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Effects of humic acid on decrease of phosphorus usage in forage maize var. KSC704 (*Zea mays* L.)

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Abstract

This study was conducted on the effects of humic acid on yield and the yield components of Forage Corn (*Zea mays* L. Var. KSC704) in Chenaran, Mashhad, Iran on 2010. The evaluation process was based on 3 levels of phosphorus (0, 100, 200 kg/ha) and 4 levels of humic acid usage consisting of control (without humic acid), seedling, flowering, seedling and flowering as factorial experiments based on RCBD with 3 replications. The results showed that using different levels of Phosphorus had significant effects on de-husked ear, cob weight and harvest index of forage Corn ($P \leq 0.05$). Furthermore, the levels of humic acid on corn dry material, de-husked ear, cob weight /ha, row no. and forage harvest index (HI) was significant at 5% level. Moreover, consumption of 100 kg/ha Phosphorus led to the highest yield of dry material (24937 kg/ha). After using humic acid in flowering, the forage dry material increased to 31035 kg/ha. The result of this study showed that level of organic matter and phosphorus content of soil were low and high, respectively. Thus, the low level of organic matter and high soil phosphorus can be lead to forage yield decrease, therefore it is necessary low levels of the phosphorus fertilizer usage. Therefore, farmers should be aware of improved usage of phosphorus fertilizer. Also, we concluded the consumption of humic acid in seedling and flowering stages of maize var. KSC704 could be raised up forage yield and reduce the chemical pollution of soil.

Keywords: Forage yield, Maize, Micro nutrients, Phosphorus.
Abbreviations: D deci-Siemens/meter (Ds m^{-1}) , ha Hectare , kg Kilogram, no. Number, HI harvest index.

Introduction

After nitrogen, phosphorus is the most vital substance for plants to grow, and the procedure of collecting it is a limitative factor in production of agricultural products worldwide (Afif et al., 1993). Phosphorus shows unique reactions in surface absorption and its sediment in soil; therefore, it becomes useless for the plant. In lime soil and lime-plaster soil, like most of the soil found in Iran, reduction of soil Phosphorous is necessary for plants due to dissolving of phosphorous turns into low level dissolved compounds just like calcium phosphate. This is considered a feeding problem for plants. Their regular use of chemical fertilizer and inorganic fertilizer in recent years has been the cause of considerable reduction in organic substances found in the soil in Iran (Latifi et al., 1998). On the contrary, excessive usage of chemical fertilizers in agriculture has caused environmental problems such as physical destruction of the soil and nutritional substances imbalance in the soil (Sebahattin et al., 2005). Majidian et al. (2006) state that by using organic and chemical fertilizers simultaneously, it can obtained higher corn bean quality with a better yield in addition to reducing the use of chemical fertilizer and improving the soil's condition, This helps lead us to sustainable agriculture (Majidian et al., 2006).

Amirabadi et al. (2009) declared that the application of "*Micorisa*" and "*Azetobacter*" in addition to reducing the Phosphorous usage resulted in a better performance (Amirabadi et al., 2009). In general, we can result that usage of humic acid in addition to enhancement in maize's performance, gives us better results by reducing the usage of chemical fertilizers because of its variant physiological effects; it is also used as a substance with natural sources that stabilize and increase agricultural production (Ghorbani et al., 2010). The plant's root growth was dependent on the plant's air system, but since the root plays an important role in raw material supply, the root and air system have a mutual relationship. The root's growth is affected by the environmental factors, provided other factors such as humidity, temperature and soil's nutritional substances exist (Liu et al., 1998). Having made some environmental considerations, various organic acids are widely used to improve quality and quantity of farm and garden products. Very little usage of organic acids has noticeable effects on physical, chemical and biological soil features. Because of hormone compounds, they have beneficial effects on increasing quantity and enhancement in the quantity of agricultural products. Humic and folvic acid are extracted from different sources like soil humus, pit, lignite oxide,

Table 1. Phosphorous effect on yield and yield components of forage maize.

Used phosphorous amount kg/ha	Forage yield /ha	Dry material /ha	ear weight /ha	De-husked ear weight /ha	husk weight /ha	Cob weight /ha	Row no./ear	Kernel no./row	Forage harvest index
0	53720[a]	22925[a]	18837[a]	11926[a]	6491[a]	1002[b]	14[a]	41[a]	35%[a]
100	52333[a]	24937[a]	16628[a]	10718[a]	5112[b]	950[b]	14[a]	41[a]	31.7%[b]
200	54066[a]	23858[a]	16515[a]	11470[a]	6016[ab]	1423[a]	14[a]	40[a]	30.5%[b]

Means of at least one letter in common, do not have a significant difference in a level of 1% or 5 %.

