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EFFECT OF HUMIC ACID SEED TREATMENT ON YIELD AND SOME YIELD CHARACTERISTIC OF CORN PLANT (*Zea mays* L. *indentata*)

Abdullah Öktem[1], Abdurrahman Çelik[2], Ayşe Gülgün Öktem[1]

[1]University of Harran, Faculty of Agriculture, Department of Field Crops, Sanliurfa, TURKEY
[2]Provincial Directorate of Agriculture, Sanliurfa, TURKEY

Corresponding author: aoktem@harran.edu.tr

Abstract
This study was aimed to determination of seed treated humic acid effects to yield and some yield characteristics of corn plant (*Zea mays* L. *indentata*) as grown second crop conditions. Study was set up according to randomized complete blocks experimental design with 3 replicates under Harran Plain conditions in 2012, Sanliurfa, Turkey. Motril hybrid corn variety was used as a plant material. Humic acid seed treatments were 0 (control), %2.5, %5, %7.5, %10, and %12 humic acid concentrations. Humic acid concentrations were applied to corn seed before sowing. Some yield and yield characteristic of corn plant such as tassel flowering duration, plant height, leaf number per plant, grain weight of ear, thousand kernel weights and grain yield were evaluated in the study. As a result of research; statistical significant differences were seen among humic acid seed treatments at tassel flowering duration and leaf number per plant ($P \leq 0.05$). Also, humic acid seed treatments were significant at grain weight of ear, thousand kernel weights and grain yield ($P \leq 0.01$). Tassel flowering duration decreased with humic acid seed treatment whereas leaf number per plant, grain weight of ear, thousand kernel weights and grain yield values increased with humic acid seed treatment. The highest values were found in % 7.5 humic acid seed treatment.

Keywords: Corn, humic acid, seed treatment, Harran Plain.

Introduction

Corn is used as an animal feed and industry raw material as well as directly and indirectly in human nutrition. Corn grain has a very important place in the world for human and animal feeding. Corn is cultivated in 184 800 969 hectares in the world, producing amount is 1 037 791 518 tons and average yield is 5615.7 kg ha^{-1} (Anonymous, 2017a). Corn ranks first in terms of production quantity, but in the third place after wheat and rice in terms of planting area in the world. In Turkey, grain corn cultivation area is 680 000 hectares, production is 6 400 000 tons and yield is 9420 kg ha^{-1} (Anonymous, 2017b). Also corn is an important plant for Turkey's industry. Corn plant consumes more nutrients from soil and produces too much dry matter in the unit area. The intake of the plant's nutrients depends on the amount and condition of these substances in the soil, the climate and soil factors, the growing season and the developmental period of the plant. In order to obtain high yields from the corn plant, which is in need of nutrients in high amounts, the soil fertility must also be high. Due to the chemical fertilizers used in agriculture, the chemical, physical and biological properties of the soil have been degraded and especially the level of organic matter has fallen below 1% (Gok et al. 1995). One of the most economical and rapid solutions to the problem of organic matter in modern agriculture is direct application of humic acid to the soil or plant. Humic acid improves soil's physical structure. Application of humic acid increases soil aeration and water holding capacity of the soil. Humic acid maximizes the cation exchange capacity of the soil and regulates soil pH. It will also help to lower the pH of the soil to a more neutral level and will flush high levels of salts out of the root zone, all of which will help to promote better plant health and growth. Humic acid is considered to increase the permeability of plant membranes and enhance the uptake of nutrients. Moreover, humic acid increases the availability of nutrients in our fertilizers and

