted to determine the yield and quality characteristics of oil sunflower genotypes as candidates for registration under Konya and Karaman conditions, in 4 replications according to the "Random Blocks Trial Design". The differences between the cultivars used in both locations of the study in terms of the number of days to bloom, the number of days to physiological maturity, the diameter of the tray, the thousand seed weight, seed moisture, seed yield, oil content, and oil yield were found to be statistically significant. The number of flowering days of the genotypes was found to be 64.5-60.8 days (H412; P63LLE113), the number of days to physiological maturity was 113.9-110.3 days (H412; P63LLE113), plant height 169.0-164.6 cm (M94S35; P63LE113), head diameter 20.9-17.3 cm (H412; P63LLE113), thousand-seed weight 60.3-47.4 g (H408; P64LE119), seed moisture 7.8-5.9 % (H408; P63LE113), seed yield 43.6-43.2 t ha^{-1} (H412; P64LE119), oil content 44.2-41.8 (H412; M94S35), and oil yield 19.2-17.0 t ha^{-1} (H412; P63LE113). The study showed that high yields could be achieved by using newly-developed hybrid sunflower genotypes in the conditions in the region. According to the averages of the location, it can be argued that the H412 hybrid that has high seed and oil yield can be successfully grown in regional conditions.

Keywords: Sunflower; breeding; yield; hybrid

1. Introduction

The consumption of foodstuffs, and for this reason, vegetable oil consumption is increasing with the increasing world population. Vegetable oils have become the raw material of the energy sector in recent years because they have been used extensively in biodiesel production in some countries other than the food sector. In this way, vegetable oils are considered a strategic product used extensively in the food, energy, and chemistry sectors. The main problem of the Turkish vegetable oil industry is not the vegetable oil production, but the 60-70% foreign-dependent sector of raw material supply. Although it changes according to years, oilseed plants and their derivatives are the only agricultural product group included in the top 10 in Turkey's import items (Anonymous 2021). Oilseed plants cultivated in Turkey are sunflowers, cottonseed, soybean,

Citation: Ada R (2023). Determination of yield and quality characteristics of *Tribenuron methyl* group sunflower genotypes newly developed. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 409-418. https://doi.org/10. 15316/SJAFS.2023.039
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Received date: 27/01/2023
Accepted date: 04/07/2023

peanut, poppy, sesame, rapeseed, and safflower. Among these plants, sunflower is an important oil plant in terms of vegetable crude oil production, which can be grown in many regions of our country because of its high adaptability, and contains a high percentage of seeds (22-55%) and quality oil [69% unsaturated fat (Linoleic acid 50-65%, Oleic acid 25-35%)]. It takes the first place among the oilseed plants produced in our country because of its characteristics such as being resistant to drought and low temperatures, and adapting to several soil types and very different environments, (Arıoğlu et al. 2010).

According to the 2022 data from the Turkish Statistical Institute (TUIK), the oil sunflower cultivation area was 900.517 hectares, the production was 2.350.000 tons and the average yield was 2.610 t ha^{-1}.

It is essential to prevent the decrease in yield and quality and the most important factors in this decrease are diseases, pests, and weeds. In this context, the chemical control method is among the most preferred control methods in the fight against diseases and pests as a problem in plant production. One of the most important agricultural struggles against diseases, pests, and weeds is chemical control in our country (Yücel 2011). In terms of chemical applications, the response of today's sunflower cultivars to herbicides applied to the soil has varied widely. The sensitivity and tolerance levels of the sunflower plant can change with several molecular studies, and the tolerance levels can also vary according to the growth periods, the herbicide dose, and environmental conditions such as temperature and relative humidity (Gillespie and Miller 1983).

Hybrid seeds are employed in sunflower production in Turkey, and producers prefer hybrid varieties are preferred by producers because of their high yield performance, superior quality characteristics, homogeneous appearance, and resistance to some diseases and Orobanche. For this reason, cultivation programs in our country and the world are generally aimed at the hybrid cultivation of sunflowers (Kaya et al. 2009).

Also, increasing crop yields necessitates the development of novel, more productive genotypes, and the advancement of growing technology. Plant cultivation for tolerance to herbicides covers both these aspects. Although it is possible to develop plants tolerant to any herbicide theoretically, a real commercial application has been made only for combinations of economically important plants and herbicides with favorable properties (glyphosate, glufosinate ammonium, sulfonylurea, imidazolinones, etc.) (Malidža et. al. 1999).

The early stages of plant cultivation for herbicide resistance did not involve any study on the sunflower plant. Plant species for which herbicide-tolerant genotypes were developed started to be grown more widely with their improved production and high economic returns, and as a result, sunflower production decreased in South and North America, where new technologies were accepted without any legal restrictions. The herbicides used in sunflowers are less developed than the rest of the field crop species produced. Because of the studies conducted on broad-leaved weeds and the lack of post-emergence herbicides, weeds caused large yield losses in sunflowers. Although the present chemical precautions are ineffective against large-seeded broad-leaved weeds, existing soil herbicides are generally not adequately effective in suppressing small-seeded weed species, especially in years when rainfall is scarce after herbicide application (Malidža et al. 2004). On the other hand, sunflower (*Helianthus*) is among the most important oilseed crops on a global scale, cultivated on a total area of 22 million hectares worldwide (Škorić et al. 2008). All of this had effects in having sunflower researchers start working on the plant's tolerance to herbicides. In the first breakthrough, Al-Khatib et al. (1998) used a wild population of *Helianthus annuus* L. (ANN-PUR) that originated in Rossville, Kansas (USA) as resistant to imidazolinone-based herbicides. After the genetics of resistance were studied and understood (Miller and Al-Khatib 2000; Jocić et al. 2001), this population was used to develop the first sunflower hybrids tolerant to Imidazolinone Herbicides. These hybrids were developed in the USA in 2003 and in 2004 in Serbia and Turkey (Jocić et al. 2004).

The discovery of a wild population of *Helianthus annuus* L. (ANN-KAN) resistant to a Sulfonylurea Herbicide (Tribenuronmethyl) in the USA (Al-Khatib et al. 1999) opened up the possibility of expanding sunflower cultivation for tolerance to herbicides. In this study, the purpose was to develop sunflower hybrids

with Tribenuronmethyl tolerance. The introduction of such hybrids brings with them many benefits, including reducing or avoiding the high-cost applications used to suppress some annual broadleaf weeds after sunflower emergence, and providing a wide range of herbicides in sunflowers and more effective control of Canadian Thistle (*Cirsium arvense*) (Zollinger 2003; Malidža et al. 2006).

However, as well as chemical control, new approaches such as cultural, mechanical, biological, genetic, integrated, and biotechnological control are required in this respect. Alternative methods are sought in weed control in the world and our country to minimize chemical contamination, reduce input costs, and increase the amount and quality of the product taken from the unit area. Many studies are conducted on hoeing plants such as sugar beet, sunflower, cotton, corn, and hoeing, and its combinations are preferred for weed control, especially in these plants where hoeing is very important (Yücel 2011).

There is the resistance of commercial varieties to herbicide groups, which provide significant advantages in combating weeds at the forefront of hybrid cultivation issues in sunflowers. An important issue in this respect is the development of fast and effective solutions by considering the economic conditions while fighting against foreigners. Resistance to herbicides with Tribenuronmethyl active ingredient, one of the herbicides called SU group (Sulfonyl Urea), comes to the forefront for the development of new varieties of sunflower. The use of this herbicide is increasing in Turkey because of its broad spectrum, cost-effective status, and easy accessibility. Cultivation studies for SU group sunflower varieties have gained momentum in the cultivation studies conducted in Turkey in recent years.

