Selcuk Journal of Agriculture and Food Sciences
http://sjafs.selcuk.edu.tr/sjafs/index
Research Article
SJAFS
(2022) 36 (2), 174-186
e-ISSN: 2458-8377
DOI:10.15316/SJAFS.2022.023

Determination of Agricultural Characteristics of Local Potato Breeding Lines

Nursel ÇÖL KESKİN[1,*], Rahim ADA[1]

[1]Selcuk University, Faculty of Agriculture, Department of Field Crops, Konya, Türkiye

ARTICLE INFO

Article history:
Received date: 24.05.2022
Accepted date: 06.06.2022

Keywords:
Adaptation
Potato
Solanum tuberosum L.
Tuber yield
Yield components

ABSTRACT

This study aimed to determine the potato breeding lines that show superior agricultural characteristics and can be variety candidates by selection. The experiment was arranged in a randomized complete blocks design in both years with four replications. In the study, 20 potato breeding lines developed by Selcuk University, Faculty of Agriculture, Department of Field Crops and 18 registered varieties as plant material were used in the first year. In the second year, the study continued with 7 breeding lines and 8 registered varieties that were at the end of the first year. In the study; emergence period (days), maturation time (1-9 scale), plant growth type (3-7 scale), plant height (cm), number of main stems per plant (pieces), number of tubers per hill (pieces), average tuber weight (g), tuber yield per hill (g), total, large, medium small, discarded tuber yields (kg da^{-1}), number of eyes per tuber (piece), tuber shape (1-9 scale) were examined. In all field parameters, the differences between genotype in 2019 and between location, genotype and location x genotype interactions in 2020 were statistically significant. The total tuber yield varied between 2001.2 kg da^{-1} and 6029.8 kg da^{-1} in 2019. For the year 2020; It was determined between 2766.4 kg da^{-1} and 5598.2 kg da^{-1}. Among the potato breeding lines in both years, ELAF11 (6029.8 kg da^{-1} in 2019; 4939.9 kg da^{-1} as genotype average in 2020) was the leading line in terms of total tuber yield per decare. Overall, the potato breeding lines that gave the best results differed. ELAF11 and ELAF10 lines were determined as potato breeding lines with high tuber yield.

1. Introduction

Extensive usage area of potato has caused it to become an essential food in many fields of the world. Its usage area includes frozen food products (French fry, potato chips, mashed potatoes), flour, alcohol, starch etc. Its greens and discarded tubers are important for animal feeding (Caliskan et al. 2010).

According to 2019 data, approximately 370.436 million tons potatoes are produced in 17.3 million hectares of field area worldwide. When it is looked at the potato production countries, China is in the first position with 91.8 million tones and it is followed by India (50.2 million tone), Russia (22.1 million tons), Ukraine (20.3 million tons), United States of America (19.2 million tons) and other countries. Turkey is in the 14th position with 5.0 million tons in the list of potato production around the world (Anonymous, 2021a).

The potato production is mainly done in the cities such as Nigde (≅ 689 thousand tons), Konya (≅ 638 thousand tons), Afyon (≅ 551 thousand tons), Kayseri (≅ 540 thousand tons), İzmir (≅ 435 thousand tons), Nevşehir (≅ 289 thousand tons), Aksaray (≅ 250 thousand tons), Adana (≅ 211 thousand tons), Sivas (≅ 192 thousand tons), Bolu (≅ 137 thousand tons) in our country (Anonymous, 2021a).

Although potato production as a primary or second product is possible because of our country's climate, European countries and North countries such as Russia and Ukraine continue to export early potatoes successfully. Our country's early potato export rate of 1 % or 2 % seems insufficient compared with Egypt, Israel, or South Cyprus. Turkey's import rate was 97.348 tons, and the export rate was 288.793 tons in 2019.Potato seeds have been imported such as mainly Holland, Germany, Scotland, Canada, France, Ireland and USA. (Caliskan et al. 2010; Gunel et al. 2010; Anonymous, 2021a). While industrial potato production is over 50 % globally, Turkey's industrial potato production rate is approximately 11 % and is in the growth trend (Caliskan, 2014).

* Corresponding author email: *nurselcol@selcuk.edu.tr;* It is the summary of a part of Nursel Çöl Keskin's Doctorate Thesis

Setbacks in the procurement of certified seeds have caused the farmers to use the crops from last year. Tubers are not pure from diseases; it causes diseases and viruses to spread, consequently, yield decreases critically (Caliskan et al. 2011).

Considering the potato is the most used plant as a seed for unit area, seeds are the biggest input in the cost sheet. Therefore, good and qualified seed usage is essential for a healthy production (Caliskan et al. 2015). During the variety development process, it is necessary to activate the transfer program of local potato varieties that are brought into our country's agriculture to our farmers, found the seed production system, increase the studies for breeding of varieties that have a high special adaption ability other than varieties that have a high general adaption ability (Caliskan et al. 2010, Ozturk and Polat 2017). In recent years, potato variety development studies have been accelerated. In conclusion, there are 191 registered potato varieties today (Anonymous, 2021b).

This study aimed to evaluate the field performance of some trade registered potato varieties and promising variety lines selected as 5th field generation in the breeding program by Associate Professor Rahim Ada and determine the lines that can be variety candidates by making an intended selection.

2. Materials and Methods

This study was conducted in Konya for the first year and both in Konya and Karaman-Akçaşehir locations for the second year of 2019-2020 vegetation periods. In Konya location, field studies were conducted at Selcuk University Faculty of Agriculture Abdulkadir Akcin Trial Field and Karaman-Akcasehir farmer field, as extending to the time period of April and September.

Soil samples were collected from experimental areas at 0-30 cm depth before basal fertilizer application. The all samples were analyzed by Selcuk University, Agriculture Faculty, Department of Soil Science and Plant Nutrition and results are presented in Table 1. The all soil samples show a neutral reaction and have a salt character, a little organic matter content.

Soil samples taken from Konya location in 2019, have included high amount of extractable K, Mg, enough amount of Ca, Mn, Cu, Zn, B and an average amount of N, P, Fe. Soil samples that were taken from Konya location in 2020 included high amount of extractable Mg, Cu, enough amount of Ca, Zn, an average amount of P, Mg, Fe and insufficient amount of N, B. These values of soil samples that were taken from Akcasehir location in 2020, have been determined as high amount of extractable Ca, K, Mg, enough amount of P, Mn, Cu, Zn and insufficient amount of N, B (Namli, 2012; Demir, 2021; Anonymous, 2021c).

Table 1
Some physcial and chemical characteristics of the 0-30 cm soil layer of the experimental sites

Soil parameters	Konya 2019	Konya 2020	Karaman 2020
pH (1:2.5 s:w)	7.46	7.43	7.11
EC (µS cm^{-1}; 1:5 s:w)	208.4	158.8	269
Organic matter (%)	1.08	1.37	1.76
Inorganic nitrogen (%)	20.9	36.1	10.0
$CaCO_3$ (%)	50.8	36.2	38.5
Textural class	Loam	Loam	Clay-Loam
P (mg kg^{-1})	9.33	14	25.3
K (mg kg^{-1})	798	416	630
Ca (mg kg^{-1})	3221	3811	3398
Mg (mg kg^{-1})	565	178	456
Na (mg kg^{-1})	453	108	267
B (mg kg^{-1})	1.45	0.05	0.05
Cu (mg kg^{-1})	1.19	1.17	1.15
Fe (mg kg^{-1})	2.49	3.99	2.65
Zn (mg kg^{-1})	3.42	1.57	1.61
Mn (mg kg^{-1})	5.17	8.82	6.44

The monthly climatic data were obtained from Konya Meteorology Services General Directorate. The mean values of climatic data are given in Table 2. Considering the average temperature values, Karaman location's value was determined as higher at 20.2 Cº than Konya location's (19.9 Cº). According to total precipitation values, Konya location's value (110.9 mm) was determined as higher than Karaman location's (73.2 mm). Considering relative humidity values, Konya location's value (45.2 %) was determined as higher than Karaman (44.3 %) (Table 2).

In the first year of the study 20 promising potato lines and 18 standard potato lines developed by Associate Professor Rahim ADA, were used. In the second year, the performances of 7 promising potato lines and 8 standard potato lines that were selected among the first-year lines were evaluated in different field conditions. The breeding lines were selected as crossbreed seeds developeded to the 5th field generation by selection. The information about these lines and varieties is shown in Table 3.

The study was conducted according to "Randomized Complete Blocks Design" with four replications between 2019 and 2020. Field was plowed with disc harrow and packer; seedbed was prepared in the spring of both first and second years.

In 2019, planting was done manually in the plant beds that were determined by markers as 70 cm x 30 cm (row spacing – intra-row) on 30th April 2019. In 2020, experiments were done by potato planting machine on 20th April 2020 at Konya and on 22nd April 2020 at Karaman. In 2019 experiments, each parcel was organized as 3 meters long and in 2020 experiments, each parcel was organized as 6 meters long by making 2 rows for each genotype.

Seed tubers preserved in suitable conditions were prepared for planting by disinfecting with imidacloprid active substance herbal medicine. The study used 15+15+15 N-P-K for 100 kg da^{-1} bottom fertilizer before planting.In the growing period, 18+18+18 N-P-K for 20 kg da^{-1} easy soluble composite fertilizer, 30 kg da^{-1} ammonium nitrate and 15 kg da^{-1} potassium sulfate fertilizer was used for the surface fertilizing (Bulbul, 2018).