in those already existing in our soil (Piccolo et al. 1997). Humic acid increases the uptake of nitrogen, phosphorus, potassium, iron, zinc and trace elements in the soil by the plant (Kacar and Katkat 2011). Humic acid increases seed germination and accelerates the formation and development of fringe root. It is an excellent root stimulator. It allows the plant to grow faster and stronger. It has a stimulating effect on the development and multiplication of useful soil microorganisms. Humic acid increases the amount and activity of microorganisms in the soil. Humic acid also increases the tolerance of the plant against to stress conditions of plants such as cold, hot and physical effects and resistance to disease (Kacar and Katkat 2011). Many researchers reported that humic acid application has positive effects on plant growth and yield characteristics (Bohme et al. 2001, Hopkins and Stark 2003, Bozoglu et al. 2004, Karakaya and Paksoy 2008, Day et al. 2011, Gursoy et al. 2016). Sharif et al. (2002) found that addition of 0.5-1.0 kg ha^{-1} humic acid resulted in increased wheat grains yield by 25-69% over control. Selcuk and Tufenkci (2009) stated that application of humic acid (0, 2, 4 L HA/da) to corn plant resulted in a significant increase in the kernel number of ear, length of ear, height of plant and thousand kernel weight. It is stated by Oren and Basal (2005) that humic acid application affects earliness, seed weight and yield in a positive way. Cimrin et al. (2001) reported that application of humic acid increased the yield and quality. Many researchers (Chain and Aviad 1990, Padem and Ocal 1998, Kaya et al. 2005) reported that humic acids have an impact on plant growth and development, and that when applied in low quantities they affect development positively. Nevertheless, they stated that when applied in excessive amounts, they have ineffective or negative effects on development. It has been reported that humic acid application promotes germination by increasing enzyme activities in seeds and increases germination rate, root and shoot growth (Rauthan and Schnitzer 1981). In this study, it was aimed to determine the effect of different humic acid concentrations applied to seed on yield and some yield components of corn plant.

Material and methods

This study was conducted in 2012, Sanliurfa, Turkey. The experimental field is located in Harran Plain (altitude: 465 m; 37^0 08' N and 38^0 46' E) where the climate varies from arid to semi-arid. Table 1 provides the climatic data obtained at the Sanliurfa City Meteorological Station. As can be seen from Table 1 that the weather is hot and dry in the months of June, July and August where maximum temperatures were all above 40 ^oC while the relative humidity was below 50%. Rainfall was very low from June to August in 2012.

Table 1. Monthly some climatic data during 2012 corn growth period in Sanliurfa†.

Meteorological observations	Months					
	June	July	August	September	October	November
Min. Temp. ^0C	17.6	20.0	22.4	15.6	11.6	7.1
Max. Temp. ^0C	42.2	44.2	42.1	39.9	37.0	26.9
Av. Temp.^0C	30.6	33.3	32.3	28.4	21.0	14.9
Av. Humidity (%)	21.2	18.8	29.0	28.0	48.5	65.6
Rainfall (mm)	5.8	0.2	0.2	2.0	35.2	68.4
Sunshine (hour)	11.9	12.0	10.8	9.6	6.1	4.2

†Data collected from the Sanliurfa Meteorological Station (Anonymous, 2012).

The soil of the research field was clay, slightly alkaline, high in lime and very low in salt contents. Field capacity of the soil was 33.8% on dry basis, permanent wilting point was 22.6% and bulk density was 1.41 g cm^{-3}. Some physical and chemical properties of research soil were given in Table 2. Motril hybrid single cross dent corn variety (*Zea mays* L. *indentata*) was used as crop material. Humic acid seed treatments were 0 (control), %2.5, %5, %7.5, %10, and %12 humic acid concentrations. Solutions were prepared and sprayed onto the seeds with a small hand sprayer. In control applications, the seeds were just sprayed with water. After application of humic acid to the seeds were dried for 24 hours at room temperature. Land was ploughed and cultivated then

prepared for planting with a single pass of a disk-harrow. The experiment was laid out in a randomize block design with three replications. Each plot area was 14 m^2 (5 m x 2.8 m) and consisted of four rows of 5 m in length. The plants were grown 70 cm apart between the rows with 18 cm spacing in each row. The seeds were sown in second part of June at a 50-60 mm depth. At sowing, 80 kg ha^{-1} of pure N, P and K, as a 15-15-15 composed fertilizer, was applied to each plot; this was followed by 160 kg ha^{-1} of N as urea when the plants reached 30-40 cm in height. Irrigation water was first applied to all the plots using a sprinkler irrigation system. After the emergence of plants, plots were irrigated equally by the furrow irrigation system. All tested characteristics were measured on randomly selected 20 plants in the center of each plot. An analysis-of-variance (ANOVA) was performed to evaluate statistically differences between results. Means of the data obtained from research were compared using least significant difference (LSD) at $P \leq 0.05$.