The performance of SU group hybrids obtained by sunflower cultivation studies conducted in Selcuk University Faculty of Agriculture, in different locations is emphasized in the present study.

2. Materials and Methods

The present study was conducted in two separate trials in Konya and Karaman in 2022. Commercial hybrid sunflower varieties (P63LE113, P64LE119, and M94S35), which are resistant to SU group (Tribenuronmethyl) herbicides and the H408 and H412 hybrids developed by Assoc. Prof. Rahim ADA in Selcuk University Faculty of Agriculture was used in the study. The 75% Tribenuronmethyl active ingredient (Granstar) herbicide was applied with a licensed dose of 30 g ha^{-1} + Spreading Adhesive in the trial areas. The study was conducted when the plants in the plots had 4-6 leaves.

The study was conducted in four replications according to the "Randomized Blocks Trial Design" at each location (Düzgüneş et al. 1987).

The trial fields, where the front crop was wheat, were plowed deeply with a socket in the autumn following the preliminary crop harvest and left for the winter. The disc harrow and the field were raked several times and made ready for planting Before planting in the spring.

The study plots were 2.8 mx 7.5 m = 21.0 m^2 and each plot was arranged in a way that there were 70 cm in 4 rows in the row spacing and 120 kg ha^{-1} N and 80 kg ha^{-1} P_2O_5 were applied to all trial plots, all together with sowing.

3. Results and Discussion

The results of the analysis of variance of the characteristics examined in the sunflower genotypes of the SU group included in the trial are given in Table 1, and the average values of the Karaman and Konya are given in Table 2.

Konya, where the number of flowering days (%) values were evaluated, was ahead of Karaman (61.5 days) with 63.4 days. In terms of genotypes, the H412 hybrid took the lead with 64.5 days, although the P63LE113 variety (60.8 days) took the lowest place. Genetic factors and environmental conditions are effective in flowering time. Especially

air temperatures are an environmental factor in flowering, and the difference between locations has ecologically determinative effects on the flowering time in climate and soil conditions (Poyraz 2012).

Physiological maturity values paralleled the study number of flowering days. Although it was 112.9 days in Konya, it was 111.5 days in Karaman. After the accumulation of nutrients in the seed is over, the maturation of the accumulated materials continues. During this period, called physiological maturity, plants reach their maximum dry weight. Although the harvest time in sunflowers varies among regions, it starts from mid-August and lasts until the end of September. Knowing the appropriate harvest time for the preferred variety is essential. Early harvest causes the seeds not to ripen, the oil content to decrease and the seed yield to decrease; On the other hand, late harvest causes yield loss in the form of seed shedding in the plant (Kolsarıcı et al., 1987). Earliness in Turkey is an important characteristic in areas with a short growing season in sunflower agriculture. Also, late planting for reasons such as second crop or hail damage brings advantages in terms of harvest time (Süzer, 1991). These results are consistent with the findings of Jocić et al. (2011), who conducted a study on Tribenuron tolerant sunflower hybrids, which they found to vary between 109.9 -127.5 days.

The plant height values were insignificant in the present study in terms of location, genotype, and location x genotype. Plant height values varied between 177.3 and 164.6 cm. Genetic structure is one of the determining factors of plant height (Önder et al. 2001; Akkaya 2006; Ceyhan et al. 2008; Öztürk et al. 2008; Day 2011; Tan 2014).

Statistical differences were detected between genotypes when the head diameter values were evaluated. The highest head diameter value of 20.9 cm was obtained in the H412 hybrid, although the lowest was obtained in the commercial variety P63LE113 (17.3 cm). the results were supported by Gürbüz et al. (2003), who reported that the diameter of the head diameter in sunflowers varied greatly depending on ecological conditions, soil structure, cultivation techniques, irrigation status, and a variety of factors. The heritability of the head size is quite low in sunflowers (Turan and Göksoy 1998). Also, the diameter of the head is an important indicator of seed yield in sunflowers (Özkahraman 2021).

Although a statistical difference was detected between genotypes in terms of thousand seed weights, no difference was detected in terms of locations and location x genotype interaction. In the present study, the highest 1000-seed weight was obtained in the H408 hybrid, although the lowest was obtained in the P64LE119 variety. One thousand seed weight, which is one of the most important yield factors in sunflowers, varies according to the variety and growing conditions (Ilbaş et al., 1996). However, it can also be argued that the differences between varieties in terms of thousand seed weight occur mostly because of genotypic differences (Yılmaz and Bayraktar 1996, Özer et al. 2003).

When the seed moisture values were evaluated in the study, it was found that the highest value was obtained in the H408 hybrid (7.8%), and the lowest value was obtained in the commercial variety P63LE113 with 5.9%. Seed moisture is an important indicator of physiological maturity and harvest period in sunflowers.

When Table 1 is evaluated in terms of seed yields, although the genotypes were statistically significant at the 1% level, the interaction of location and location x genotype was insignificant. When the average data were evaluated, the highest seed yield was obtained in the (A) P64LE119 (4.32 t ha^{-1}), M94S35 (4.10 t ha^{-1}), and H412 (4.36 t ha^{-1}) genotypes, which were in the same statistical group followed by P63LE113 (4.02 t ha^{-1}) and H408 (3.54 t ha^{-1}) genotypes, respectively. Besides genetic structure, yield is affected by many elements in sunflowers along with ecological, morphological, physiological, and agronomic factors (Bange et al, 1997). On other words, the different results of the cultivars in terms of seed yield stem from their genotypic structures being different and reacting differently to ecological variables associated with years (Kıllı 1997). Because of the great influence of environmental factors, the heritability of seed yield is quite low (Turan and Göksoy 1998). For this reason, when evaluating the study results, it should not be forgotten that the cultural treatments (e.g., rotation, planting time, irrigation) will significantly change the yield performance of the varieties. As in other cultivated plants, the using of varieties that are suitable for the area is one of the main factors that increase yield and quality in sunflower cultivation. Several seed yield results were obtained in previous studies conducted by many researchers in different varieties and different ecologies (Öztürk et al. 2008).

Table 1. Results of variance analysis in the experiment conducted in Konya-Altinekin and Karaman Locations

Source of Variation	df	Means square				
		Flowering days	Physiological maturity days (day)	Plant height (cm)	Head diameter (cm)	Thousand seed weight (g),
Location	1	36,10**	21,03**	1849,60**	4,23	193,60*
Replication [L]	6	2,25	0,93	23,12	2,19	14,20
Genotypes	4	17,65**	17,98**	30,10	16,29**	199,90**
L x G	4	2,60	12,65**	10,98	4,41	15,85
Error	24	2,38	2,61	24,72	1,73	13,66
Source of Variation	**df**	**Seed moisture (%)**	**Seed yield (t ha^{-1})**	**Oil content (%)**	**Oil yield (t ha^{-1})**	
Location	1	0,41	396,90	2,50	189,23	
Replication [L]	6	0,21	701,57	0,80	83,69	
Genotypes	4	4,08**	8566,96**	6,10*	2057,77**	
L x G	4	0,11	986,96	5,89*	120,12	
Error	24	0,12	1540,46	1,67	334,98	

[1] Tables may have a footer.