After planting, Defi Maxx, which consists of 800 g l^{-1} prosulfocarb + 80 g l^{-1} metribuzin as the active substance, was used on all the soil surfaces by an herbal medicine pump as a care operation. After the plants were grown taller than 5-10 cm, weeding was done to struggle with weeds. The weeding operation was repeated after 15-20 days. Irrigation was done as drip irrigation regularly every 5 or 7 days. In 2019, the earthing-up operation was repeated manually in the growing and second development processes using a spade. In 2020, earthing up operation was done in every two locations by machine. Fungicidal, insecticide, and foliar fertilizers were used according to the needs. On 23rd September 2019, harvest was done manually when the plants became ready to be harvested. In 2020, potatoes were harvested on 24th September at Konya and on 28th September at Karaman by a potato raising machine..

Table 2
Monthly rainfall, temperature and relative humidity during the growing period of 2019 and 2020*

Months-Konya	Mean Temperature (ºC)			Rainfall (mm)			Relative humidity (%)		
	Long-term	2019	2020	Long-term	2019	2020	Long-term	2019	2020
April	10.9	9.5	10.8	33.2	44.8	35.3	58.4	64.8	59.5
May	15.7	17.8	15.9	39.2	6.8	43.5	56.6	46.0	53.6
June	20.4	21.6	20.3	26.0	62.8	23.9	47.4	51.1	47.9
July	24.1	22.8	25.5	6.0	19.6	0.9	36.6	42.3	36.4
August	23.2	23.3	24.2	6.7	8.4	0.4	39.8	43.2	31.4
September	19.2	19.5	22.6	17.0	6.6	6.9	44.4	42.9	42.6
Mean	22.1	19.1	19.9	-	-	-	47.2	48.4	45.2
Total	-	-	-	128.1	149	110.9	-	-	-

Months-Karaman	Mean Temperature (ºC)		Rainfall (mm)		Relative humidity (%)	
	Long-term	2020	Long-term	2020	Long-term	2020
April	11.5	11.7	36.7	28.2	58.2	56.5
May	16.1	17.3	34.8	14.8	55.9	47.1
June	20.2	21.0	27.6	28.0	49.8	24.5
July	23.4	25.1	0.9	0.0	43.6	5.3
August	23.0	23.3	3.9	0.0	44.5	6.7
September	18.8	22.8	7.4	2.2	49.4	8.8
Mean	18.8	20.2	-	-	50.2	44.3
Total	-	-	116.8	73.2	-	-

*: Climate data provided from Konya Meteorology Services General Directorate

Table 3
Information on potato varieties and breeding lines used in the study

Varieties	Usage	Varieties	Usage	Lines	Usage	Lines	Usage
VR 808	Chips	Marabel	Cooking	AFAG-C	Chips	ELAF-10	Cooking
Brooke	Chips	Agata	Cooking	HEAF-5	Chips	ELAF-11	Cooking
Doruk	Chips	Madeleine	Cooking	T7LA-8	French fry	T3AG-14	Cooking
Russet Burbank (R.B.)	French fry	Melody	Cooking	PA-9	French fry	T1AG-14	Cooking
Lady Olimpia (L.O.)	French fry	Zirve	Cooking	AFLA-9	French fry	T2AG-13	Cooking
Innovator	French fry	Çağlı	Cooking	AFLA-20	French fry	T3PO-13	Cooking
Kutup	French fry	Leventbey	Cooking	AFHE-11	French fry	T3LA-8	Cooking
Agria	Cooking-Chips	Muratbey	Cooking	MK-2	Cooking	PAG-5	Cooking
Jelly	Cooking-Chips			AFK-3	Cooking	AFBR-4	Cooking
Challenger	Cooking-Chips			GAF-4	Cooking	AFAG-12	Cooking

In the study, phenological qualities such as emergence period (day – the time when 50% of seed tubers come to the surface), maturation time (1-9 scale), plant growing type (3-7 scale) (Anonymous, 2001). plant height (cm), number of main stems $plant^{-1}$, number of tubers $hill^{-1}$, tuber yield $hill^{-1}$ (g) that became ready to be harvested were evaluated by covering all the plants for each parcel (Bulbul,2018; Ozyildirim, 2014).

Moreover, average tuber weights (g), average number of eyes $tuber^{-1}$, total tuber yield per decare (kg) and tuber yields per decare that present total tuber yields according to tuber sizes (kg) were determined. These were classified as large (tubers that are stayed on 5.0 cm diameter sieve), medium (tubers that aren't stayed on 5.0 diameter sieve but stayed on 3.5 cm diameter sieve), small (tubers that aren't stayed on 3.5 cm diameter sieve but stayed on 2.8 cm diameter sieve), discarded (tubers that aren't stayed on 2.8 cm diameter sieve) tuber yields (kg). After the harvest, tuber shapes (1-9 scale) were determined by measuring random 5 tubers taken from each parcel according to the formula below (Gunel, 1976; Karan, 2013).

Formula: tuber shape = 100 x [tuber height (mm) / tuber width (mm)].

The data were analyzed using technique of analysis of variance (JUMP) and treatment means were separated by Least Significant Differences (LSD) at 1 % probability level by using MSTAT-C as described by Nissen (1989).

3. Results and Discussion

The variance sources and their statistical significance were shown in Table 4 and 5 for the phenological features, yield and yield components. Data of variance analysis in Table 4 showed that the genotypes' effect on all parameters was statistically significant at 1 % probability level.

According to emergence period values in 2019 year, the highest average emergence duration value was recorded in line T3LA8 (33.3) and the lowest average emergence duration value was recorded invariety Brooke (19.5) and variety Agata (19.8) and classified the same group (Table 6). According to 2020 growing season, in terms of genotype, variety Doruk was in the first group (36.0), variety Brooke (19.3) and line ELAF10 (19.8) classified in the last group (Table 7). Yildirim and Yildirim (2002) reported that emergence duration of tubers was affected by directly or indirectly many factors. These factors can be listed as planting depth, soil content, soil temperature and moisture saturation, and genetic structure of the variety. In addition, Kara at al. (2002) reported that the physiological age of the tuber also directly affected the emergence duration. As the tubers aged physiologically, the number of shoots increased and created direct early emergence. Differences in emergence durations of genotype might be due to these reasons. Previous studies have shown that the there is a close relationship between physiological age and emergence time (Coleman and McInerney, 1997; Coleman and Coleman, 2000; Kammoun et al., 2020). The dormancy period and the earliness of the varieties also affect the emergence period. The earliest emergence duration value was recorded in the very early variety Agata.

Data recorded in plant height values revealed that the response to the years, locations, location x genotype interactions varied according to the genotypes. While the highest plant height value was recorded at line T2AG13 (85.8) in the first growing season, line ELAF11 in terms of genotype (113.9) was the highest value in second growth season. Although plant height is a variety trait, it is also affected by environmental factors such as plant density, day length, temperature, relative humidity, soil content, humidity, and nitrogen content (Caliskan and Incekara, 1980; Gunel et al., 1991; Yilmaz and Tugay, 1999). On the other hand, main maintenance practices such as irrigation also affect plant heights closely (Darabad, 2014). Late varieties are taller than early varieties and it is known that leaf area indexes increase in parallel with this (Manrique et al., 1990; Yilmaz and Tugay, 1999). The Agata variety, which was in the early group, was detected with the lowest plant height value of 45.9 cm in 2019 (Table 6).

As the trial average, the number of main stems was recorded as 4.5 per plant in 2019. The highest number of main stems was observed as 7.0 piece/plant in MK2 line, and the least number of main stems was determined in T2AG13 line with 2.2 piece/plant. 12 of these lines were below the trial average in terms of main stem number (Table 6). Looking at the data for 2020; the average number of main stems of varieties and lines was recorded as 6.1 piece/plant. In terms of main stem numbers, the location average was in the group (a) with 7.3 piece/plant in the Konya region, while the Karaman region represented the group (b) with 4.9 piece/plant. When we evaluate the genotypes; as the highest number of main stems was determined in PAG5 (8.2 piece/plant) and ELAF10 lines (8.1 piece/plant), the lowest main stem number was counted in Melody variety (4.5 piece/plant) (Table 7). Among the factors affecting the number of main stems, the number of shoots on the tuber and the size of the tuber can be listed. Because; the number of main stems is also a determinant for the estimation of tuber size and average tuber weight (Arioglu, 1990; Esendal, 1990). In addition, the temperature of the soil, nitrogen application and day length can be listed among the factors that directly affect the number of main stems (Marinus and Bodlaender, 1975; Fahem and Haverkort, 1988; Gunel and Karadogan, 1991). The data on the main stem numbers determined in this study were similar to the findings of Yilmaz and Tugay (1999), and it was recorded close to the upper limit and at higher values than Hajianfar et al. (2017) and Yilmaz et al. (2018)'s findings.

