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Research Article

Determination Effects of Active Dry Yeast on Morphological and Chemical Components of Maize Plants Grown in Alkaline Soils for Silage Purposes

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Abstract: In agriculture, the use of environmentally friendly materials both in place of and alongside chemical ones is continuously increasing. Two field experiments were conducted during the 2019 and 2020 seasons to investigate the effects of foliar application of three doses (5.0, 7.5, and 10 g L^{-1}) of active dry yeast were sprayed on maize (*Zea mays* L. Cv. Tuano) at two intervals, the first 54 days after planting (DAP), and the second 15 days later. Plants were grown for silage purposes under alkaline soil conditions at the Experimental and Research Station of the Field Crops Dep., Van Yuzuncu Yıl University-(VYYU), Turkey. Measurements were taken three times at the vegetative stage 64, 74, and 84-DAP, and one times at the dough stage 117-123 DAP. Morphologically, the results showed that the foliar application of different doses of yeast increased the plant height (cm), stem, leaves, and cobs weight per plant and total plant weight (g), number of cobs $plant^{-1}$ (piece), and green and dry herbage yield (ton da^{-1}) at 117-123 DAP during the two seasons. In contrast, there was no significant increase in plant height (cm), chlorophyll as SPAD (The Soil Plant Analysis Development) value, and the number of leaves per plant at 64 DAP. Chemically, the spraying of the yeast improved the P, K, Ca, Mg, Fe, Cu, Se, and Zn concentrations at 117-123 DAP as well as chlorophyll content at 74 and 84 DAP compared to the control. From this study, it could be concluded that the highest values of the studied parameters were recorded when active dry yeast was used at a dose of 10 g L^{-1} on maize under high pH soil.

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1. Introduction

Maize or corn is one of the most important cereal crops in the world. It is grown under a wide range of agronomic and environmental circumstances (Khan et al., 2014; Rouf Shah et al., 2016). It is the main source of energy and food source for humans and animals in addition to its content of natural phytochemical compounds such as pigments, substantial fats, and starch (Rouf Shah et al., 2016; Kaul et al., 2019). Moreover, over the past few decades, the silage of corn has become the main fodder ingredient in the dairy cows' rations (Khan et al., 2014). The cultivation area of corn produced for silage in Turkey is approximately 4.7 million decares. Total silage corn production is 23.2 million tons, and the silage yield is 4915 kg da^{-1} on average, although it may vary by region (Acar et al., 2020). 73% of corn production in the world and 90% in developed countries is used for animal feeding. In Turkey, 70% of corn production, which ranks third after wheat and barley, is used for animal nutrition (Öz et al., 2017).

Nutrient materials solubility and availability, in addition to soil microorganism activity, mainly depend on soil reaction (pH). Most micronutrients, for instance, are less available in neutral-alkaline soils compared to acid soils, which are considered the preferred conditions to plant growth (Lončarić et al., 2008). In general, under alkaline soil conditions, the availability of most macronutrients is increased. In contrast, the availability of micronutrients and some macronutrients such as phosphorus is decreased. This decrease leads to a negative impact on plant growth and yield (Jiang et al., 2017). According to the salinity and alkalinity criteria used in the Turkey Improved Soil Map studies, there is a problem with salinity and alkalinity in an area of 1.518.722 ha in Turkey. Where 0.5% is alkaline, 8% is slightly salty alkali, and 17.5% is salty alkali. The barren lands are equivalent to 5.48% of the total cultivated agricultural lands (Sönmez and Beyazgül, 2008).

The use of bio/organic fertilizers is increasing all over the world for environmental and human health safeguard purposes, which has become endangered as a result of the excessive use of chemical fertilizers and pesticides (Agamy et al., 2013). Bio-stimulants influence plant metabolism if it used in low concentrations through prompting of natural plant growth regulators driving and vigor, reinforcement of nutrients absorption, enhancement of root growth, and increasing resistance to stress as abnormal conditions. In addition, these materials could be used as systemic agents when they are applied as a foliar application (Hassan et al., 2020).