Table 2. Means of two locations for Number of days to bloom (day), Physiological maturity days (day), Plant height (cm), Head diameter (cm), Thousand seed weight (g), Hectoliter weight (kg) of 9 sunflower genotypes evaluated in Konya and Karaman Locations

	Number of days to bloom (day)			Number of days to physiological maturity (day)			Plant height (cm)		
Genotypes	**Altinekin**	**Karaman**	**Mean**	**Altinekin**	**Karaman**	**Mean**	**Altinekin**	**Karaman**	**Mean**
H194	65,0	66,3	65,6 A	117,0	114,8	115,9 A	120,0 I	171,8 A	145,9 DE
H249	62,3	63,8	63,0 BC	113,3	113,8	113,5 BC	145,0 FG	141,5 GH	143,3 E
H250	62,3	63,0	62,6 BC	113,3	113,8	113,5 BC	142,5 G	152,8 C-E	147,6 C-E
H253	63,0	65,0	64,0 AB	115,0	115,8	115,4 AB	160,3 B	161,0 B	160,6 B
H5	62,5	64,8	63,6 B	116,3	115,3	115,8 A	148,5 D-G	144,5 FG	146,5 C-E
H55	60,3	63,0	61,6 CD	110,5	112,3	111,4 C	144,3 FG	158,3 BC	151,3 C
P63MM54	59,0	62,3	60,6 D	108,3	109,8	109,0 D	134,3 H	155,8 B-D	145,0 DE
Tunca	63,8	67,3	65,5 A	116,8	117,0	116,9 A	172,3 A	173,0 A	172,6 A
Gibraltar	61,3	63,5	62,4 BC	112,8	113,8	113,3 BC	146,3 E-G	151,5 C-F	148,9 CD
Mean	62,1 B	64,3 A	63,2	113,7	114,0	113,8	145,9 B	156,7 A	151,3
		$Lsd_{genotype\ (0.01)}$ = 1,78			$Lsd_{genotype\ (0.01)}$ = 2,16			$Lsd_{genotype\ (0.01)}$ = 5,25	
								$Lsd_{locationx\ genotype\ (0.01)}$ = 7,42	
Genotypes	**Head diameter (cm)**			**Thousand-seed weight (g)**			**Hectoliter weight (kg)**		
H194	15,8 EF	19,8 A	17,8 A-C	46,8	50,8	48,8 A-C	30,3	30,2	30,3
H249	16,5 D-F	16,8 C-F	16,6 BC	51,5	53,1	52,3 AB	32,0	29,3	30,6
H250	19,0 AB	18,5 A-D	18,8 A	56,9	51,6	54,2 A	30,5	31,5	31,0
H253	17,8 A-E	18,8 A-C	18,3 AB	50,8	53,6	52,2 AB	31,1	31,0	31,0
H5	19,0 AB	17,3 B-E	18,1 AB	51,1	49,9	50,5 AB	31,6	30,6	31,1
H55	19,0 AB	17,0 B-F	18,0 AB	45,5	47,0	46,3 BC	29,9	31,9	30,9
P63MM54	15,0 F	16,8 C-F	15,9 C	46,1	54,1	50,1 AB	32,7	31,9	32,3
Tunca	17,5 B-E	18,5 A-D	18,0 AB	52,9	52,1	52,5 AB	31,5	31,6	31,6
Gibraltar	15,8 EF	16,8 C-F	16,3 BC	44,9	41,8	43,4 C	30,8	30,4	30,6
Mean	17,3	17,8	17,5	49,6	50,4	50,0	31,2	30,9	31,0
		$Lsd_{genotype\ (0.01)}$ = 2,07			$Lsd_{genotype\ (0.01)}$ = 6,70				
		$Lsd_{locationx\ genotype\ (0.05)}$ = 2,19							

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Table 3. Means of two locations Seed moisture (%), Seed yield (t ha^{-1}), Oil content (%), Oil yield (t ha^{-1}) of 9 sunflower genotypes evaluated in Konya and Karaman Locations

	Seed moisture (%)			Seed yield (t ha^{-1})		
Genotypes	**Altinekin**	**Karaman**	**Mean**	**Altinekin**	**Karaman**	**Mean**
H194	8,4	7,4	7,9	4,40	4,34	4,37 A
H249	7,9	8,1	8,0	3,85	3,78	3,82 B
H250	7,8	8,4	8,1	4,33	4,22	4,27 AB
H253	8,7	7,6	8,1	3,93	3,87	3,90B
H5	7,9	7,6	7,7	4,18	4,13	4,16AB
H55	7,8	7,5	7,7	4,25	4,15	4,20AB
P63MM54	7,5	7,1	7,3	4,10	4,24	4,17 AB
Tunca	8,3	7,7	8,0	4,01	3,94	3,98AB
Gibraltar	7,5	7,1	7,3	4,26	4,04	4,15AB
Mean	8,0	7,6	7,8	415,0	4,08	4.11
					Lsd $_{genotype\ (0.05)}$ = 4.6	

Genotypes	**Oil rate (%)**			**Oil yield (t ha^{-1})**		
H194	44,4	45,8	45,1 BC	1,95	1,99	1,97 AB
H249	41,9	44,0	43,0 C	1,61	1,67	1,64 D
H250	47,8	47,9	47,8 A	2,07	2,02	2,04 A
H253	46,1	45,3	45,7 AB	1,81	1,75	1,78 B-D
H5	44,9	45,4	45,2 BC	1,88	1,88	1,88 A-C
H55	43,2	42,5	42,9 C	1,83	1,76	1,79 B-D
P63MM54	43,5	43,0	43,2 C	1,78	1,82	1,80 B-D
Tunca	43,8	43,6	43,7 BC	1,75	1,72	1,73 CD
Gibraltar	44,7	43,1	43,9 BC	1,90	1,74	1,82 A-D
Mean	44,5	44,5	44,5	184,6	1,82	1,83
		Lsd $_{genotype\ (0.01)}$ = 2,31			Lsd $_{genotype\ (0.01)}$ = 2,3	

[1] Tables may have a footer.

In the present study, conducted in Konya and Karaman in 2022, genotype and location x genotype interaction were found to be statistically different at a 1% significance level in terms of oil content values. In terms of genotype averages, the highest oil content was obtained in the H412 sunflower hybrid with 44.2%, followed by P64LE119 (42.6 %), H408 (42.5%), and P63LE113 (42.4%). The results of the present study confirmed that the oil content is affected by environmental factors, cultural practices, and sunflower genotypes (Esechie et al. 1996, Özer et al. 2003). The effects of the cultivars on the oil content are very important, and the oil content is around 38-50% in commercial hybrid cultivars. For this reason, care should be taken to ensure that this ratio in sunflower varieties consumed as oil is 40% or more (Coşge and Ulukan 2005). Also, the oil content is a quantitative character significantly affected by environmental conditions (temperatures, day lengths, and precipitation rates) because of cultural processes (Zürrer and Bachofen 1985; Karasu et al. 2006).

When the study results were evaluated in terms of oil yield, the differences between the genotypes were found to be statistically significant. The highest oil yield was obtained in H412 (1.92 t ha^{-1}) followed by P64LE119 (1.84 t ha^{-1}), M94S35 (1.71 t ha^{-1}), P63LE113 (1.70 t ha^{-1}), and H408 (1.50 t ha^{-1}) genotypes, respectively. Oil yield, a combination of seed yield and oil content, is influenced by all growing conditions and ecological factors affecting seed yield and oil content, as well as variety characteristics.