Table 4
Results of variance analysis of the growth and yield components in the experiment conducted in 2019

Source of Variation	df	Means square					
		Emergence period (day)	Plant height (cm)	Number of main stem plant^{-1}	Number of tubers hill^{-1}	Average tuber weights (g)	Tuber yield hill^{-1} (g)
Replication	3	0.11	0.13	0.01	0.32	319.29	16070.42
Genotypes	37	50.82**	291.05**	4.95**	15.88**	2960.96**	244334.74**
Error	111	0.23	0.23	0.01	0.15	108.87	10041.83

Source of Variation	df	Total tuber yield da^{-1} (kg)	Large tuber yield da^{-1} (kg)	Medium tuber yield da^{-1} (kg)	Small tuber yield da^{-1} (kg)	Discarded tuber yield da^{-1} (kg)	Average number of eyes tuber^{-1}
Replication	3	122.65	636.90	151.14	80.29	3.55	0.35
Genotypes	37	4499073.46**	4359197.05**	473692.66**	19228.42**	3845.87**	14.07**
Error	111	921.06	561.02	297.37	64.49	8.67	0.20

*P < 0.05, **P < 0.01

Table 5
Results of variance analysis of the growth and yield components in the experiment conducted in 2020

Source of Variation	df	Emergence period (day)	Plant height (cm)	Number of main stem plant^{-1}
Location	1	24.30**	351.58**	174.97**
Replication [L]	6	2.23	0.18	0.12
Genotypes	14	2601.92**	1515.23**	10.48**
L x G	14	206.95**	571.12**	13.26**
Error	84	21.27	0.24	0.07
Source of Variation	**df**	**Number of tubers hill^{-1}**	**Average tuber weights (g)**	**Tuber yield hill^{-1} (g)**
Location	1	100.83**	12683.46**	281572.03**
Replication [L]	6	0.08	42.87	456.04
Genotypes	14	44.48**	6261.71**	174046.62**
L x G	14	13.40**	2946.88**	69967.48**
Error	84	0.20	81.32	840.29
Source of Variation	**df**	**Total tuber yield da^{-1} (kg)**	**Large tuber yield da^{-1} (kg)**	**Medium tuber yield da^{-1} (kg)**
Location	1	5171357.53**	128236.33**	3710716.36**
Replication [L]	6	8373.49	6533.02	2794.60
Genotypes	14	3196588.46**	1201170.77**	778438.15**
L x G	14	1285097.50**	1836795.73**	469782.12**
Error	84	1540.01	8737.45	5654.37
Source of Variation	**df**	**Small tuber yield da^{-1} (kg)**	**Discarded tuber yield da^{-1} (kg)**	**Average number of eyes tuber^{-1}**
Location	1	119088.90**	119303.21**	156.41**
Replication [L]	6	1856.43	837.52	0.33
Genotypes	14	493104.46**	96082.67**	76.89**
L x G	14	1093662.08**	80048.37**	8.84**
Error	84	2046.10	940.35	0.25

*P < 0.05, **P < 0.01

According to 2019 data; the average number of tubers per hill of the genotypes examined in the study was 9.5. 9 lines and 13 standard varieties remained below this average value (Table 6). According to the data for 2020; In terms of the number of tubers per hill, the trial average was 8.7. In terms of locations, 9.6 piece/hill were determined in Konya location and 7.8 piece/hill in Karaman location. The number of tubers formed by each main stem gives the number of tubers in that hill. The increase in the number of tubers directly affects the tuber yield per hill and therefore the total tuber yield per decare. As a general expression; the number of main stems, the number of eyes per tuber and the variety characteristics that affect the number of tuber per hill (Yalcin and Tunçturk, 2018). In this study, there were differences in terms of the number of tubers per hill, both in terms of years and locations. This was because; the quality of the seed, the climate and soil conditions, the size of the seed tubers and other agronomic practices (Svensson, 1962). Although the values in this study were within Ozturk et al. (2008) and Yalcin and Tuncturk (2018)'s findings, it was found closer to the lower limit.

Table 6
Means of 2019 year emergence period (day), plant height (cm), number of main stem plant^{-1}, number of tubers hill^{-1}, average tuber weights (g), tuber yield hill^{-1}(g) of 38 potato genotypes evaluated under Konya location.

Genotypes	Emergence period (day)	Plant height (cm)	Number of main stem plant^{-1}	Number of tubers hill^{-1}	Average tuber weights (g)	Tuber yield hill^{-1} (g)
Agata	19.8 s	45.9 x	4.5 j	11.7 cd	88.7 ı-l	1035.0 d-f
Agria	23.8 kl	76.5 d	5.7 d	6.6 q	138.8 a-c	918.6 e-h
Brooke	19.5 s	62.9 m-o	4.8 ı	11.9 c	110.6 d-h	1317.2 ab
Challenger	29.0 de	60.5 s	4.9 hı	11.1 de	84.9 ı-o	942.3 e-g
Çağlı	26.3 gh	62.5 n-p	5.1 fg	8.1 l-p	88.1 ı-m	708.5 ı-m
Doruk	25.8 hı	71.1 f	5.0 gh	7.6 op	120.3 c-e	910.6 e-h
Innovator	24.3 jk	61.9 pq	5.2 ef	8.1 l-p	87.7 ı-n	710.5 ı-m
Jelly	24.8 j	60.8 rs	3.5 pq	7.9 n-p	151.8 a	1201.5 b-d
Kutup	29.5 cd	66.3 j	4.0 m	7.7 op	121.3 c-e	927 2 e-h
L.O.	25.0 ıj	56.5 v	5.7 d	10.2 fg	86.7 ı-n	882.8 f-ı
Leventbey	22.3 no	67.6 hı	3.6 op	7.9 n-p	99.5 f-ı	781.1 g-k
Madeleine	20.8 pr	57.4 tu	3.8 n	7.4 p	147.1 ab	1091.7 c-e

Table 6 (continued)
Means of 2019 year emergence period (day), plant height (cm), number of main stem plant^{-1}, number of tubers hill^{-1}, average tuber weights (g), tuber yield hill^{-1}(g) of 38 potato genotypes evaluated under Konya location.

Marabel	20.8 pr	63.6 lm	4.0 m	8.7 ı-m	149.1 a	1292.4 ab
Melody	25.8 hı	66.7 ıj	5.6 d	13.8 a	85.4 ı-o	1176.7 b-d
Muratbey	24.5 jk	69.9 g	3.5 pq	6.1 q	110.3 d-h	670.3 j-m
R.B.	23.3 lm	63.8 l	3.7 no	6.6 q	128.4 b-d	849.4 f-j
VR808	24.5 jk	52.5 w	4.1 d	9.4 hı	103.7 e-ı	962.0 e-g
Zirve	27.3 f	65.1 k	5.6 j	8.7 ı-m	148.1 a	1286.7 ab
AFAG12	30.0 c	72.7 e	5.3 e	8.8 h-l	95.9 f-j	844.3 g-j
AFAG-C	29.3 c-e	72.3 e	4.3 k	9.0 h-k	137.6 a-c	1243.2 a-c
AFBR4	22.3 no	69.3 g	2.5 s	8.0 m-p	98.2 f-ı	785.6 g-k
AFHER 11	32.3 b	62.1 op	4.3 k	10.4 ef	69.3 m-q	721.4 ı-m
AFK3	21.5 op	61.4 qr	6.3 b	12.3 bc	64.6 pq	794.7 g-k
AFLA20	22.5 mn	64.7 k	4.2 kl	10.2 fg	64.5 pq	656.2 k-m
AFLA9	28.5 e	63.1 l-n	5.3 e	8.6 j-n	87.7 ı-n	747.5 h-l
ELAF10	20.3 q-s	69.5 g	6.3 b	14.5 a	93.5 g-j	1357.3 ab
ELAF11	22.5 mn	75.7 d	3.8 n	12.7 b	111.3 d-g	1407.0 a
GAF4	25.0 ıj	84.6 b	4.0 m	10.4 ef	114.2 d-f	1184.9 b-d
HEAF5	25.0 ıj	61.0 rs	3.6 op	12.1 bc	72.3 l-q	874.6 f-ı
MK2	22.3 no	58.0 t	7.0 a	8.0 m-p	58.6 q	466.9 n
PAG5	21.0 pq	60.5 s	3.0 r	10.2 fg	91.9 h-k	931.7 e-h
PAG9	20.0 rs	53.0 w	4.5 j	10.8 ef	66.1 o-q	713.3 ı-m
T1AG14	27.5 f	57.0 uv	6.1 c	9.5 gh	68.4 n-q	652.0 k-n
T2AG13	29.8 cd	85.8 a	2.2 t	9.4 hı	59.4 q	556.5 mn
T3AG14	26.8 fg	67.6 h	2.7 q	8.3 k-o	78.8 j-p	651.9 k-n
T3LA8	33.3 a	69.7 g	3.4 lm	9.2h-j	77.4 j-p	703.2 ı-m
T3PO13	23.8 kl	71.3 f	4.1 ı	8.0 m-p	73.1 k-q	585.4 l-n
T7LA8	27.5 f	82.9 c	4.8 lm	10.2 fg	94.4 g-j	958.7 e-g
Mean	24.9	65.6	4.5	9.5	98.1	907.9
Lsd $_{genotype\ (0.01)}$	0.89	0.89	0.19	0.72	19.34	185.70

When the average tuber weight data for 2019 was evaluated, the trial average was determined as 98.1 g. The highest average tuber weight was found in Jelly with 151.8 g, Marabel with 149.1 g and Zirve with 148.1 g and represented the same group (a). The lowest average tuber weight was recorded from the MK2 lines with 58.6 g and T2AG13 lines with 59.4 g, and 4 lines (AFAG-C, AFBR4, ELAF11, GAF4) were determined to be above the average (Table 6). Considering the average tuber weight values of 2020; as a location average, Karaman location was ahead of Konya location (111.5 g) with 132.0 g. According to the genotype averages; While AFAG-C line gave the highest value with 200.7 g, Doruk cultivar recorded the lowest value with 95.6 g (Table 7). For 2020, the differences in terms of locations are obvious. Generally, average tuber weights were found to be higher in Karaman location. Lower values were determined in Karaman location regarding tuber numbers per hill (Table 7). As the number of tubers per hill increases, the weight of a single tuber decreases (Caliskan and Arioglu, 1997). In this study, the lower number of main stems of genotypes in Karaman location compared to Konya location decreased the number of tubers per hill. Therefore, competition among plants decreased and it was thought that the few tubers formed grew more. As a result, it can be said that the average tuber weight values are higher in Karaman location (Table7).