Abbas (2013) and Alsaady et al. (2020) concluded that the application of bio-stimulants such as yeast in small quantities affected several metabolic processes and promoted plant growth, productivity, and development through increased photosynthesis, natural hormones, ion uptake, and protein synthesis as well as a relative increase in the availability of the micronutrients in the soil. It may also increase antioxidants and enhance metabolism and water holding capacity.

Yeast *Saccharomyces cerevisiae* extract, which is plant nutritious as well as an, environmentally friendly, and convenient to use, has a feature over common plant growth regulators and soil conditioners (Xi et al., 2019) and includes natural plant hormones i.e., free and associated IAA, free GA_3 and associated GA_3 (Twfiq, 2010) and vitamins, amino acids, necessary macro and micronutrients for plant growth, and growth stimuli such as Cytokinins (Medani and Taha, 2015) and it is counted as a natural source of biostimulants that motivate some enzymes, cell expansion and division, synthesis of pigments, and nucleic acid and protein formation (Wanas, 2006), and also it releases CO_2 which leads to improvement of photosynthesis (Kurtzman and Fell, 2005). Al-Shaheen et al. (2019) stated that the application of active dry yeast had positive effects on corn plants. All sprayed maize plants with active dry yeast extract produced the highest yield rate of all the studied characters.

This research aimed to study the effect of spraying bio-fertilizers (active dry bread yeast) in improving the growth of maize crops for silage purposes under alkaline soil conditions.

2. Material and Methods

Two field experiments were performed to evaluate the effects of active dry yeast on the growth, morphological changes, and chemical constituents of maize (*Zea mays* L. Cv. Tuano) for silage purposes. The experiments were carried out in the experimental field of VYYU-Campus, Fac. Agric., Field Crops Department as well as in the Science Application and Research Center labs, Van, Turkey, during the two successive summer seasons, 2019 and 2020. Some climatic data of the province of Van during the years of the experiment are given in Table 1. The average temperature in Van city in the 2019 and 2020 seasons were higher than the average temperature for the long years. In contrast, total precipitations in the experimental seasons (2019 and 2020) were lower than the long-term ones. The same trend was recorded for the average humidity in Van city during the 2019 and 2020 seasons were lower compared to long years average, as shown in Table 1.

Table 1. Some climate values of the experimental area for the years 2019 and 2020 and the long-term average*

Month	Average Temperature (ºC)			Total Precipitation (mm)			Average Humidity (%)		
	2019	2020	Long Years	2019	2020	Long Years	2019	2020	Long Years
April	7.2	8.6	8.4	36.2	50.9	57.4	66.1	65.4	59.3
May	15.4	14.5	13.4	15.3	27.8	45.3	51.9	54.0	55.1
June	21.4	19.3	18.8	7.2	13.4	16.4	45.4	44.4	47.1
July	23.0	23.0	22.7	0.4	17.9	6.9	39.0	46.4	42.3
August	23.7	21.6	22.9	0.9	10.0	5.3	40.2	44.5	40.5
September	18.8	20.1	18.3	0.8	5.6	20.4	43.9	41.3	43.9
October	13.4	13.3	12.0	24.1	1.8	48.2	52.9	47.2	57.3
Mean/Total	17.6	17.2	16.6	85	127	199	48.4	49.0	49.3

* Van Meteorology Regional Directorate records.

Soil samples were randomly taken each year before cultivation at the two depths of 0-20 and 20-40 cm, and were subjected to some physical and chemical analysis (VYYU, Fac. Agric., Dep. Soil Science and Plant Nutrition) were illustrated in Tables 2. Experiments soil pH ranged between 7.94 and 8.16 in the 0-20 cm and 20-40 cm, respectively. The experiment's soil was sandy-clay in VYYU-Campus, as shown in Table 2.