The most economically important yield criterion is the oil yield in all oil crops (Öztürk et al. 2008). In the present study, oil yield showed variability under the influence of ecological and growing conditions and various characteristics.

4. Conclusions

As a result of the present study which was conducted to determine the yield and quality characteristics of SU group (Tribenuronmethyl) hybrid oil sunflower genotypes as candidates for registration in Konya and Karaman, it can be argued that the H412 hybrid and P64LE119 commercial hybrid variety used in both locations are suitable for the ecology of the region in which the study was conducted, in terms of crude oil yield and the characteristics investigated.

Author Contributions: The author has read and agreed to the published version of the manuscript.

Conflicts of Interest: The author declares no conflict of interest.

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Selcuk Journal of Agriculture and Food Sciences

https://dergipark.org.tr/tr/pub/selcukjafsci

Research Article

(2023) 37(2), 419-429 DOI:10.15316/SJAFS.2023.040 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Determination of the Effects of Organic and Chemical Fertilization on Grain Yield and Some Agricultural Characteristics of Pea

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HIGHLIGHTS

- Pea (*Pisum sativum* L.) is used as a vegetable for fresh consumption as well as frozen, canned, or dried and processed and consumed as a dry grain.
- Organic fertilizers are used to meet the nutrient needs of plants, enrich the soil, and increase productivity.

Abstract

Pea (*Pisum sativum* L.) plant, a legume species, is used as a vegetable for fresh consumption and frozen, canned or dried and processed and consumed as dry grain. The effects of organic fertilization, which is important for plant nutrition and soil fertility in pea cultivation, on grain yield and some agricultural characteristics were investigated. The experiment was carried out in the experiment field belonging to Selçuk University, Faculty of Agriculture, Prof. Dr. Abdülkadir AKÇİN Research and Application Station in 2021 according to the "Split Plots Experiment in Randomized Blocks" design with 3 replications. In the research, fertilizers were randomly placed in the main plots and varieties were randomly placed in the sub-plots. In the experiment, high yielding 16002, 16011, 16018, 16022 and Ultrello x Rondo genotypes suitable for fresh consumption and registered Betagreen pea variety were used as materials. Grain yield, some agronomic traits, protein yield and protein ratio were analyzed in the study. It was determined that the effects of chemical fertilizer and some organic fertilizer applications on all other traits examined in peas were statistically significant. According to the results of the research, the number of branches in pea plants was 3.18 pieces/plant (control) and 4.13 pieces/plant (chemical fertilizer), plant height was 45.89 cm (sheep manure) and 49.51 cm (chemical fertilizer), the number of pods was 14.31 pieces/plant (control) and 25.90 pieces/plant (chemical fertilizer), the number of grains in pods was 4.90 pieces (control) and 6.64 pieces (chemical fertilizer), the number of grains per plant was 70. 03 (control) to 172.20 (chemical fertilizer), hundred seed weight 29.30 g (control) to 33.22 g (chemical fertilizer), grain yield 128.75 kg da^{-1} (control) to 300.38 kg da^{-1} (chemical fertilizer), protein content 22.49% (control) to 23.12% (sheep manure) and protein yield 28.96 kg da^{-1} (control) to 67.91 kg da^{-1} (chemical fertilizer). The responses of genotypes to organic fertilizer applications showed differences. As a result, it was determined that organic fertilization in peas gave less grain yield than those grown with chemical fertilization, but protein content had higher values. This showed that organic fertilization is a sustainable and environmentally friendly option for pea cultivation.

Keywords: Chemical fertilizer; pea; organic fertilizers; seed yield

Citation: Karadaş S, Ceyhan E (2023). Determination of the effects of organic and chemical fertilization on grain yield and some agricultural characteristics of pea. *Selcuk Journal of Agriculture and Food Sciences*, 37(2), 419-429. https://doi.org/10. 15316/SJAFS.2023.040

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Received date: 04/01/2023

Accepted date: 14/07/2023

1. Introduction

The pea (*Pisum sativum* L.) plant, a legume species, is used as a vegetable for fresh consumption, as well as processed as frozen, canned, or dried and consumed as dried grains. It can also be used as animal feed. Pea plant is a very important place in crop rotation due to its soil enrichment feature (Ceyhan 2004).

Pea production may vary from year to year, depending on various factors. Factors such as weather conditions, agricultural policies, and changes in cultivation areas can affect the amount of production. In addition, consumer demand is also an essential factor in determining the amount of production. One point that should be remembered is the impact of agriculture on the environment and ecosystem. In pea production worldwide and Türkiye, it is extremely important to pay attention to sustainable agricultural practices and the conservation of natural resources. This will contribute to maintaining soil fertility, sustainable use of water resources and the balance of ecosystems (Ceyhan 2004).

Organic fertilizers are fertilizers derived from natural sources and composed of organic materials. Such fertilizers are used to meet the nutrient needs of plants, enrich the soil and increase productivity. Organic fertilizers contain nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which are essential nutrients needed by plants. They also contain micronutrients and other beneficial elements. In this way, plants grow in a healthy and balanced way. Organic fertilizers improve the structural properties of the soil. Organic matter increases the water-holding capacity of the soil and promotes better root growth through aeration (Yolcu 2010; Göksu 2012; Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

Organic fertilizers improve the structural properties of the soil. Organic matter increases the soils water-holding capacity the water-holding capacity of the soil and promotes better root growth by providing aeration. Organic fertilizers provide plants with a long-term source of nutrients because they contain slowly soluble compounds. This meets the nutritional needs of plants over a longer period and leaves less waste without accumulating in the soil. Unlike chemical fertilizers, organic fertilizers, pollute the soil and the environment less, break down and return to nature through natural processes and do not harm water resources (Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

The disadvantages of organic fertilizers are their lower nutrient content than chemical fertilizers and the slower dissolution rate of some nutrients such as nitrogen. For this reason, chemical fertilizers may be preferred in situations requiring quick action or urgent nutrient deficiencies. However, when considering soil health and environmental protection in the long term, organic fertilizers are a more sustainable and environmentally friendly option (Yolcu 2010; Göksu 2012; Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

Chemical fertilizers can negatively affect the life of microorganisms and other beneficial organisms in the soil. In long-term use, they can reduce soil fertility and disrupt the natural structure of the soil. Excessive use of chemical fertilizers can be carried into water sources through rainwater or irrigation and cause water pollution. When misused or applied in excessively, chemical fertilizers can cause burning, leaf spots and other harmful effects on plants. They can also contribute to the spread of plant diseases due to mineral imbalances. The production, distribution and use of chemical fertilizers can generate environmentally harmful waste and greenhouse gas emissions. This can contribute to climate change and environmental pollution (Yolcu 2010; Göksu 2012; Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

Considering the above-mentioned harms of chemical fertilizers, alternatives such as the transition to sustainable agricultural practices and organic fertilizers should be preferred. Organic fertilizers support the natural structure of the soil, cause less water pollution and are a more suitable option for a healthy ecosystem. However, the type of fertilizer to be used in each case may vary depending on factors such as soil characteristics and the geographical region where agriculture is carried out. In this study, the effects of cow

and sheep manure as organic fertilizers on grain yield and some agronomic characteristics in pea production were tried to be determined.