Table 7

Means of two locations for emergence period (day), plant height (cm), number of main stem plant^{-1}, number of tubers hill^{-1}, average tuber weights (g), tuber yield hill^{-1}(g) of 15 potato genotypes evaluated in 2020 year.

Genotypes	Emergence period (day)			Plant height (cm)			Number of main stem plant^{-1}		
	Konya	Karaman	Mean	Konya	Karaman	Mean	Konya	Karaman	Mean
Agria	27.5 g	27.5 g	27.5 e	79.9 op	75.5 q	77.7 ı	7.1 de	3.4 o	5.3 fg
Brooke	19.3 l	19.3 l	**19.3 ı**	84.0 m	56.4 s	70.2 k	5.1 k	6.2 g-j	5.7 de
Doruk	34.5 b	37.5 a	**36.0 a**	101.0 h	104.5 c	102.7 b	7.5 d	4.5 m	6.0 cd
Kutup	31.5 d	26.3 h	28.9 d	103.2 de	85.0 l	94.1 e	7.3 de	4.5 m	5.9 d
L.O.	28.3 fg	28.3 fg	28.3 d	76.0 q	53.5 t	**64.7 l**	6.5 f-h	3.3 o	4.9 h
Melody	25.5 h	25.5 h	25.5 f	98.5 ı	104.6 c	101.5 c	6.4 g-ı	2.6 p	**4.5 ı**
R.B.	23.5 ı	22.0 j	22.8 h	101.5 gh	88.0 k	94.7 e	9.3 b	4.6 lm	6.9 b
Zirve	30.3 e	37.3 a	33.8 b	82.0 n	83.8 m	82.9 h	6.4 g-ı	3.5 o	5.0 gh
AFAG-C	31.0 de	31.0 de	31.0 c	85.9 l	80.5 o	83.2 h	6.9 ef	7.1 de	7.0 b
AFBR4	28.3 fg	28.3 fg	28.3 d	80.3 op	104.1 cd	92.2 f	6.6 fg	4.0 n	5.3 fg

Table 7 (continued)
Means of two locations for emergence period (day), plant height (cm), number of main stem plant^{-1}, number of tubers hill^{-1}, average tuber weights (g), tuber yield hill^{-1}(g) of 15 potato genotypes evaluated in 2020 year.

ELAF10	18.8 l	20.8 k	**19.8 ı**	102.1 fg	101.1 h	101.6 c	10.1 a	6.0 ıj	**8.1 a**
ELAF11	25.8 h	28.5 f	27.1 e	125.0 a	102.7 ef	**113.9 a**	10.3 a	4.2 mn	7.2 b
GAF 4	30.5 e	32.5 c	31.5 c	95.8 j	82.0 n	88.9 g	5.8 j	5.0 kl	5.4 ef
PAG 5	22.3 j	25.8 h	24.0 g	66.5 r	79.4 p	73.0 j	6.1 h-j	10.2 a	**8.2 a**
T7LA8	31.5 d	31.5 d	31.5 c	82.1 n	111.6 b	96.9 d	8.3 c	4.3 mn	6.3 c
Mean	**27.2 b**	**28.1 a**	**27.7**	**90.9 a**	**87.5 b**	**89.2**	**7.3 a**	**4.9 b**	**6.1**
Lsd $_{genotype\ (0.01)}$ = 0.66			Lsd $_{genotype\ (0.01)}$ = 0.65			Lsd $_{genotype\ (0.01)}$ = 0.35			
Lsd $_{locationx\ genotype\ (0.01)}$ = 0.93			Lsd $_{locationx\ genotype\ (0.01)}$ = 0.91			Lsd $_{locationx\ genotype\ (0.01)}$ = 0.49			

Genotypes	Number of tubers hill^{-1}			Average tuber weights (g)			Tuber yield hill^{-1} (g)		
	Konya	Karaman	Mean	Konya	Karaman	Mean	Konya	Karaman	Mean
Agria	12.3 bc	6.5 l-n	9.4 e	68.2 o	148.7 e	108.4 fg	831.4 k-m	961.1 gh	896.2 h
Brooke	13.3 a	8.3 gh	10.8 c	92.2 mn	106.7 h-m	99.5 gh	1226.9 b	872.6 jk	1049.8 de
Doruk	11.3 de	13.8 a	**12.5 a**	109.6 h-k	81.6 no	**95.6 h**	1230.1 b	1122.6 cd	1176.3 b
Kutup	6.9 k-m	9.6 f	8.3 f	155.5 d-e	118.2 f-ı	136.8 cd	1058.1 ef	1135.1 cd	1096.6 c
L.O.	7.8 h-j	5.0 p	6.4 h	110.3 g-k	187.8 b	149.1 b	858.1 kl	938.2 hı	898.1 h
Melody	9.5 f	7.3 ı-l	8.4 f	106.9 h-m	150.6 de	128.7 de	1013.8 fg	1099.2 de	1056.5 d
R.B.	7.1 j-l	6.7 k-m	6.9 h	101.8 ı-m	115.2 f-j	108.5 fg	720.2 op	757.0 no	**738.6 j**
Zirve	12.1 cd	12.4 bc	**12.2 a**	108.8 h-m	92.6 l-n	100.7 gh	1306.3 a	1143.1 cd	**1224.7 a**
AFAG-C	6.1 m-o	2.8 q	**4.5 ı**	166.3 cd	235.2 a	**200.7 a**	1013.7 fg	645.5 q	829.6 ı
AFBR4	8.0 g-ı	7.1 j-l	7.5 g	126.6 fg	118.9 f-h	122.8 e	1008.0 fg	833.3 k-m	920.6 gh
ELAF10	13.0 ab	7.3 ı-l	10.2 d	96.3 k-n	107.5 h-m	101.9 gh	1251.2 b	783.2 mn	1017.2 e
ELAF11	12.3 bc	10.6 e	11.4 b	95.9 k-n	107.6 h-m	101.7 gh	1172.7 c	1132.6 cd	1152.7 b
GAF 4	9.4 f	8.8 fg	9.1 e	109.4 h-l	101.0 j-m	105.2 gh	1021.5 f	884.9 ık	953.2 fg
PAG 5	7.5 h-k	5.4 op	6.5 h	109.7 h-k	129.1 f	119.4 ef	818.1 lm	687.5 pq	**752.8 j**
T7LA8	8.1 g-ı	5.7 n-p	6.9 h	114.6 f-j	179.6 bc	147.1 bc	925.0 h-j	1005.9 fg	965.5 f
Mean	**9.6 a**	**7.8 b**	**8.7**	**111.5 b**	**132.0 a**	**121.7**	**1030.3 a**	**933.4 b**	**981.9**
Lsd $_{genotype\ (0.01)}$ = 0.59				Lsd $_{genotype\ (0.01)}$ = 11.88			Lsd $_{genotype\ (0.01)}$ = 38.20		
Lsd $_{locationx\ genotype\ (0.01)}$ = 0.83				Lsd $_{locationx\ genotype\ (0.01)}$ = 16.81			Lsd $_{locationx\ genotype\ (0.01)}$ = 54.02		

The trial average tuber yield per hill was calculated as 907.9 g in 2019. In addition, it was determined that the values for tuber yield per hill in the 2019 season varied between 466.9 g hill^{-1} (MK2 line) and 1407.0 g/hill (ELAF11 line) (Table 6). When we examine the average tuber yield values per hill in 2020; in terms of location averages, Konya location surpassed Karaman location (933.4 g hill^{-1}) with 1030.3 g. According to the genotype averages; Zirve variety with 1224.7 g was recorded with the highest value, while Russet Burbank variety with 738.6 g and PAG5 line with 752.8 g shared the lowest value (Table 7). When the findings of Tuncturk (2006) were compared with the data in this study, it can be said that the data for 2019 was within the limits, and the data for 2020 was close to the lower limit. Yildirim et al. (2005) and Ozturk et al. (2008), it was seen that the data for 2020 was quite high, close to the determined limits of 2019. According to 2020 data, from Konya location to Karaman location; higher tuber yield values per hill were determined; It was determined that there were differences between the numbers in terms of year, location and genotype. It can be said that this may be because the genotypic structures of the varieties and lines are different and that they react differently to the ecological variables related to the years. It was stated in other studies that the effect of ecological conditions on yield is important (Kan and Akinerdem, 2000; Caliskan, 2001; Tuncturk, 2006).