Table 2. Some physical and chemical properties of research soil

Deep (cm)	Organic Matter (%)	Total Salt (%)	pH	$CaCo_3$ (%)	P_2O_5 kg/da	K_2O kg/da	Texture (%)		
							Sand	Clay	Silt
0-20	0.81	0.098	7.7	25.4	3.6	99.3	24.16	53.84	22.0

Results and discussion

Tassel flowering duration, plant height, leaf number per plant, grain weight of ear, thousand kernel weights and grain yield values and LSD groups were given in Table 3.

Tassel Flowering Duration (day)

According to variance analyses, humic acid concentrations were significant (P≤0.05) at tassel flowering duration. Tassel flowering duration ranged from 53.66 to 56.00 day (Table 3). The longest tassel flowering duration value was seen at control application whereas the shortest tassel flowering duration value was found at %7.5 humic acid concentration. Flowering period decreased with humic acid application. Similar findings were reported by Dogan (2002) and Day et al. (2011). Oren and Basal (2005) reported that humic acid applications provide earliness.

Plant Height (cm)

Variance analyses results show that humic acid concentrations were not significant at plant height. The longest plant height value was found at %7.5 humic acid concentration as 229.33 cm whereas the shortest plant height was 227.33 cm at control application (Table 3). Similar results were obtained by Padem (1998) and Selcuk and Tufenkci (2009). These authors observed that humic acid application increase plant height.

Leaf Number per Plant (number $plant^{-1}$)

Humic acid concentrations for leaf number per plant were significant (P≤0.05) according to variance analyses. Leaf number per plant values varied from 11.13 to 13.70 number $plant^{-1}$ (Table 3). The highest leaf number per plant value was seen at %7.5 humic acid concentration. Also the lowest leaf number per plant value was found at control application. Some researchers' emphases that humic acid effects positively yield characteristics of plant (Bozoglu et al. 2004, Karakaya and Paksoy 2008, Day et al. 2011).

Grain Weight of Ear (g)

Humic acid concentrations were significant (P≤0.01) at grain weight of ear. Grain weight of ear values varied between 131.33 and 167.66 g. The highest grain weight of ear value was found at %7.5 humic acid concentration as 167.66 g whereas the lowest grain weight of ear value was 131.33 g at control application (Table 3). Our results were supported by Gursoy et al. (2016). It was stated that humic acid increased grain weight in plant (Oren and Basal 2005).

Table 3. Tassel flowering duration, plant height, leaf number per plant, grain weight of ear, thousand kernel weights and grain yield values and LSD groups

Humic acid (%)	Tassel flowering duration (day)	Plant height (cm)	Leaf number (number plant^{-1})	Grain weight of ear (g)	Thousand kernel weights (g)	Grain yield (kg da^{-1})
% 0	56.00 a†	227.33	11.13 c†	131.33 c†	364.66 e†	940.14 c†
% 2.5	54.66 b	228.66	12.46 b	160.66 b	374.00 d	1146.00 ab
% 5	54.00 bc	229.33	13.50 ab	163.00 ab	392.33 b	1162.64 ab
% 7.5	53.66 c	229.66	13.70 a	167.66 a	400.00 a	1186.64 a
% 10	54.33 bc	229.00	13.23 ab	162.00 ab	394.33 ab	1158.66 ab
% 12	54.66 b	229.00	13.20 ab	158.33 b	383.00 c	1131.71 b
Average	54.555	228.83	12.872	157.16	384.722	1120.968
LSD	0.917	-	1.222	6.8956	6.012	54.50
Significance	*	ns	*	**	**	**

†There is no statistical difference among values annotated with the same letter at 0.05 according to the LSD test