2. Materials and Methods

High yielding 16002, 16011, 16018, 16022, and Ultrello x Rondo genotypes and registered Betagreen variety developed by Prof. Dr. Ercan CEYHAN and suitable for fresh consumption were used as materials in the research.

Some properties of sheep manure used as material in the study were moisture 10.35%, organic matter 74.1%, pH 7.53, nitrogen 1.63%, water-soluble P_2O_5 0.17%, water-soluble K_2O 3.26%, water-soluble Zn 1.60 ppm and water-soluble Fe 4.80 ppm. Some properties of cow manure were moisture 2.96%, organic matter 76.67%, pH 7.38, nitrogen 1.55%, water-soluble P_2O_5 0.16%, water-soluble K_2O 3.00%, water-soluble Zn 2.40 ppm and water-soluble Fe 29.60 ppm (Kahraman and Ceyhan2022; Küçük and Ceyhan 2022).

According to the 17-year meteorological observations made in Konya province during the vegetation period in the year, the trials were established, the 17-year average temperature, total precipitation, and average relative humidity were 22.5 ^{0}C, 80.1 mm and 40.8%, respectively. In 2021, when the experiment was established, it was realized as 21.8 ^{0}C, 105.2 mm and 42.2%.

The previous crop in the research area was wheat. After the wheat plant was harvested, the soil was deeply plowed in October, allowing it to spend the winter in this way. In March, the experimental area was ploughed and parceled, and organic fertilizers (cow and sheep manure) were applied to the main plots. Control (no fertilizer), nitrogen 50 kg ha^{-1} as pure matter from chemical fertilizer (urea), cow manure 30000 kg ha^{-1}, sheep manure 20000 kg ha^{-1} were randomly placed in the main plots. According to the experimental design, control (no fertilizer), 0.72 kg of urea fertilizer, 195 kg of cow manure, and 130 kg of sheep manure were applied to the main plots. The organic fertilizers and chemical fertilizers, previously weighed for each main plot, were evenly distributed into the plots with the help of a shovel and rake and mixed into the soil with a hand hoe rotavator.

The experiment was established on May 2, 2021, in the experimental field of Selçuk University, Faculty of Agriculture, Prof. Dr. Abdülkadir AKÇİN Research and Application Station on tempered soil with 3 replications according to the "Split Plots Experiment in Randomized Blocks" design. In the research, fertilizers were randomly placed in the main plots, and varieties were randomly placed in the sub-plots. The sub-plots were 5.0 m x 2.5 m = 12.5 m2. Seeds were sown by hand to a depth of 3 cm in the rows opened with a marker, with 50 cm between rows and 10 cm above rows. Five rows were sown in each plot.

During the plant growth period, hoeing was performed twice to clean the test plots from weeds, and irrigation was performed 3 times to meet the water needs of the pea plant depending on the climatic conditions. The first irrigation was done when the plants were 10-15 cm after emergence due to lack of rainfall, the second irrigation was done at flowering time and the last at the pod filling period. Harvesting was done manually between July 20 and 25, 2021. Harvesting was done when all plants were mature in each genotype.

Each agricultural traits examined in the experiment was subjected to statistical analysis separately. The differences of the averages calculated for each treatment were grouped according to the "LSD test", some at 1% and some at 5%. Statistical analyses were performed by using the MSTATC software program.

3. Results and Discussion

3.1. Number of Branches per Plant

The difference between fertilizer treatments and genotypes, and fertilizer treatments x genotype interactions were found to be statistically significant at a 1% level in terms of branch number values of pea cultivars (Table 1). Göksu (2012); Ceyhan et al. (2005); Ceyhan et al. (2012) reported that there were statistically significant differences between the genotypes in their study.

As can be seen from the examination of Table 2, when the fertilizer treatments of the varieties are compared with each other in terms of the number of branches, it is seen that they produce different results. As the average of the varieties, the highest number of branches was obtained in chemical fertilizer application with 4.13 number/plant. This was followed by cow manure (3.96 number/plant) and sheep manure (3.57 number/plant) treatments in descending order. The lowest number of branches was obtained from the plants grown in the control treatment with 3.18 number/plant. In general, fertilization treatments positively affected on the number of branches compared to the control (Göksu 2012).

According to the averages of fertilizer treatments, the number of branches of the varieties varied between 3.32 - 4.25 number/plant. The highest number of branches was obtained in 16011 and the lowest number was obtained in Betagreen variety. The number of branches of other varieties was between these values. It was determined that the varieties gave different reactions according to the fertilizer type. If the number of branches is high, the pods formed and therefore as the number of seeds per plant will also increase, the yield also increases (Ceyhan et al. 2005; Göksu 2012; Ceyhan et al. 2012; Al-Bayati et al. 2019).

The highest number of branches was obtained in genotype 16011 with 5.11 number/plant in chemical fertilizer. In contrast, the lowest number of branches was determined in the Betagreen variety with 2.56 number/plant in the control treatment. These results show that although the number of branches is a cultivar trait, fertilizer application also highly affects it. Some researchers also reported that different fertilizer applications increased the number of branches in some plants (Göksu 2012).

3.2. Plant Height

As shown in Table 1, the difference among fertilizer treatments, genotypes and fertilizer treatments x genotype interaction was statistically significant at 1% level in terms of plant height values. In previous studies, Gopinath et al. (2009); Göksu (2012) Al-Bayati et al. (2019) reported that there were statistical differences among fertilizer treatments in terms of plant height, while Ceyhan et al. (2008) reported that there were statistical differences among genotypes in terms of plant height.

According to the average of genotypes, the highest plant height was obtained from cow manure treatment with 47.67 cm, while the lowest plant height was determined in sheep manure treatment with 45.89 cm. These results show that plant height is significantly affected by chemical and organic fertilizer applications as well as cultivar characteristics (Gopinath et al. 2009; Bulut 2013; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

In pea plant, the highest plant height was measured in the Ultrillo x Rondo variety with 51.79 cm as the average of fertilizer treatments. This was followed by Betagreen (48.71 cm), 16011 (48.15 cm), 16022 (45.89 cm) and 16018 (45.43 cm) in descending order. The lowest plant height was measured from genotype 16002 with 43.84 cm (Table 2). The genetic structure of the cultivars is the most determining factor on plant height in pea (Ceyhan 2004; Ceyhan et al. 2008). Many previous studies reported that the stature of pea varieties was different (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012; Avcı and Ceyhan 2013).

Table 1. Analysis of variance for the traits examined in pea genotypes treated with organic and chemical fertilizers.