Table 8
Means of 2019 year total tuber yield ha^{-1} (kg), large tuber yield ha^{-1} (kg), medium tuber yield ha^{-1} (kg), small tuber yield ha^{-1} (kg), discarded tuber yield ha^{-1} (kg), average number of buds tuber^{-1} of 38 potato genotypes evaluated under Konya location.

Genotypes	Total tuber yield da^{-1} (kg)	Large tuber yield da^{-1} (kg)	Medium tuber yield da^{-1} (kg)	Small tuber yield da^{-1} (kg)	Discarded tuber yield da^{-1} (kg)	Average number of eyes tuber^{-1}
Agata	4435.7 h	2623.8 n	1432.2 d	296.4 a	83.4 ef	6.9 h-j
Agria	3824.4 l	2914.3 l	757.7 st	131.0 k	21.4 s	6.9 h-j
Brooke	5017.8 d	3945.3 e	900.0 op	134.5 jk	38.1 o-q	6.4 ı-n
Challenger	3979.8 j	1929.8 s	1681.0 a	300.0 a	69.1 ıj	4.9 s-u
Çağlı	3036.3 r	1913.1 st	933.4 mn	125.0 kl	64.9 jk	5.5 o-s
Doruk	3902.4 k	3066.7 j	733.3 t	72.6 rs	29.8 r	5.9 l-q
Innovator	2954.2 s	1398.8 y	1325.0 fg	155.4 hı	75.0 gh	9.5 cd
Jelly	4922.6 e	4092.9 d	740.5 t	46.4 t	42.9 o	7.1 g-ı

Table 8 (continued)
Means of 2019 year total tuber yield ha^{-1} (kg), large tuber yield ha^{-1} (kg), medium tuber yield ha^{-1} (kg), small tuber yield ha^{-1} (kg), discarded tuber yield ha^{-1} (kg), average number of buds tuber^{-1} of 38 potato genotypes evaluated under Konya location.

Kutup	3973.8 j	3078.6 j	785.7 rs	90.5 o-q	19.0 s	6.0 k-p
L.O.	3603.55 n	2197.6 q	1156.0 j	165.5 gh	84.5 e	4.5 t-v
Leventbey	3143.45 q	2460.7 o	560.7 x	88.1 pq	33.9 qr	5.3 p-t
Madeleine	4678.6 g	3915.5 e	684.5 u	61.9 s	16.7 s	5.6 n-s
Marabel	5538.7 c	4782.8 b	636.9 vw	82.1 qr	36.9 pq	5.7 m-s
Melody	4969.7 de	3323.2 h	1310.7 gh	244.1 b	91.7 cd	4.1 uv
Muratbey	2872.6 t	2056.0 r	676.2 u	103.6 m-o	36.9 pq	7.5 gh
R.B.	3466.7 o	2288.1 p	1061.9 k	97.6 n-p	19.0 s	11.6 a
Vr808	4122.6 ı	3139.3 l	876.2 pq	66.7 s	40.5 op	6.6 ı-l
Zirve	5514.3 c	3810.7 f	1528.6 b	125.0 kl	50.0 n	6.3 ı-o
AFAG12	3027.4 r	1928.6 s	943.5 m	112.5 lm	42.9 o	10.5 b
AFAG-C	4736.9 f	3728.6 g	806.5 r	149.4 ı	52.4 n	7.8 fg
AFBR4	3366.7 p	2986.9 k	297.6 y	65.5 s	16.7 s	5.0 r-t
AFHER 11	2414.9 x	1267.9 y	846.4 q	217.3 de	83.4 ef	4.0 v
AFK3	3406.0 p	1738.1 u	1276.2 ı	288.1 a	103.6 b	6.2 j-o
AFLA20	2627.3 v	1615.5 w	733.9 t	206.4 ef	71.4 hı	6.8 h-k
AFLA9	3106.6 q	1541.1 x	1282.7 hı	197.0 f	85.7 e	6.5 ı-m
ELAF10	5817.3 b	4237.5 c	1353.6 ef	167.9 gh	58.3 lm	5.2 p-t
ELAF11	6029.8 a	4946.4 a	907.2 n-p	122.6 kl	53.6 mn	6.3 l-o
GAF4	4158.9 ı	2907.2 l	979.2 l	176.2 g	96.4 c	5.8 l-r
HEAF5	3693.5 m	1872.1 t	1494.1 c	242.9 b	84.5 e	8.8 de
MK2	2001.2 z	1129.2 z	628.0 w	166.7 gh	77.4 g	6.4 l-n
PAG5	3992.9 j	2444.1 o	1308.9 gh	147.1 ıj	92.9 c	4.5 t-v
PAG9	2963.7 s	1309.5 y	1358.3 e	217.9 de	78.0 fg	8.4 ef
T1AG14	2710.1 u	1679.8 v	688.1 u	234.5 bc	107.8 b	9.9 bc
T2AG13	2226.2 y	1611.3 w	238.7 z	222.0 cd	154.2 a	5.2 p-t
T3AG14	2535.1 w	1660.7 v	663.7 uv	150.6 ı	60.1 kl	10.1 bc
T3LA8	2713.7 u	1544.1 x	914.3 m-o	168.5 gh	86.9 de	3.9 v
T3PO13	2272.6 y	1558.9 x	557.1 x	106.5 mn	50.0 n	5.1 q-t
T7LA8	4109.0 ı	2756.6 m	1002.4 l	247.6 b	102.4 b	5.7 m-s
Mean	3733.3	2563.2	949.0	157.7	63.5	6.5
Lsd $_{genotype (0.01)}$	56.24	43.90	31.96	14.88	5.46	0.83

When the total tuber yield values for the first year of the experiment were examined; the trial average was calculated as 3733.3 kg da^{-1}. The highest tuber yield was obtained from the ELAF11 line with 6029.8 kg da-^{1}, and the lowest tuber yield was found in the MK2 line with 2001.2 kg da^{-1} (Table 8). It is known that yield values are closely related to tuber numbers per hill, tuber yield per hill and number of main stems. All of these parameters were determined at lower value in the field season of 2019 compared to the values of 2020. When the total tuber yield values are evaluated in terms of locations, Konya location is ahead of Karaman location (4000.5 kg da^{-1}) with 4416.7 kg da^{-1}. As genotype averages; while the highest yield (5248.5 kg da^{-1}) was obtained from Zirve variety, the lowest yield was determined from Russet Burbank variety with 3165.3 kg da^{-1} and PAG5 lines with 3226.2 kg da^{-1}.When the location x genotype interaction values are examined; the highest yield was obtained from the Zirve variety in Konya location with 5598.2 kg da^{-1}, and the lowest yield was obtained from the AFAG-C line in Karaman location with 2766.4 kg da^{-1} (Table 9).

Table 9
Means of two locations for total tuber yield da^{-1} (kg), large tuber yield da^{-1} (kg), medium tuber yield ha^{-1} (kg), small tuber yield ha^{-1} (kg), discarded tuber yield ha^{-1} (kg), average number of buds tuber^{-1} of 15 potato genotypes evaluated in 2020 year.

Genotypes	Total tuber yield ha^{-1}			Large tuber yield			Medium tuber yield ha^{-1}		
	Konya	Karaman	Mean	Konya	Karaman	Mean	Konya	Karaman	Mean
Agria	3562.9 k-m	4119.1 gh	3841.0 h	1865.2 e-g	741.1 r	1303.1 h	1019.3 m-o	1006.0 m-o	1012.6 ıj
Brooke	5258.2 b	3739.6 jk	4498.9 de	2168.9 cd	1571.4 ı-k	1870.2 c	2038.7 b	1517.9 e-g	1778.3 b
Doruk	5271.8 b	4811.0 cd	5041.4 b	1765.0 gh	3142.9 a	2454.0 a	1853.1 c	1034.2 m-o	1443.6 e
Kutup	4534.7 ef	4864.6 cd	4699.6 c	1234.3 m-o	3080.4 a	2157.3 b	1610.6 d-f	1256.0 ıj	1433.3 ef
L.O.	3677.4 kl	4020.8 hı	3849.1 h	1746.4 gh	1065.5 op	1405.9 f-h	1139.3 j-m	1369.1 hı	1254.2 gh
Melody	4344.8 fg	4710.7 de	4527.8 d	1035.7 pq	2407.2 b	1721.4 d	1645.1 de	1442.9 gh	1544.0 d
R.B.	3086.5 op	3244.1 no	3165.3 j	1291.2 l-n	1699.4 g-ı	1495.3 ef	1192.8 j-l	913.7 o	1053.3 ı
Zirve	5598.2 a	4898.8 cd	5248.5 a	2339.3 bc	2511.9 b	2425.6 a	2374.3 a	1675.6 d	2024.9 a
AFAG-C	4344.5 fg	2766.4 q	3555.5 ı	2220.5 c	1440.5 kl	1830.5 cd	1225.7 jk	608.6 p	917.2 j
AFBR4	4319.8 fg	3571.4 k-m	3945.6 gh	1154.8 n-p	1523.8 jk	1339.3 gh	1729.5 cd	949.4 no	1339.5 fg
ELAF10	5362.4 b	3356.6 mn	4359.5 e	2038.7 de	1066.8 op	1552.8 e	2404.8 a	921.8 o	1663.3 c

Table 9 (continued)
Means of two locations for total tuber yield da^{-1} (kg), large tuber yield da^{-1} (kg), medium tuber yield ha^{-1} (kg), small tuber yield ha^{-1} (kg), discarded tuber yield ha^{-1} (kg), average number of buds $tuber^{-1}$ of 15 potato genotypes evaluated in 2020 year.