Table 2. Some physical and chemical analysis of the soil experimental field

Deep	pH Sat.	Clay (%)	Silt (%)	Sand (%)	Lime (%)	Ca+Mg (me $100g^{-1}$)	CEC (me $100g^{-1}$)	Organic Matter (%)
0-20	7.94	35.08	20.95	43.97	21.06	13.30	16.00	1.87
20-40	8.16	31.76	18.88	49.39	21.41	14.25	17.00	1.69

Maize seeds were obtained from the Van Directorate of Provincial Agriculture and Forestry. Seeds were sown on 15th May in both seasons, and all experimental units were 5.0×3.5 m, containing 6 rows (70 cm between rows) and 12 cm between plants. The distance between plots has been arranged as 2 m and between blocks as 3 m. With the planting, fertilizer will be applied to all plots at the rate of 8 kg N da^{-1} at the first batch and 8 kg P_2O_5 da^{-1}. When corn is 50-60 cm tall, second dose of nitrogen fertilizer will be applied at the rate 10 kg N da^{-1} (Sabancı, 2015). Hoeing has been done two times to cover the bottom of the plant stem, aerate the soil, and fight weeds. Plants were irrigated with a sprinkler irrigation system. The active dry yeast was prepared from bread yeast (*Saccharomyces cerevisiae*), by solving dry yeast in hot water, then added sugar in a ratio of 1:1 and kept in a warm place for 24 hours, according to Morsi et al. (2008). Three different doses of active dry bread yeast (5.0, 7.5, and 10.0 g L^{-1}), as well as control plots treated with tab water, were sprayed on maize plants under alkali soil stress two times started at 54 DAP and repeated after 15 days.

2.1. Data Recorded

In both experiments, three samples on five plants per plot, i.e., at 64, 74, and 84-DAP, were read from each treatment 10 days after each application. In which each one was represented by three replicates for the morphological studies (plant height (cm), number of leaves per plant), and total chlorophyll SPAD. At the dough stage (117-123 DAP), a sample was taken to record the following: plant height (cm), number of leaves per plant, number of cobs per plant (piece), stem, leaves, cobs weight per plant (g), plant weight (g), stem diameter (mm), and green and dry herbage yield (ton da^{-1}). Macronutrients (P, K, Ca, Mg) and micronutrients (Fe, Cu, Mn, Mo, Se, Zn) concentrations were determined using by wet digestion inductively coupled plasma-optical emission spectrometer (ICP-OES) and atomic absorption spectrophotometer (AAS) in VYYU, Science Application and Research Center labs according to Association of official analytical chemists (1995, chap. 50).

2.2. Experimental design and statistical analysis

The field experiments were arranged in the Randomized Complete Block Design (RCBD) with three replications. Three different doses of active dry bread yeast (*Saccharomyces cerevisiae*), as well as control, were sprayed on maize plants. All data recorded were subjected to normal statistical analysis (One-Sample Kolmogorov-Smirnov Test), and the test distribution is normal. One-way analysis of variance (ANOVA) and Duncan multiple comparison test were used to evaluate the treatment effects. Then the combined analysis of the two seasons was done according to Steel and Torrie (1960). The differences among treatment mean values were compared using Duncan multiple range test, and a p-value of 5% was used for statistical significance as reported by Gomez and Gomez (1984). All statistical analysis was performed by using the analysis of variance (ANOVA) technique of SAS Software package Stat-view-9.0.1 (SAS Institute, 2002).

3. Results and Discussions

3.1. Vegetative Characters

The effects of active dry yeast applications on plant height (cm), number of leaves per plant, and leaf chlorophyll content (SPAD value) are given in Table 3. Progressive significant height of maize plant, number of leaves per plant, and SPAD measurements were achieved with the foliar application of active dry yeast. When 10 g of yeast was sprayed on the plant above soil, the plant height and number of leaves of maize reached the highest records of the second and third vegetative stages than the yeast-free treatment, control, while the differences between effects of yeast concentrations at 64 DAP were insignificant.