Sources of Variance	df	Number of Branches per Plant	Plant Height	Number of Pods per Plant
Total	71			
Replication	2	0,051	2,272	0,786
Fertilizer Treatments (FT)	3	3,248**	50,109**	406,165**
Error$_1$	6	0,128	2,797	0,615
Genotypes (G)	5	1,508**	96,821**	33,865**
FT x G Interaction	15	0,387**	16,921**	4,772**
Error$_2$	40	0,100	6,116	0,564
Sources of Variance	**df**	**Number of Seeds per Pod**	**Number of Seeds per Plant**	**Hundred-Seed Weight**
Total	71			
Replication	2	0,078	1,927	0,343
Fertilizer Treatments (FT)	3	9,706**	31639,800**	47,210**
Error$_1$	6	0,083	64,243	0,230
Genotypes (G)	5	1,028**	1977,180**	232,899**
FT x G Interaction	15	0,095*	300,572**	2,357**
Error$_2$	40	0,047	32,250	0,254
Sources of Variance	**df**	**Seed Yield**	**Protein Content**	**Protein Yield**
Total	71			
Replication	2	61,184	0,025	2,240
Fertilizer Treatments (FT)	3	93024,700**	1,383**	4835,620*
Error$_1$	6	119,120	0,004	6,489
Genotypes (G)	5	2763,770**	2,170**	147,916*
FT x G Interaction	15	161,238	0,239**	8,790
Error$_2$	40	87,000	0,018	4,809

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Table 2. Means and LSD groups of the number of branches per plant, plant height and number of pods per plant of pea genotypes treated with organic and chemical fertilizers.

Genotypes	Chemical and Organic Fertilizers				
	Control	Chemical Fertilizer	Cow Manure	Sheep Manure	Mean
			Number of Branches per Plant		
16002	3,67 c-g	3,72 c-g	3,33 fgh	3,52 d-g	3,56 b
16011	3,31 fgh	5,11 a	4,92 ab	3,66 c-g	4,25 a
16018	3,15 ghı	3,88 c-f	3,90 c-f	3,40 efg	3,58 b
16022	2,67 hı	4,06 cde	3,78 c-g	3,56 d-g	3,52 b
Betagreen	2,56 ı	3,92 c-f	3,50 d-g	3,30 fgh	3,32 b
Ultrello x Rondo	3,73 c-g	4,11 cd	4,33 bc	3,97 c-f	4,04 a
Mean	3,18 c	4,13 a	3,96 ab	3,57 bc	3,71
	$Lsd_{Çeşit\ x\ Gübre}$: 5,461; $Lsd_{Çeşit}$: 2,730; $Lsd_{Gübre}$: 2,067				
			Plant Height (cm)		
16002	40,89 h	46,96 c-g	44,81 e-h	42,71 fgh	43,84 d
16011	49,56 a-e	49,56 a-e	48,70 b-e	44,79 e-h	48,15 bc
16018	44,71 e-h	47,36 c-f	46,42 d-g	43,22 fgh	45,43 cd
16022	41,66 gh	49,96 a-e	46,82 c-g	45,11 e-h	45,89 cd
Betagreen	45,74 e-h	54,00 ab	47,71 c-f	47,38 c-f	48,71 b
Ultrello x Rondo	54,30 a	49,22 a-e	51,55 a-d	52,10 abc	51,79 a
Mean	46,14 b	49,51 a	47,67 ab	45,89 b	47,30
	$Lsd_{Çeşit\ x\ Gübre}$: 1,658; $Lsd_{Çeşit}$: 0,8292; $Lsd_{Gübre}$: 0,9691				
			Number of Pods per Plant		
16002	14,84 fg	28,51 b	21,30 d	19,81 de	21,12 b
16011	14,78 fg	30,78 a	24,25 c	23,54 c	23,34 a
16018	14,40 fg	24,59 c	20,27 de	19,19 e	19,61 c
16022	15,22 f	23,14 c	19,40 e	19,21 e	19,24 c
Betagreen	13,26 g	24,28 c	19,86 de	19,18 e	19,15 c
Ultrello x Rondo	13,35 g	24,11 c	20,08 de	19,09 e	19,16 c
Mean	14,31 c	25,90 a	20,86 b	20,00 b	20,27
	$Lsd_{Çeşit\ x\ Gübre}$: 0,3578; $Lsd_{Çeşit}$: 0,2394; $Lsd_{Gübre}$: 0,3560				

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The highest plant height average was 54.30 cm in the Ultrillo x Rondo genotype in the control treatment and the lowest was 40.89 cm in 16002 genotype in the control treatment (Table 2). Plant height of the genotypes used in the study showed differences according to fertilizer applications (Gopinath et al. 2009; Göksu 2012; Bulut 2013; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

3.3. Number of Pods per Plant

Fertilizer treatments, genotypes and fertilizer treatments x genotype interaction were statistically significant at 1% level (Table 1). While it was reported by Gopinath et al. (2009); Göksu (2012); Al-Bayati et al. (2019) that fertilizer applications affected the number of pods in pea, it was also reported by Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013) that there were significant differences among cultivars in terms of pod number.

According to the mean of the varieties, the highest number of pods was obtained from chemical fertilizer application with 25.90 number/plant. This was followed in descending order by cow dung application (20.86 pcs/plant) and sheep dung application (20.00 number/plant). The lowest number of pods was found in the control treatment with 14.31 number/plant. Gopinath et al. (2009); Göksu (2012); Bulut (2013); Al-Bayati et al. (2019); Kahraman and Ceyhan (2022); Küçük and Ceyhan (2022) reported that organic fertilizer applications increased the number of pods.

The mean values for the number of pods of pea varieties are given in Table 2. According to the averages of fertilizer treatments, the number of pods of the varieties varied between 19.15 - 23.34 number/plant. Among the varieties, the highest number of pods was determined in genotype 16011 and the lowest number of pods was determined in the Betagreen variety. Similar results were obtained in many previous studies (Ceyhan 2004; Ceyhan et al. 2008; Gopinath et al. 2009; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013).

When the varieties were compared with each other in terms of number of pods in terms of fertilizer applications, it was observed that they produced different results. The highest number of pods was obtained from genotype 16011 in chemical fertilizer treatment with 30.78 number/plant, while the lowest number of pods was obtained from the Betagreen variety in control treatment with 13.26 number/plant. This shows that although the number of pods is a cultivar characteristic, it is also highly affected by fertilizer applications (Gopinath et al. 2009; Göksu 2012; Bulut 2013; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

3.4. Number of Seeds per Pod

The difference between fertilizer treatments and genotypes regarding of the number of seeds in pods was statistically significant at 1% level, while the fertilizer treatment x genotype interaction was statistically significant at 1% level (Table 1). It was reported in previous studies that the effects of organic fertilizer applications on the number of grains in pods were statistically significant in pea (Gopinath et al. 2009; Göksu 2012; Al-Bayati et al. 2019) and bean (Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022). In previous studies, many researchers reported that there were statistical differences between varieties in terms of the number of grains in pods (Ceyhan 2004; Ceyhan et al. 2008; Gopinath et al. 2009; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013).

According to the mean of the varieties, the highest number of seeds in pods was determined in chemical fertilizer application with 6.64. This was followed by cow manure application (6.13 number/pod) and sheep manure application (5.90 number/ pod) in decreasing order. The lowest number of seeds per pod was obtained from the control treatment with 4.90 (Table 2). It was determined that fertilizer applications increased the number of seeds in pods of peas (Gopinath et al. 2009; Göksu 2012; Al-Bayati et al. 2019) and beans (Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

According to the averages of fertilizer applications, the number of seeds per pod of the varieties varied between 5.64 (Betagreen) and 6.43 (16018 genotype). The number of seeds per pod of other varieties were between these values. Similar results were also reported by Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013) who conducted studies on this subject.

Table 3. Means and LSD groups of the number of seeds per pods, number of seeds per plant and hundred-seed weight of pea genotypes treated with organic and chemical fertilizers.