ELAF11	5025.8 c	4854.1 cd	4939.9 b	2192.3 cd	1978.2 ef	2085.2 b	1096.1 k-m	1486.3f-hj	1291.2 g
GAF 4	4377.6 f	3792.5 ı-k	4085.1 fg	2232.0 c	1402.6 k-m	1817.3 cd	1267.0 ıj	1431.0 gh	1349.0 e-g
PAG 5	3505.9 lm	2946.4 pq	3226.2 j	1804.8 f-h	867.9 qr	1336.3 h	1022.6 m-o	933.3 no	978.0 ıj
T7LA8	3964.3 h-j	4311.0 fg	4137.7 f	1656.0 h-j	1264.9 mn	1460.4 e-g	1273.8 ıj	1071.5 l-n	1172.6 h
Mean	4416.7 a	4000.5 b	4208.1	1783.0 a	1717.6 b	1750.3	1526.2 a	1174.5 b	1350.3
Lsd $_{genotype\ (0.01)}$= 163.7				Lsd $_{genotype\ (0.01)}$ = 123.2			Lsd $_{genotype\ (0.01)}$ =99.09		
Lsd $_{locationx\ genotype\ (0.01)}$ = 231.6				Lsd $_{locationx\ genotype\ (0.01)}$ = 174.2			Lsd $_{locationx\ genotype\ (0.01)}$ = 140.1		
Genotypes	Small tuber yield			Discarded tuber yield			Average number		
	Konya	Karaman	Mean	Konya	Karaman	Mean	Konya	Karaman	Mean
Agria	466.1 n-p	1863.1 a	1164.6 a	212.3 hı	508.9 b	360.6 c	13.0 d	10.1 h-j	11.6 c
Brooke	647.3 jk	583.3 k-m	615.3 h	403.3 c	67.0 l	235.1 de	11.4 fg	9.9 ıj	10.6 d
Doruk	1465.6 d	445.0 op	955.3 de	188.1 hı	189.0 hı	188.6 f-h	8.9 kl	8.3 lm	8.6 f
Kutup	1572.6 c	312.5 q	942.5 e	117.4 j-l	215.8 g-ı	166.6 g-ı	14.8 c	8.3 lm	11.5 c
L.O.	629.8 j-l	1410.7 d	1020.2 c	161.9 ı-k	175.6 hı	168.8 g-ı	12.1 d-f	10.8 g-ı	11.4 c
Melody	1484.5 d	767.9 hı	1126.2 ab	179.5 hı	92.8 l	136.2 ı	8.3 lm	5.5 qr	6.9 h
R.B.	500.6 m-p	431.6 p	466.1 ı	101.9 l	199.4 hı	150.6 hı	19.9 a	17.5 b	18.7 a
Zirve	704.6 ıj	479.2 n-p	591.9 h	180.1 hı	232.2 f-h	206.1 e-g	10.9 gh	12.4 de	11.6 c
AFAG-C	286.9 q	546.1 l-n	416.5 ı	610.9 a	171.2 ıj	391.0 bc	11.6 e-g	12.1 d-f	11.9 c
AFBR4	1117.9 ef	904.8 g	1011.4 cd	317.6 de	193.5 hı	255.5 d	9.3 jk	5.0 r	7.1 gh
ELAF10	770.1 hı	1173.0 e	971.5 c-e	178.6 hı	195.1 hı	186.8 f-h	9.4 jk	6.0 pq	7.7 g
ELAF11	1129.0 ef	1059.9 f	1094.4 b	608.5 a	329.7 d	469.1 a	14.4 c	12.1 d-f	13.3 b
GAF 4	699.1 ıj	851.0 gh	775.1 f	179.5 hı	107.9 kl	143.7 b	7.0 no	6.8 op	6.9 h
PAG 5	516.7 m-o	875.0 g	695.8 g	161.9 ı-k	270.3 e-g	216.1 d-f	11.0 gh	7.9 mn	9.4 e
T7LA8	466.7 n-p	1699.4 b	1083.1 b	567.9 a	275.3 d-f	421.6 b	11.1 g	6.1 o-q	8.6 f
Mean	830.5 b	893.5 a	862.0	278.0 a	214.9 b	246.4	11.5 a	9.2 b	10.4
Lsd $_{genotype\ (0.01)}$ = 59.61				Lsd $_{genotype\ (0.01)}$ =40.41			Lsd $_{genotype\ (0.01)}$ =0.66		
Lsd $_{locationx\ genotype\ (0.01)}$= 84.30				Lsd $_{locationx\ genotype\ (0.01)}$ = 57.15			Lsd $_{locationx\ genotype\ (0.01)}$ = 0.93		

In potatoes; yield, number of tuber, tuber size, specific gravity and some quality parameters vary greatly according to environmental conditions (Jansky, 2009). The variety candidate must be tested in various locations before acquiring cultivar features. Different locations require standardization of a set of characters affected by environmental conditions and allow to determine the adaptation (Maharijaya et al., 2021). However, it should be taken into account that yield and quality losses pose a potential risk, as new cultivar candidates create phenotypical variations according to environmental conditions (Gold et al., 2020). Total tuber yield values per decare; variation according to genotypes used, location and years were shown. Although the yield values obtained from the Konya location for 2020 were higher than the Karaman values (Table 9); number of tuber per hill and tuber yield values per hill (Table 7) were recorded higher in parallel with this.

As the seed tuber size decreases, tuber yield also decreases. The increase in seed tuber size increases both the number of main stems and the rate of marketable tuber (Yilmaz, 1995). The variation in total tuber yields per decare on the based on locations, years and genotypes has also caused large tuber yields per decare to differ. At the same time, the change in tuber size is an expected result. In this study, large tuber yield values per decare were recorded from Konya location compared to Karaman. Genotypes have had different responses to different environments. This situation was also noted in the results of some researchers on the subject (Yilmaz, 1995; Kara, 2002; Sari et al., 2017; Sanli et al., 2020).

Many factors can be related to the size of the tuber. For example, with delayed harvest, total number of tuber, percentage of large and medium tubers, total tuber yield and plant dry biomass increase (Khan et al., 2011). In a study in which a significant and negative correlation was found between total tuber yield and medium tuber ratio, it was determined that the two main contributors to total tuber yield were average tuber weight and tuber weight per plant (Arslan, 2007). There were obvious differences between locations in the medium tuber yields of this study. This situation was also reflected in the location x genotype interactions. When the average tuber yield per decare was examined, values for the 2020 year were higher than that of 2019. In addition, medium tuber yields in tuber distributions were higher in Konya location (Table 9). The values obtained in terms of medium tuber yields, were found Kara et al. (2002)'s findings closer to the upper limit, Ozturk et al. (2007) 's findings quite higher than the limits.

Considering the trial averages of small tuber yield per decare, 2020 was found to be higher. In addition, based on location in tuber distribution, small tuber yields were higher in Karaman location. Many researchers found small tuber yields per decare in different ranges. These values were; according to 2019 data, it was close to the lower limit of Kara (2002) (136.4-376.7 kg/da), Ozturk et al. (2007) (119.5 kg/da-289.5 kg/da). Yield values for 2020; remained at high values like other large and medium tuber yield parameters. The increase in total yield can be explained by the change in tuber distribution and the increase in values.

Considering the trial averages of discarded tuber yield per decare, it was found that higher values were found in 2020 compared to 2019 (278.0 kg/da) (Table 9). In addition, discarded tuber yields based on location in tuber distributions were higher in Konya. Caliskan (2001) and Sanli and Karadogan (2012) reported that the lower tuber size in cultivars with a high number of tuber per hill and low tuber yield per hill caused an increase in discarded tuber yield. Although this is also valid for the discarded tuber yields of this study; it may also be a result related to environmental conditions and the development status of plants.

The number of eyes in the tuber in both years of the trial; according to the genotype used, location and years varied. The trial average of the average number of eyes in tuber in 2019 was 6.5 pieces (Table 9). According to the data of 2020; when the number of eyes in the tuber were compared in terms of location, Konya location surpassed Karaman location (9.2 pieces) with 11.5 pieces. According to the genotype averages; Russet Burbank with the highest value 18.7 pieces/tuber. While it represented group (a), the lowest value was detected in GAF4 line and Melody variety with 6.9 pieces and took place in the same group (g). The location x genotype interactions; Konya x Russet Burbank with 19.9 pieces/tuber. The trial average was calculated as 10.4 pieces/tuber (Table 9). The number of eyes per tuber increases with tuber size. At the same time, it is known that the eyes of tubers with large seeds are larger than the eyes of tubers with small seeds, and the differences are due to the variety (Allen, 1978). Many researchers have reported that increasing the number of eyes also increases the tuber yield, on the contrary, the average tuber yield decreases (Mahmud et al. 2010; Sanli et al., 2015). According to the number of eyes in the tuber of this research; Although the number of eyes per tuber was higher in Konya location (Table 8 and Table 9), the number of tubers per hill (Table 6 and Table 7) and the total tuber yield per decare (Table 8 and Table 9) were also higher in the same location. This result confirms the opinion of the researchers mentioned above.