*, ** and ns denotes P≤0.05, P≤0.01 and no significant, respectively

Thousand Kernel Weights (g)

Variance analyses results show that humic acid concentrations at thousand kernel weights were significant (P≤0.01). Thousand kernel weights values were between 364.66 g and 400.0 g. The highest thousand kernel weights value was found at %7.5 humic acid concentration as 400.0 g whereas the lowest thousand kernel weights value was 364.66 g at control application (Table 3). These results are in accord with the findings of some researchers (Chain and Aviad 1990, Padem and Ocal 1998, Kaya et al. 2005). Selcuk and Tufenkci (2009) and Oren and Basal (2005) stated that humic acid effects positively thousand kernel weights.

Grain Yield (kg da^{-1})

Humic acid concentrations were significant (P≤0.01) at grain yield. Grain yield varied from 940.14 kg da^{-1} to 1186.64 kg da^{-1} (Table 3). The highest grain yield value was found at %7.5 humic acid concentration as 1186.64 kg da^{-1} whereas the lowest grain weight of ear value was 940.14 kg da^{-1} at control application (Figure 1). Humic acid effected positively grain yield. Similar research results reported by some other researchers (Chain and Aviad 1990, Padem and Ocal 1998, Kaya et al. 2005). It was stated that significant positive effects of humic acid on the grain yield (Dogan 2002, Bozoglu et al. 2004, Cimrin et al. 2001, Day et al. 2011, Gursoy et al. 2016). Sharif et al. (2002) found that addition of 0.5-1.0 kg ha^{-1} humic acid resulted an increase wheat grain yield by 25-69% over control. It was stated that humic acid is created a synergetic effect during uptake of nutrients from soil (Lee and Bartlett 1976, David et al. 1994). Also it could be the effect of humic acid substances in manner similar to plant growth substances (Casenave de Sanfilippo et al. 1990). Increase in grain yield may be due to these effects.

Conclusions

Based on the results of research it may be concluded that statistical significant differences were seen among humic acid seed treatments at tassel flowering duration and leaf number per plant (P≤0.05). Also, humic acid seed treatments were significant at grain weight of ear, thousand kernel weights and grain yield (P≤0.01). Tassel flowering duration decreased with humic acid seed treatment whereas leaf number per plant, grain weight of ear, thousand kernel weights and grain yield values increased with humic acid seed treatment. The highest values at tested characteristics were found in % 7.5 humic acid seed treatment.

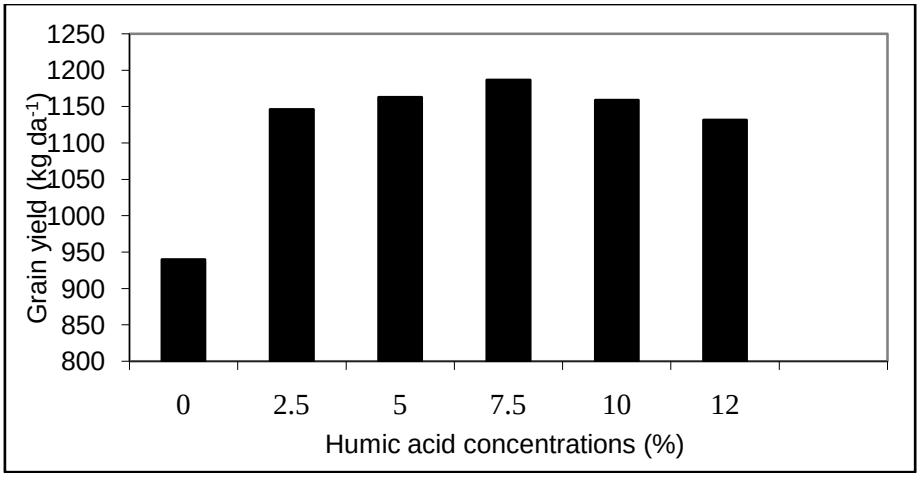

Figure 1. The grain yield values obtained from the different seed application of humic acid

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