Table 3. Effect of dry yeast foliar application on vegetative characters of maize grown under high pH soil conditions at 64, 74, and 84 DAP during 2019 and 2020 seasons

Treatments Spray	Plant height (cm)	Number of leaves per plant	SPAD Value
	64 Days After Planting		
Control	*137.83±26.84 ^{NS}	10.20±0.872 ^{NS}	41.07±5.06 ^{NS}
M1: 5.0 g L^{-1}	137.03±9.99	10.30±0.755	38.82±2.62
M2: 7.5 g L^{-1}	146.50±19.02	10.80±0.361	43.14±3.80
M3: 10.0 g L^{-1}	131.97±17.60	10.90±0.265	42.28±2.13
Mean	138.33	10.55	41.33
***P*-Value**	0.4758	0.2774	0.5168
S.E.D.**	9.500	0.505	2.930
	74 Days After Planting		
Control	163.15±10.79 ^{c}	11.84±0.703 ^{NS}	36.11±3.47 ^{c}
M1: 5.0 g L^{-1}	196.36±12.48 ^{b}	12.03±0.701	42.19±0.68 ^{b}
M2: 7.5 g L^{-1}	204.23±17.62 ^{ab}	12.33±0.351	43.87±1.99 ^{b}
M3: 10.0 g L^{-1}	216.47±13.83 ^{a}	12.73±0.252	48.45±1.33 ^{a}
Mean	195.05	12.23	42.66
***P*-Value**	0.0003	0.0967	0.0001
S.E.D.	11.360	0.442	1.740
	84 Days After Planting		
Control	196.31±11.18 ^{d}	13.33±0.635 ^{NS}	38.55±1.53 ^{c}
M1: 5.0 g L^{-1}	220.76±11.14 ^{c}	13.43±0.751	45.03±1.14 ^{b}
M2: 7.5 g L^{-1}	233.13±11.33 ^{b}	13.55±0.253	47.25±0.49 ^{b}
M3: 10.0 g L^{-1}	247.67±14.02 ^{a}	14.29±0.278	51.08±0.70 ^{a}
Mean	224.47	13.65	45.48
***P*-Value**	0.0001	0.0781	0.0001
S.E.D.	9.780	0.430	0.855

The means within each column within main effects and interactions followed by the same letter are not significant at $P \leq 5\%$.
*Mean±Standard deviation. **S.E.D.: Standard errors of differences of means, NS: insignificant difference.

The illustrated parameters (Table 3) are in agreement with the findings presented by (Abu Khouder et al., 2019; Al-Shaheen et al., 2019; Al-madhagi., 2019); they pointed out that the application of yeast increased the plant height, number of leaves per plant and rate of chlorophyll in the plant leaves. In this context, the highly impactful CO_2 release was due to the use of active dry yeast, which subsequently leads to an increase the net plant photosynthesis (Ferguson et al., 1995; Vas and Papanas, 2019). The increase of the concentration of chlorophyll when the foliar application of yeast is because it contains the natural hormones that motivate the chlorophyll formation. Yeast includes Cytokinin, which is vital for chloroplast up growth and is the backbone of chlorophyll synthesis EzzEL-Din and Hendawy (2010). Moreover, activating of plant vegetative growth using dry yeast could be due to its effect on the transmission of the nutritional signal that constitutes growth regulators (El-Ghadban et al., 2003).

3.2. Morphological Characters at the Dough Stage

The impact of spraying active dry yeast on morphological characters of maize at the dough stage for the mean of the two seasons (2019 and 2020) is indicated in Tables 4 and 5. Using the 5.0, 7.5, and 10.0 g L^{-1}doses of dry yeast have a positive effect on the maize plant growth for silage purposes in comparison with the control treatment (without yeast spraying). Plant height, stem weight per plant, and plant leaf weight in the dough stage differed significantly according to doses of yeast and control applications ($p \leq 0.05$). The greatest value was detected in corn treated with active dry yeast (10 g L^{-1}), followed by (7.5 g L^{-1}), then by (5 g L^{-1}), and the smallest values were in control non-sprayed plants. While no significant difference was detected between the M2: 7.5 g $L^{-1}$and M3: 10.0 g $L^{-1}$of dry yeast on the plant leaf weight (Table 4).