Maturation time was classified according to the drying periods of the upper part of the plant. There is a significant relationship between tuber maturation time, tuber yield and starch content. Late maturing varieties tend to produce higher tuber and starch yields (van Eck, 2007; Camire et al., 2009). Also, late maturing cultivars have higher yield potential than early maturing cultivars. Among the reasons potato varieties and lines mature at different times in terms of year and location; environmental conditions, temperature, day length and characteristic features of the variety can be counted. In terms of environmental conditions, the fact that the vegetative part of the plant stays alive longer in years or locations where precipitation or irrigation is good causes the maturation period to prolong. In addition, the ripening period is prolonged in high and cool areas (Yilmaz and Tugay, 1999). The two most important factors affecting the storage quality of potatoes are dormancy periods and maturation characteristics. it is imperative to adjust the storage time and temperature by paying attention to the variety characteristics (Ozcan et al., 2019). For this reason, the maturation time parameters must be taken for their storage resistance. In general, when the studies with standard varieties were examined; In terms of maturation times, many researchers were recorded values similar to the scale values determined in this study (Şanlı and Karadoğan, 2012; Karan, 2013; Bülbül, 2018).

Table 10
Maturation time[A], plant growth type[B], tuber shape[C] scale values of the trial conducted in Konya location in 2019*

Varieties	A	B	C	Lines	A	B	C
Agata	1	5	7	AFAG12	5	5	7
Agria	5	3	7	AFAG-C	5	3	3
Brooke	5	7	5	AFBR4	7	5	7
Challenger	5	5	7	AFHER 11	5	7	8
Çağlı	3	5	7	AFK3	5	7	5
Doruk	7	3	3	AFLA20	5	3	3
Innovator	5	3	8	AFLA9	7	5	8
Jelly	7	3	7	ELAF10	5	5	3
Kutup	5	5	7	ELAF11	5	5	5
L.O.	5	5	7	GAF4	7	3	5
Leventbey	5	5	5	HEAF5	3	5	3
Madeleine	7	3	7	MK2	3	3	7
Marabel	5	5	7	PAG5	5	3	7
Melody	7	5	5	PAG9	3	3	7
Muratbey	5	3	7	T1AG14	5	5	8
R.B.	5	5	8	T2AG13	9	5	7
Vr808	5	7	3	T3AG14	5	5	7
Zirve	5	5	5	T3LA8	7	5	8
				T3PO13	3	3	3
				T7LA8	7	5	8

*A: 1 = very early, 3 = early, 5 = medium early, 7 = late, 9 = very late; B: 3= upright, 5= semi-upright, 7=tilt; C: 1=(<98mm) inverted oval, 2=(98mm-104mm) round, 3=(104mm-110mm) round-oval, 4= (110mm-120mm) oval round, 5= (120mm-130mm) oval, 6=(130mm-145mm) oval long, 7=(145mm-160mm) long oval, 8= (160mm-200mm) long, 9=(>200mm) very long

Table 11
Maturation time[A], plant growth type[B], tuber shape[C] scale values of the trials conducted in Konya[1] and Karaman-Akcasehir[2] locations in 2020*

Genotypes	A1	A2	B1	B2	C1	C2
Agria	5	7	3	3	7	3
Brooke	5	5	7	7	3	5
Doruk	7	7	3	3	3	3
Kutup	5	5	5	5	7	3
L.O.	5	5	5	5	8	7
Melody	7	7	5	5	3	3
R.B.	5	5	5	5	9	8
Zirve	5	5	5	5	1	7
AFAG-C	5	5	3	3	7	8
AFBR4	7	7	5	5	7	7
ELAF10	5	7	5	3	3	5
ELAF11	5	5	5	3	3	3
GAF4	7	7	3	3	5	5
PAG5	7	5	3	3	8	7
T7LA8	5	7	5	7	8	5

*A: 1 = very early, 3 = early, 5 = medium early, 7 = late, 9 = very late; B: 3= upright, 5= semi-upright, 7=tilt; C: 1=(<98mm) inverted oval, 2=(98mm-104mm) round, 3=(104mm-110mm) round-oval, 4= (110mm-120mm) oval round, 5= (120mm-130mm) oval, 6=(130mm-145mm) oval long, 7=(145mm-160mm) long oval, 8= (160mm-200mm) long, 9=(>200mm) very long

The plant growth type was recorded by observation when the plants started to cover the soil. Selection criteria based on phenotypes, such as plant growth type, flower and leaf colors, are grouped according to certain scales with the eye of the breeder. In this way, the breeder obtains information about the plant and selects it in terms of plant growth. As a plant type, upright growing plants have a higher leaf area index and benefit more from light (Beukema and van der Zaag, 1990).

When both years are compared in tuber shape scale values, Brooke, ELAF11, Melody, PAG5, Russet Burbank, Lady Olympia, AFAG-C and Zirve genotypes are among the genotypes that differ in tuber shape. Consumer market share is directly related to the size of potato tubers. Producers aim to implement the breeding program in such a way as to get the best yield in field production in order to maximize tuber size. Tuber size varies with many different growing packages and applications in the field. For example; Inter-row and above-row applications, late sowing, early harvest, amount of fertilizer and water inputs, different growth regulators, and changing the physiological age of seed tuber can be counted (Pavek, 2014). The length/width ratio of the potato tuber is an indicator of the phenotype shape of the tuber used in potato breeding (Si et al., 2018). In this study, most of the lines in the 2019 season were eliminated due to the tuber type in amorphous structure. When evaluated in general; Although tuber size scales of cultivars are cultivar characteristics, there was an increase and decrease in tuber size in some genotypes related to yield and yield components.

4. Coclusion

Tuber yield is accepted as the main criterion in potato breeding. According to the 2019 growing season; when the lines were evaluated, the highest tuber yields per decare were obtained in the ELAF11 (6029.8 kg da^{-1}) line. However, yield values differ in year and location; It was determined as 5362.4 kg da^{-1} in the ELAF10 line for 2020 and was determined below the 2019 trial average. The distribution of large and medium tubers per decare is as important as the total tuber yield per decare. Marketable tuber yield is preferred because it is the size demanded by the consumer. In addition, there are certain size standards for chips and French-fries. On the other hand, tuber shape is the breeding criterion sought to minimize shell loss. The presence of amorphous tubers negatively affects the peeling efficiency and is one of the most important consumer preference criteria. Accordingly, although it varies according to the growing regions and years, the lines are generally recorded as round oval, oval shape. In addition, the tuber shape of the GAF4 and PAG5 lines was one of the most striking lines. As a result of the field studies, ELAF11 and ELAF10 lines were determined as potato breeding lines with high tuber yields.

5. Acknowledgements

The study was supported by OYP allowances numbered as 2018-OYP-007; and also, we would like to thank the authorities and our coordinator who provided us this opportunity.

6. References

Allen E (1978). Plant density, In: The Potato Crop, Eds: Springer, p. 278-326.

Anonymous (2001). Seed Registration Certification Central Directorate, Agricultural values measurement and evaluation instruction (Potato), https://www.tarimorman.gov.tr/BUGEM/TTSM/Belgeler/Tescil/Teknik%20Talimatlar/End%C3%BCstri%20Bitkileri/pates.pdf: [Visit Date: 10.04.2021]

Anonymous (2021a). Turkish statistical institute data, www.tuik.gov.tr, [Visit Date: 26.03.2021].

Anonymous (2021b). TTSM https://www.tarimorman.gov.tr/BUGEM/TTSM/Menu/30/Kayit-Listeleri [Visit Date: 10.04.2021].

Anonymous (2021c). Physical properties of mineral soils lecture notes (Chapter 7), https://acikders.ankara.edu.tr/pluginfile.php/51509/mod_resource/content/0/7.%20Hafta.pdf: [Visit Date : 11.04.2021].

Arioglu H (1990). Starch sugar crops, Adana, A.U. Faculty of Agriculture Textbook No: 22.

Arslan B (2007). Relationship among yield and some yield characters in potato (*S. tuberosum* L.), *Journal of Biological Sciences*, 7 (6), 973-976.

Beukema H, van der Zaag DE (1990). Introduction to potato production, In, Eds: Pudoc Wageningen.

Bulbul MK (2018). Determination of yield and quality traits of some potato breeding lines under early and main crop, Master's thesis. Niğde Ömer Halisdemir University, Institute of Science and Technology, Niğde.82 p.

Caliskan C, Incekara F (1980). Photoperiodic thermal behavior of some different potato varieties, Turkey I. Potato Congress Communiqués, Ankara, 57-67.

Caliskan ME, Arioglu H (1997). The effect of different planting times on earliness and tuber yield of some potato varieties in early season potato cultivation in Çukurova region, Turkey II. Field Crops Congress, Samsun, 652-654.

Caliskan ME (2001). Determination of yield and quality characteristics of some potato varieties in different ripening groups in Hatay ecological conditions, Journal of MKU Agriculture Faculty, 6 (1-2), 39-50.

Caliskan ME, Onaran H, Arioglu H (2010). Overview of the Turkish potato sector: challenges, achievements and expectations, *Potato Research*, 53 (4), 255-266.

Caliskan ME, Karaat EF, Celen H (2011). Comparison of Seed Potato Production and Certification Systems Turkey and Some Selected Countries. Turkey IV. Seed Congress: 37-47.