Genotypes	Chemical and Organic Fertilizers				
	Control	Chemical Fertilizer	Cow Manure	Sheep Manure	Mean
			Number of Seeds per Pod		
16002	4,67 j	6,70 b	6,18 efg	5,92 fgh	5,87 bc
16011	5,01 ıj	6,60 bcd	6,26 def	5,91 fgh	5,94 b
16018	5,21 ı	7,48 a	6,77 b	6,26 def	6,43 a
16022	4,89 ıj	6,07 e-h	5,85 gh	5,74 h	5,64 cd
Betagreen	4,93 ıj	6,68 bc	5,95 fgh	5,85 gh	5,85 bcd
Ultrello x Rondo	4,66 j	6,33 cde	5,79 h	5,73 h	5,63 d
Mean	4,90 c	6,64 a	6,13 b	5,90 b	5,89
	$Lsd_{Çeşit\ x\ Gübre}$: 12,54; $Lsd_{Çeşit}$: 6,270, $Lsd_{Gübre}$: 9,905				
			Number of Seeds per Plant		
16002	69,29 hı	190,98 ab	131,74 ef	117,30 g	127,33 b
16011	73,83 hı	203,07 a	151,60 cd	138,98 e	141,87 a
16018	75,11 h	183,96 b	137,20 e	120,03 fg	129,08 b
16022	74,54 hı	140,44 de	113,38 g	110,30 g	109,67 c
Betagreen	65,22 hı	162,14 c	118,26 g	112,28 g	114,47 c
Ultrello x Rondo	62,18 ı	152,58 cd	116,31 g	109,32 g	110,10 c
Mean	70,03 d	172,20 a	128,08 b	118,03 c	122,09
	$Lsd_{Çeşit\ x\ Gübre}$: 1,113; $Lsd_{Çeşit}$: 0,5564; $Lsd_{Gübre}$: 0,5927				
			Hundred-Seed Weight (g)		
16002	22,61 ı	25,71 gh	23,60 ı	22,92 ı	23,71 d
16011	24,96 h	32,08 cde	26,98 f	26,27 fg	27,57 c
16018	32,34 cde	35,99 a	34,71 b	35,24 ab	34,57 a
16022	32,41 cde	35,33 ab	34,36 b	34,31 b	34,10 a
Betagreen	31,47 e	34,81 b	32,95 cd	32,95 cd	33,05 b
Ultrello x Rondo	32,00 de	35,42 ab	32,88 cd	33,15 c	33,36 b
Mean	29,30 c	33,22 a	30,91 b	30,81 b	31,06
	$Lsd_{Çeşit}$: 10,30; $Lsd_{Gübre}$: 13,49				

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The highest number of seeds in pods was determined in genotype 16018 in chemical fertilizer treatment with 7.78, while the lowest number of seeds in pods was obtained in Ultrillo x Rondo genotype in control treatment with 4.66. The highest number of seeds in pods was obtained in the chemical fertilizer treatment. Similar results were also reported by Kahraman and Ceyhan (2022); Küçük and Ceyhan (2022) in beans.

3.5. Number of Seeds per Plant

As shown in Table 1, fertilizer treatments, genotypes and fertilizer treatments x genotype interaction were found to be statistically significant at 1% level. It was reported by many researchers that there were significant differences among fertilizer treatments in terms of the number of seeds per plant in pea (Göksu 2012; Al-Bayati et al. 2019). Ceyhan (200) and Ceyhan (2003) found significant differences among varieties in the number of seeds per plant.

In this study, the highest number of grains per plant was obtained from chemical fertilizer application with 172.20 and the lowest number of seeds per plant was obtained from control application with 70.03. The number of grains per plant was 128.08 in cow manure and 118.03 in sheep manure treatment (Table 2). These results show that the number of grains per plant is significantly affected by fertilizer applications as well as genetic structure (Göksu 2012; Al-Bayati et al. 2019).

As the average fertilizer treatments, the highest number of grains per plant was determined in genotype 16011 with 141.87. This was followed by 16018 (129.08 number), 16002 (127.33 number), Betagreen (114.47) and Ultrillo x Rondo (110.10) genotypes in descending order. The lowest number of seeds per plant was obtained from genotype 16022 with 109.67 number (Table 2). In many previous studies, it was reported that the number of seeds per plant of pea genotypes were different (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013; Al-Bayati et al. 2019).

In the study, the highest number of seeds per plant was determined in genotype 16018 in chemical fertilizer treatment with 203.07 number, while the lowest number of seeds per plant was determined in the Ultrello x Rondo genotype in control treatment with 62.18 number. The chemical fertilizer treatment determined the highest number of seeds per plant. The number of seeds per plant of pea cultivars was affected differently by organic and chemical fertilizer applications. Similar results were also reported by Al-Bayati et al. (2019).

3.6. Hundred-Seed Weight

The effect of fertilizer treatments, genotypes and fertilizer treatments x genotypes interaction on hundred-seed weight was found statistically significant at 1% level (Table 1). In many studies, researchers have stated that there are significant differences among varieties in terms of hundred-seed weight in peas (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012; Göksu 2012; Avcı and Ceyhan 2013).

As the average of the varieties used in the study, the highest hundred-seed weight was determined in chemical fertilizer treatment with 33.22 g. The lowest hundred-seed weight was determined in the control treatment with 29.30 g. In this study, the hundred-seed weight was 30.91 g in cow manure and 30.81 g in sheep manure application (Table 2). As in other plants, thousand-seed weight, which is one of the most important agricultural traits affecting seed yield in peas (Göksu 2012) and bean (Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022), is highly affected by fertilizer applications.

According to the average of fertilizer treatments, the highest hundred-seed weight was obtained from genotype 16018 with 34.57 g, followed by genotypes 16022 (30.10 g), Ulltrillo (33.36 g), Betagreen (33.05 g) and 16011 (27.57 g) in descending order. The lowest hundred-seed weight was found in genotype 16002 with 23.71 g (Table 2). The facial grain weight values obtained in this study are similar to the results of similar studies conducted on the subject by Ceyhan (2004); Ceyhan et al. (2008); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013).

Table 4. Means and LSD groups of the seed yield, protein content and protein yield of pea genotypes treated with organic and chemical fertilizers.

Genotypes	Chemical and Organic Fertilizers				
	Control	Chemical Fertilizer	Cow Manure	Sheep Manure	Mean
			Seed Yield (kg/da)		
16002	115,07	288,04	218,36	208,97	207,61 d
16011	114,90	294,43	250,59	217,62	219,39 bc
16018	139,74	325,03	273,19	245,07	245,76 a
16022	136,37	292,55	242,13	235,89	226,73 b
Betagreen	121,10	287,83	235,91	215,86	215,18 cd
Ultrello x Rondo	145,31	314,37	271,85	237,18	242,18 a
Mean	128,75 d	300,38 a	248,67 b	226,77 c	226,14
	$Lsd_{Çeşit}$: 10,30; $Lsd_{Gübre}$: 13,49				
			Protein Content (%)		
16002	22,28 gh	22,18 h	23,09 bcd	22,29 gh	22,46 d
16011	22,42 gh	23,17 bcd	23,22 bcd	23,27 bc	23,02 b
16018	22,14 h	22,26 gh	22,21 gh	22,98 cde	22,40 d
16022	23,19 bcd	23,33 b	23,38 b	24,13 a	23,51 a
Betagreen	22,48 fg	22,32 gh	22,39 gh	22,93 de	22,53 d
Ultrello x Rondo	22,42 gh	22,43 gh	22,73 ef	23,13 bcd	22,68 c
Mean	22,49 d	22,62 c	22,84 b	23,12 a	22,77
	$Lsd_{Çeşit\ x\ Gübre}$: 0,2963; $Lsd_{Çeşit}$: 0,1481; $Lsd_{Gübre}$: 0,07816				
			Protein Yield (kg/da)		
16002	25,64	63,88	50,42	46,58	46,63 c
16011	25,75	68,23	58,21	50,64	50,71 b
16018	30,94	72,35	60,68	56,32	55,07 a
16022	31,62	68,26	56,60	56,92	53,35 a
Betagreen	27,23	64,24	52,83	49,50	48,45 bc
Ultrello x Rondo	32,57	70,51	61,79	54,85	54,93 a
Mean	28,96 d	67,91 a	56,76 b	52,47 c	51,52
	$Lsd_{Çeşit}$: 2,421; $Lsd_{Gübre}$: 3,148				

[1] Tables may have a footer.