Table 4. Effect of dry yeast foliar application on morphological characters of maize grown under high pH soil conditions at the dough stage during the 2019 and 2020 seasons

Treatments Spray	Plant height (cm)	Number of leaves per plant	Stem diameter (mm)	Stem weight plant^{-1} (g)	Leaves weight plant^{-1} (g)
Control	*220.40±26.84 ^{d}	13.93±0.25 ^{NS}	24.56±1.27 ^{NS}	220.53±53.1 ^{d}	103.03±14.99 ^{c}
M1: 5.0 g L^{-1}	246.97±9.99 ^{c}	14.24±0.90	23.22±0.99	289.87±58.3 ^{c}	129.53±12.45 ^{b}
M2: 7.5 g L^{-1}	266.03±19.02 ^{b}	14.68±0.11	22.65±3.38	316.73±58.9 ^{b}	141.60±6.77 ^{ab}
M3: 10.0 g L^{-1}	282.91±17.6 ^{a}	14.68±0.01	24.75±1.19	396.73±73.2 ^{a}	158.00±3.50 ^{a}
Mean	254.08	14.38	23.79	305.97	133.04
***P*-Value**	0.0001	0.1103	0.5259	0.0001	0.0009
S.E.D.**	15.770	0.387	1.592	50.100	8.540

The means within each column within main effects and interactions followed by the same letter are not significant at $P \leq 5\%$.
*Mean±Standard deviation. **S.E.D.: Standard errors of differences of means, NS: insignificant difference.

On the other hand, there was not a significant difference between maize plants treated with all dry yeast concentrations and control on the number of leaves per plant and stem diameter (mm) of maize plants grown under alkaline soil conditions at the dough stage during 2019 and 2020 seasons as Table 4 shown. This may explain that these traits are associated with the genetic cultivar of corn. It is well known that the actual performance of any cultivar depends on its genetic parameters interacting with all surrounded environmental conditions (Saleh et al., 2018). For the cobs number per plant, the data presented in Table 5 indicated that because of the applying active dry yeast to maize, the highest value of number of cobs per plant (1.57) was recorded at 10 g L^{-1}, while the lowest value of number of cobs per plant (1.07) was obtained as a result of the non-application of dry yeast 0 g L^{-1} was obtained in the control plots. On the other hand, it is seen that there are no statistically significant differences between the M1: 5.0 g L^{-1} and M2: 7.5 g L^{-1} of dry yeast doses on the number of cobs per plant and the untreated plants (control). As well as between M2: 7.5 g L^{-1} and M3: 10.0 g L^{-1}.

The results in Table 5 showed that the foliar application of active dry yeast had significantly augmented cobs weight plant^{-1} and plant weight of the aerial parts indicators compared with control (spraying with tap water). The maximum mean values have been recorded by applying 10 g L^{-1} of dry yeast in the average of both seasons 2019 and 2020, while the minimum values in the untreated control. Increasing the active dry yeast concentration from 0 to 10 g L^{-1} increased the cobs weight per plant and plant weight of the aerial parts. It is clear that the level of 10 g L^{-1} of dry yeast gave the highest record of studied plant weight of the aerial parts parameter 940.03 g, with an increase of 102.69% compared to the untreated plants as a control (recorded 463.77 g). Green and dry herbage yield (ton da^{-1}) characteristics recorded significant responses when maize plants were treated by the different levels of active dry yeast in comparison to not sprayed plants in the average of the two seasons, 2019 and 2020, as shown in Table 5. Although there is a significantly green herbage yield (ton da^{-1}) difference between control and plants sprayed by yeast, there are slight differences (not significant) between the concentrations of active dry yeast themselves. For dry herbage yield (ton da^{-1}), generally, the differences between the concentrations of active dry yeast themselves and between yeast doses and control were significant in the dough stage during the 2019 and 2020 seasons.