Caliskan ME (2014). Potato production in Turkey and our potato policy, TURKTOB Magazine, 10: 20-26.

Caliskan ME., Sogut, T, Demirel U, Arioglu H (2015). Changes and New Searches in Starch and Sugar Crops Production. Turkey Agricultural Engineering VIII. Technical Congress. Ankara: 426-449.

Camire ME, Kubow S, Donnelly DJ (2009). Potatoes and human health, *Critical reviews in food science and nutrition*, 49 (10), 823-840.

Coleman WK, Coleman SE (2000). Modification of potato microtuber dormancy during induction and growth in vitro or ex vitro, *American Journal of Potato Research*, 77 (2), 103-110.

Coleman WK, McInerney J (1997). Enhanced dormancy release and emergence from potato tubers after exposure to a controlled atmosphere, *American Potato Journal*, 74 (3), 173-182.

Darabad GR (2014). Determining effects of irrigation stress on growth and yield of potato cultivars in Ardabil cold region, *Journal of Biodiversity and Environmental Sciences (JBES) Vol*, 4, 318-326.

Demir Y (2021). Plant Nutrition lectures, http://www.bingol.edu.tr/documents/Ziraat%20Fak%C3%BClte%20Plant%20Nutrition%20Notes%C4%B1.pdf

Esendal E (1990). Starch sugar crops and breeding volume: 1 Potato, Ondokuz Mayıs University, Faculty of Agriculture (49).

Fahem M, Haverkort A (1988). Comparison of the growth of potato crops grown in autumn and spring in North Africa, *Potato Research*, 31 (4), 557-568.

Gold KM, Townsend PA, Herrmann I, Gevens AJ (2020). Investigating potato late blight physiological differences across potato cultivars with spectroscopy and machine learning, *Plant Science*, 295, 110316.

Gunel E (1976). A study on the effects of different planting and harvest times on potato yield, some agronomic and technological characters in Erzurum ecological conditions, Ataturk University. Faculty of Agriculture Department of Field Crops (Associate Professor's Thesis, Unpublished) Erzurum.

Gunel E, Karadoğan T (1991). The effect of some physiological stresses on the yield of potatoes, Yüzüncü Yıl University Journal of Agricultural Sciences, 1 (3), 38-54.

Gunel E, Caliskan ME, Kusman N, Tugrul K, Yilmaz A, Agirnasligil T, Onaran H (2010). Production of starch and sugar crops, Turkey Agricultural Engineering VII. Technical Congress, 11-15.

Hajianfar R, Hassanpanah D, Nosrati AE (2017). Evaluation of advanced potato clones derived from breeding program in spring cultivated areas of Iran, *Bioscience Biotechnology Research Communications*, 10, 125-131.

Jansky S (2009). Breeding, genetics, and cultivar development, In: Advances in potato chemistry and technology, Eds: Elsevier, p. 27-62.

Kammoun M, Essid, MF, Ksouri F, Rokka VM, Charfeddine M, Gargouri-Bouzid R, Nouri-Ellouz O (2020). Assessment of physiological age and antioxidant status of new somatic hybrid potato seeds during extended cold storage, *Journal of Plant* Physiology, 254, 153279.

Kan Y, Akınerdem F (2000). Investigation on adaptation of some potatoes varieties under Konya ecology, Journal of Selçuk University Faculty of Agriculture (Selçuk Journal of Agriculture and Food Sciences), 14 (22), 124- 130.

Kara K (2002). A research on yields and adaptation of some potato varieties in ecological conditions of Erzurum, Journal of Anadolu Aegean Agricultural Research Institute, 12 (1), 105-121.

Karan YB (2013). Stability analyses of superior clones selected among genotypes from some potato (*Solanum tuberosum* L.) crosses and selectıon of new cultivar candidates, Doctorate Thesis, Graduate School of Natural and Applied Science Department of Field Crop Science, Gaziosmanpasa University, Tokat, 114p.

Khan A, Jilani M, Khan M, Zubair M (2011). Effect of seasonal variation on tuber bulking rate of potato, *The Journal of Animal & Plant Sciences*, 21 (1), 31-37.

Maharijaya A, Syukur M, Salma LN, Sanubary UL (2021). Diversity and performance of eight new promising potato (*Solanum tuberosum*) genotypes in Garut District, West Java, Indonesia, *Biodiversitas Journal of Biological Diversity*, 22 (5).

Mahmud A, Hoque M, Mamun A, Bazzaz M, Hossain M. (2010). Yield and profitability of potato as influenced by intra-row spacing and number of eye in cut tuber in northern region of Bangladesh.

Manrique L, Hodges T, Johnson B (1990). Genetic variables for potato, *American Potato Journal*, 67 (10), 669-683.

Marinus J, Bodlaender K (1975). Response of some potato varieties to temperature, *Potato Research*, 18 (2), 189-204.

Namli A (2012). Soil chemical properties lecture notes, https://acikders.ankara.edu.tr/pluginfile.php/25482/mod_resource/content/1/4trak%20chemical%20oz_plant%20besin%20materileri.pdf

Nissen O (1989). MSTAT-C a Micro computer programme design, management and analysis of agronomic research projects. Michigan State University, East Lansing, Michigan, USA.

Ozcan S, Sanli A, Ok FZ (2019). Determination of storage responses and quality changes of some potato (*Solanum tuberosum* L.) cultivars during storage, Turkish Journal of Agriculture -Food Science and Technology, 7(sp2) , 59-66.

Ozturk E, Kara K, Polat T (2007). The effects of nitrogenous fertilizer forms and application times on tuber yield and tuber size of potato, Journal of Tekirdag Agricultural Faculty, 4 (2), 127-135.

Ozturk E, Polat T, Kavurmaci Z, Kara K (2008). Determination of the tuber yield and yield components of some potato genotypes under erzurum conditions, International Journal of Agricultural and Natural Sciences, 1 (1), 15-18.

Ozturk E, Polat T (2017). Seed potato production and ıts ımportance, Alinteri Journal of Agricultural Sciences, 32 (1), 99-104.

Ozyildirim N (2014). Effects of nitrogen fertilizer forms on yiled and yiled components of potato (*Solanum tuberosum* L.) genotypes of different maturity group, Master's thesis. Ataturk University, Erzurum, 58p..

Pavek MJ (2014). Commercial potato production and cultural management, *Book: The potato: botany, production and uses,* 83-102.

Sanli A, Karadoğan T (2012). Evaluation of yield and quality performances of some potato cultivars from different maturity groups under the ecological conditions of Isparta, Suleyman Demirel University Journal of Natural and Applied Sciences, 16 (1), 33-41.

Sanli A, Karadogan T, Erbas S, Tosun B (2015). The effects of plant density and eye number per seed piece on potato (*Solanum tuberosum* L.) tuber yield, *Scientific Papers-Series A, Agronomy*, 58, 325-331.

Sanli A, Cirit Y, Tosun B (2020). The effects of organic fertilization and reduced nitrogen fertilizer applications on yield and some yield components of potato (Solanum tuberosum L.), Journal of the Faculty of Agriculture, 15 (2), 179 -185.

Sari S, Karadoğan T, Sanli A (2017). Determination of tuber abnormalities of some potato cultivars and quality of abnormal tubers, Suleyman Demirel University Journal of Natural and Applied Sciences Volume 21, Issue 2, 592-598, 2017.

Si Y, Sankaran S, Knowles NR, Pavek MJ (2018). Image-based automated potato tuber shape evaluation, *Journal of Food Measurement and Characterization*, 12 (2), 702-709.

Svensson B (1962). Some factors affecting stolon and tuber formation in the potato plant, *European potato journal*, 5 (1), 28-39.

Tuncturk M (2006). Determination of tuber calibration and quality in potatoes grown (*Solanum tuberosum* L.) in Van condition, Selcuk Journal of Agriculture and Food Sciences, 20 (39), 63-70.

van Eck H J (2007). Genetics of morphological and tuber traits, In: Potato biology and biotechnology, Eds: Elsevier, p. 91-115.

Yalcin U, Tuncturk M (2018). Determining of adaptation properties of some types of potato (Solanum tuberosum L.) in Bitlis – Ahlat ecological conditions, *Yuzuncu Yıl University Journal of Science Institute*, 23 (1), 1-9.

Yildirim B, Tuncturk M, Ciftci C (2005). Effects of various planting times on the yield and yield traits of different potato cultivars (Solanum tuberosum L.), Yüzüncü Yıl University Journal of Agricultural Sciences, 15 (1), 1- 9.

Yildirim M, Yildirim Z (2002). Potato breeding and biotechnology, İzmir, Ege University Faculty of Agriculture, Supplementary Textbooks.

Yilmaz G (1995). Effects of different seed tuber sizes on tuber yield and some traits of potato (Solanum tuberosum L.), Journal of Agricultural Faculty of Gaziosmanpaşa University, 12, 152-161.

Yilmaz G, Tugay, M (1999). Genotipe x environment interactions in potato II. the investigation based on environmental factors, Turkish Journal of Agriculture and Forestry, 23, 107-118.

Yilmaz G, Karan YB, Spilled S, Tatli M (2018). Obtaining original seed tubers from elite seed tubers of different sizes. Turkey 6th Seed Congress with International Participation. Nigde.