This study determined the highest hundred-seed weight was in genotype 16018 in chemical fertilizer treatment with 35.99 g. In comparison, the lowest hundred-seed weight was determined in genotype 16002 in the control treatment with 22.61 g. The chemical fertilizer treatment determined the highest hundred-seed weights of the varieties.

3.7. Seed Yield

The differences between fertilizer treatments and genotypes regarding seed yield in pea genotypes were statistically significant at a 1% level, while the location x genotype interaction was found statistically insignificant (Table 1). Similar to our results, Gopinath et al. (2009); Göksu (2012); Al-Bayati et al. (2019) reported that there were significant differences among fertilizer treatments and Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013) reported that there were significant differences among pea varieties in terms of seed yield.

As can be seen from the examination of Table 2, the seed yield of the genotypes used in the research, which was 128.75 kg/ha in the control treatment, increased to 226.77 kg/ha in sheep manure treatment, 248.67 kg/ha in cow manure treatment and 300.38 kg/ha in chemical fertilizer treatment. The seed yields of the genotypes varied between 114.90 (16011) - 145.31 kg (Ultrillo x Rondo) in the control treatment, 208.97 (16002) - 245.07 kg (16018) in the sheep manure treatment, 218.36 (16002) - 273.19 kg (16018) in the cow manure treatment and 292.55 (16022) - 325.03 kg (16018) in the chemical fertilizer treatment. Many traits form seed yield in peas as in all other plants, and many factors such as growing conditions and cultural practices (irrigation, sowing frequency and fertilizer etc.) besides the genetic structure of the plant affect the yield (Ceyhan 2004; Ceyhan et al. 2008; Ceyhan et al. 2012). The application of manure and chemical fertilizer increased the yield of peas. The differences between manure and chemical fertilizers show differences in their effects on seed yield as the nutrients they provide to plants differ (Jannoura et al. 2014; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022). In many previous studies, it was reported that fertilizer applications significantly increased grain yield in legume crops including peas (Gopinath et al. 2009; Göksu 2012; Al-Bayati et al. 2019; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

The mean values and groups of seed yields of the genotypes used in the study are given in Table 2. According to the mean values of the locations, the highest seed yield was determined in genotype 16018 with 245.76 kg/da and the lowest seed yield was determined in genotype 16002 with 207.61 kg/da (Table 2). The other genotypes used in the study were Ultrillo x Rondo (242.18 kg/da), 16022 (226.73 kg/da), 16011 (219.39 kg/da) and Betagreen (215.18 kg/da) in descending order (Table 2). The seed yield values of the varieties in this study were in agreement with the grain yields obtained by Ceyhan (2004); Ceyhan et al. (2008); Gopinath et al. (2009); Ceyhan et al. (2012); Göksu (2012); Avcı and Ceyhan (2013); Al-Bayati et al. (2019).

3.8. Protein Content

Fertilizer treatments, genotypes and fertilizer treatments x genotype interaction were found to be statistically significant at 1% level in terms of the protein content of pea genotypes used in the experiment (Table 1). Differences among fertilizer treatments in terms of protein content were reported by Göksu (2012) and differences among genotypes were also reported by Ceyhan (2004); Göksu (2012); Harmankaya et al. (2010); Ceyhan and Şimşek (2021).

As the average of the genotypes, the protein content was determined as 22.46% in the control treatment, 22.62% in the chemical fertilizer treatment, 22.84% in the cow manure treatment and 23.12% in the sheep manure treatment. In the study, protein contents were higher in organic fertilizer treatments than in control and chemical fertilizer treatments. Manure and chemical fertilizers are one of the most effective factors causing changes in plant protein content and improved crop quality (Göksu 2012; Kahraman and Ceyhan 2022; Küçük and Ceyhan 2022).

The highest protein ratio was obtained from genotype 16022 with 23.51%, followed by genotypes 16011 (23.02%), Ultrillo x Rondo (22.68%), Betagreen (22.53%) and 16002 (22.46%). The lowest protein content value

was found in genotype 16018 with 22.40%. The protein content in peas is closely related to the genetic structure of the genotypes and the cultivation technique (Ceyhan 2004; Harmankaya et al. 2010). The results obtained in this study are very similar to the results obtained by Ceyhan (2004); Ceyhan et al. (2005); Harmankaya et al. (2010); Ceyhan and Şimşek (2021).

The highest protein content was determined in genotype 16022 with 24.13% in the sheep manure treatment, while the lowest protein content was determined in genotype 16018 with 22.14% in the control treatment. In terms of protein content, the responses of the genotypes to the fertilizer treatments were very different (Table 2).

3.9. Protein Yield

While the differences among fertilizer treatments and genotypes in terms of protein yield were statistically significant at 1% level, the location x genotype interaction was statistically insignificant (Table 1). Similar to our results, Önder et al. (2001); Ceyhan et al. (2008) reported significant differences among fertilizer treatments and Önder et al. (2001); Ceyhan et al. (2008) reported significant differences among pea varieties in terms of protein yield.

As the average of the genotypes used in the study, protein yield, which was 28.96 kg/ha in the control treatment, increased to 52.47 kg/ha in sheep manure treatment, 56.76 kg/ha in cow manure treatment and 67.91 kg/ha in chemical fertilizer treatment. Ceyhan (2004) reported that fertilizer applications significantly increased protein yield.

According to the mean values of the locations, the highest protein yield was determined in genotype 16018 with 55.07 kg/da and the lowest was in genotype 16002 with 46.63 kg/da (Table 2). The other genotypes used in the study were Ultrillo x Rondo (54.93 kg/da), 16022 (53.35 kg/da), 16011 (50.71 kg/da) and Betagreen (48.45 kg/da) in descending order (Table 2). The protein yields of the varieties in this study agreed with the protein yields reported in previous studies (Ceyhan 2004).

4. Conclusions

Peas grown with organic fertilization give less grain yield than those grown with chemical fertilization. However, considering it provides a more long-term and sustainable nutrient source, it can be easily used in pea cultivation. In addition, it was determined that the protein content of peas grown with organic fertilization had higher values than those grown with chemical fertilization.

The study results showed that organic fertilization is a sustainable and environmentally friendly option for pea cultivation. Organic fertilization offers long-term productivity and nutritional value advantages by maintaining soil health. Therefore, preferring organic fertilization methods by considering environmental impacts will be an extremely important step for the future of agriculture.

Author Contributions: The authors have an equal contribution. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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