In this context, there are many studies on the application of yeast in different plants such as maize, sunflower, and broad bean. There are results that plant growth is positively affected the growth characteristics as well as yield and its components reported by some researchers (Seadh et al., 2015; Altunlu et al., 2019; Al-Shaheen et al., 2019; Abed and Zeboon, 2020; Al-Ani et al., 2020). The results mentioned in Table 4 are in the same trend. The increase may be due to the effect of the yeast spray because it can produce phytohormones such as Auxins, Gibberellic acid, Cytokinins, and some vitamins (EL-Kholy et al., 2007), which by their physiological action are stimulated the elongation and cell division. Besides, they contain amino acids and some mineral elements such as nitrogen and others that enhance plant growth, and this result is consistent with what (Ahmed et al., 2011). In this context, the yeast catalyzes the release of CO_2 from fermentation, which will eventually contribute to photosynthesis and increase the products resulting from the process (Khalil and Ismael, 2010).

Table 5. Effect of dry yeast foliar application on morphological characters of maize grown under high pH soil conditions at the dough stage during the 2019 and 2020 seasons

Treatments Spray	Number of cobs plant^{-1} (g)	Cobs weight plant^{-1} (g)	Plant weight (g)	Green herbage yield (ton da^{-1})	Dry herbage yield (ton da^{-1})
Control	*1.07±0.116 ^{b}	140.20±16.56 ^{d}	463.77±80.5 ^{d}	7.50±0.98 ^{b}	1.63±0.18 ^{d}
M1: 5.0 g/L	1.23±0.322 ^{b}	280.40±40.6 ^{c}	699.80±101.9 ^{c}	8.79±0.57 ^{a}	2.23±0.14 ^{c}
M2: 7.5 g/L	1.30±0.100 ^{ab}	314.40±24.3 ^{b}	772.73±85.5 ^{b}	8.90±0.28 ^{a}	2.63±0.32 ^{b}
M3: 10.0 g/L	1.57±0.058 ^{a}	385.30±44.4 ^{a}	940.03±87.2 ^{a}	9.30±0.33 ^{a}	3.18±0.35 ^{a}
Mean	1.29	280.07	719.08	8.62	2.41
***P*-Value**	0.0175	0.0001	0.0001	0.0001	0.0017
S.E.D.**	0.1472	27.320	72.800	0.4945	0.2135

The means within each column within main effects and interactions followed by the same letter are not significant at $P \leq 5\%$.
*Mean±Standard deviation. **S.E.D.: Standard errors of differences of means.

3.3. Chemical Characters at the Dough Stage

It is seen in Table 6 that the phosphorus, potassium, calcium, magnesium, and iron concentrations have increased significantly as a result of the applied different dry yeast levels. The smallest contents of previous minerals were in the control plants, followed by the records obtained from applications of active dry yeast, which the highest values recorded with M3: 10 g L^{-1} yeast. M3 active yeast dose recorded increment by 47.05% in P, 61.73% in K, 92.67% in Ca, 51.42% in Mg, and 173.68% in Fe concentrations in comparison with non-treated plants as control. In this regard, Duru (2020) reported that calcium, sulfur, and potassium are essential mineral elements in human and animal nutrition. Here, it is known that P is a vital part of nucleic acids, phospholipids, adenosine triphosphate (ATP), and several coenzymes. Also, K affects osmosis and the operation of stomata by its role as a cofactor involved in protein formation, enzymes activation, and main solute functioning in water balance. Fast-growing animals seem to have higher potassium requirements, and an increased protein level increases the demands. Potassium is the main cation in intracellular fluid and actions in acidic medium, organization of osmotic pressure, conduction of the nerve impulse, muscle contraction, especially the heart muscle, cell membrane function, and Na^+/K^+-ATPase. Potassium is also required during glycogen synthesis. Like that, Ca is important in the formation and cell wall constancy and in the maintenance of membrane composition and permeability, the stimulation of certain enzymes coordinates many responses of cells to stimuli (Soetan et al., 2010). For animals, calcium acts as a component of bones and teeth and nerve and muscle function regulation. In blood coagulation, Ca activates the conversion of prothrombin to thrombin and also participates in the coagulation of milk. Calcium activates many enzymes such as ATPase, succinic dehydrogenase, lipase, etc. (Malhotra, 1998; Murray et al., 1999; Soetan et al., 2010).

In this regard, Mg is part of the chlorophyll particles; it activates many enzymes and an active substance of several enzyme systems in which thymine pyrophosphate is a cofactor. It also stimulates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzyme for the reactions in the Krebs cycle. It is also a component of bones and teeth. Fe is a component of cytochromes, electron transport, stimulates some enzymes, and plays a role in the formation of chlorophyll. Iron acts like hemoglobin in oxygen transportation. In cellular respiration, Fe acts as a major constituent of enzymes that contribute to biological oxidation, such as cytochrome C, C1, A1, etc. (Malhotra, 1998; Murray et al., 1999; Soetan et al., 2010). While the solubility of Iron, Fe^{2+}, and Fe^{3+} ions decrease with an increase in pH being extremely low in calcareous soils, where noticeable Fe deficiency in plants not adapted to these conditions occurs (Römheld and Nikolic, 2006).

Table 6. Effect of dry yeast foliar application on P, K, Ca, Mg, and Fe concentration (%) of maize grown under high pH soil conditions at the dough stage during the 2019 and 2020 seasons

Treatments Spray	P	K	Ca	Mg	Fe
Control	*0.170±0.024 ^{d}	0.784±0.056 ^{d}	0.628±0.054 ^{d}	2.112±1.713 ^{c}	0.076±0.005 ^{d}
M1: 5.0 g L^{-1}	0.214±0.012 ^{c}	1.083±0.054 ^{c}	0.897±0.028 ^{c}	2.767±2.332 ^{b}	0.139±0.017 ^{c}
M2: 7.5 g L^{-1}	0.221±0.016 ^{b}	1.156±0.083 ^{b}	1.076±0.064 ^{b}	3.191±2.711 ^{a}	0.171±0.019 ^{b}
M3: 10.0 g L^{-1}	0.250±0.026 ^{a}	1.268±0.050 ^{a}	1.210±0.031 ^{a}	3.198±2.786 ^{a}	0.208±0.015 ^{a}
Mean	0.214	1.073	0.953	2.817	0.149
***P*-Value**	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
S.E.D.**	0.001333	0.00971	0.02393	0.0539	0.00317

The means within each column within main effects and interactions followed by the same letter are not significant at $P \leq 5\%$.
*Mean±Standard deviation. **S.E.D.: Standard errors of differences of means.

For micronutrients concentrations, it appeared from the results mentioned in Table 7 that active dry yeast applications increased the copper, selenium, and zinc contents of the samples statistically when compared to control plants. The highest Cu and Se amounts of the samples obtained from these applications were determined as 49.342 and 1.825 ppm for M3, respectively. In contrast, the highest Zn concentration resulted in M1 and M2, with non-significant changes in the copper concentration between them observed. Furthermore, the lowest concentrations detected by control with 27.190, 0.331, and 76.618 ppm for Cu, Se, and Zn, respectively. It was determined that there was an insignificant difference in the concentrations of Manganese elements between the yeast doses and the control (untreated plants).

Copper is a component of vital redox and lignin-biosynthetic enzymes (Soetan et al., 2010), and it plays a role in iron intake (Chandra, 1990). Moreover, it is significant for growth and bone synthesis (Malhotra, 1998; Murray et al., 1999). Additionally, copper is required for the synthesis of collagen and elastin fibers that provide structure and elasticity to connective tissue and blood vessels (Larson, 2005).

Selenium is integrated originally into plants by sulfur substitution in the cysteine and methionine (Soetan et al., 2010). Selenium is a mineral that is a component of a complete defense system that shelters the lively organism from the hurtful effect of reactive oxygen species (ROS) (Murray et al., 1999).

Here Malhotra (1998) and Soetan et al. (2010) indicated that zinc is effective in the construction of chlorophyll, invigorates some enzymes, and functions as a part in the creation of auxin, chloroplasts, and starch. Moreover, the absorbed zinc that enters the liver was exported to peripheral tissue in plasma, bound to albumin after being united into zinc metalloenzymes. These results may be reflected that increasing the zinc concentration in the maize plants sprinkled with active dry yeast could lead to good results on animals' health and production.

On the contrary, the use of dry yeast on corn has recorded a negative effect on molybdenum concentrations, where the control was the highest and gradually decreased with increasing the yeast doses from 5.0 to 10.0 g L^{-1}. The Mo concentration was relatively high in corn silage and other feeds linked with the lowest Cu concentrations resulting in undesirable ratios between Cu and Mo (Miltimore and Mason, 1971). This may refer to the presence of an antithesis association between Cu and Mo concentrations in maize plants.

Table 7. Effect of dry yeast foliar application on Cu, Mn, Mo, Se, and Zn concentration (ppm) of maize grown under high pH soil conditions at the dough stage during the 2019 and 2020 seasons.

Treatments / Spray	Cu	Mn	Mo	Se	Zn
Control	*27.190±2.73 ^{d}	116.048±27.99 ^{NS}	0.754±0.06 ^{a}	0.331±0.27 ^{d}	76.618±4.30 ^{c}
M1: 5.0 g L^{-1}	33.533±5.67 ^{c}	116.359±3.04	0.394±0.07 ^{c}	0.802±0.09 ^{c}	84.573±20.74 ^{a}
M2: 7.5 g L^{-1}	46.207±7.18 ^{b}	115.032±12.41	0.538±0.27 ^{b}	1.208±0.26 ^{b}	83.675±7.90 ^{a}
M3: 10.0 g L^{-1}	49.342±9.25 ^{a}	115.750±21.33	0.401±0.06 ^{c}	1.825±0.70 ^{a}	79.816±16.36 ^{b}
Mean	39.07	115.80	0.52	1.04	81.17
***P*-Value**	< 0.001	0.908	< 0.001	< 0.001	< 0.001
S.E.D.**	0.3470	1.9010	0.002404	0.00765	0.5190

The means within each column within main effects and interactions followed by the same letter are not significant at $P \leq 5\%$.
*Mean±Standard deviation. **S.E.D.: Standard errors of differences of means, NS: insignificant difference.

Similar results were in harmony with those of Abbas (2013) on beans, and Nasser et al. (2019) on lentils, they reported that chemical composition such as mineral elements improved under applying of yeast. On the other hand, Abbas (2013) revealed that the role of yeast could also be attributed to its effect on enzymatic activity, the production of some natural plant hormones, improving the ability to absorb nutrients, diversion of phosphorus from insoluble state to soluble one, and increasing its absorbability by plants, all of these increase the mineral content in plants.

4. Conclusion

In the present study, foliar dry yeast applications to maize had a positive effect on the morphological and chemical properties, and as a result of these applications, the highest properties, including the amount of the studied properties, were obtained at a dose of 10 g L^{-1}. The findings obtained from this study, when considered overall, it could be concluded that foliar applications of active dry yeast during the beginning vegetative stages might be recommended to increase vegetative growth, yield, and quality of maize for silage purposes in the soils that have high pH under Van-Turkey conditions. Furthermore, the fact that yeast is a natural and safe substance for the plants and the environment and economically feasible.

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