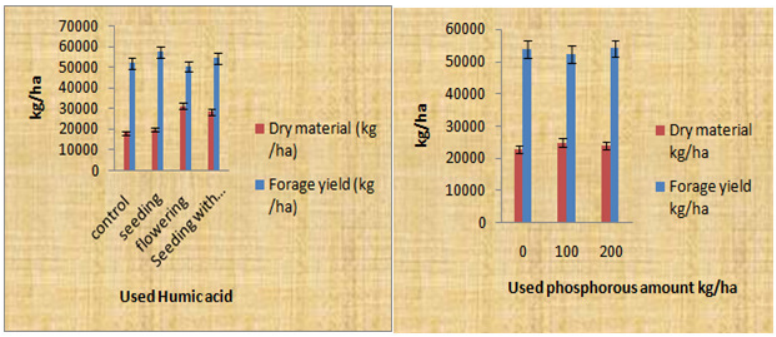

Fig 1. Phosphorous and humic acid's impact on forage yield and it's dry material.

charcoal and so on, provided that they differ in molecule size and chemical structure. The soil's fertility is extremely dependent on organic substances (Latifi et al., 1998). The application of organic matter (cattle manner) leads to a 4 percent increase in yield of ryegrass (Yolcu et al.,2011).While, co-application of green, chemical and organic manure causes an increased grain yield on canola (mohammadi et al.,2011). The application of humic acid in food solution causes the branch and root growth hence the increase in Nitrogen content in shoots (Samavat et al., 2010) and the destruction of chlorosis in the maize plant's leaves (Fernandez, 1968). In another study, the spraying of humic substances in the cluster development period found in wheat resulted in a scale up the performance of 7-8 % in comparison to the witness subject (Tan et al., 1979). Similar results were reported for sugar beet (Nardi et al., 2002) and maize (Alexandrova, 1977) cases. The main goals of this study were: I: Determining the best rate of Phosphorous chemical fertilizers in Mashhad's sandy soil condition, II: Using humic acid in order to reduce Phosphorous fertilizers, and III: Studying the phenological features and growth in SC704 maize hybrid.

Material and methods

In order to study the effects of humic acid and phosphorus on yields and the yield components of single cross hybrid of maize Var. KSC704, this experiment were done on 2009-2010. The experimental design was factorial based on RCBD with 3 replications. The first factor was phosphorous usage at 3 levels consisted of (0, 100 and 200 kg/ha) and the second factor was humic acid usage at 4 levels including without humic acid (control), humic acid usage in seedling, flowering, and as well as using it twice during the seedling and flowering process.

Experiment location

This experiment was done in 2009-2010 on northwest of Mashhad in Tabadkan, Iran. Its soil pH and its electrical conductivity was 7.15 and 2.69 Ds m^{-1}, respectively. The fertilizer that was in use was potassium sulphate to 100 kg/ha and nitrogen to 200 kg/ha. All of the potassium sulphate fertilizer and a third of nitrogen fertilizer were applied before plantation and rest of nitrogen was applied in the 6-8 and 8-10 leaves stage.

Field applications and experimental design

The applied phosphorous was of triple super phosphate source and all of phosphate fertilizer was applied to each plot at the seedling stage. Each plot was 3×5 m^2 with four rows, 0.75 and 0.19 meters distance between rows and plants, respectively. The seed plantation was started on May 20th, 2010. The farm irrigation was performed using drip irrigation technique with 20 centimeters distance between drippers. Plant density was 90000 plants/ha. During the seed doughing stage, two lateral rows and half a meter as marginal effect was discarded and two middle rows was harvested as forage yield. The measured traits were the forage yield/ha, dry material (DM)/ha, ear weight/ha, husk weight/ha, de-husked ear weight/ha, cob weight/ha, rows no., kernel no. / row and harvest index (HI).

Statistical analysis

As shown below the forage harvest equation is:

$$\textit{Forage harvest index} = (\text{Ear weight}/\text{Total biological yield}) \times 100$$

The SPSS ver. 16 software was used for statistical analysis and means comparison (Duncan's Multi-Range Test method).

Results and discussion

Effect of phosphorous

The analysis of variance showed non-significant effects of phosphorous on forage yield/ha, dry material yield/ha, ear weight/ha, dehusked ear weight/ha, rows no/ear and the kernel no/row, but it had significant effects on ear weight (Table 1). The means comparisons demonstrated that the maximum amount of maize husk is at 0 kg of Phosphorous treatment. There was no significant difference between the

Table 2. Humic acid effect on maize forage yield and the yield components.

Used humic acid	Forage yield /ha	Dry material /ha	ear weight /ha	De-husked ear weight /ha	Husk weight /ha	Cob weight /ha	Row no./ear	Kernel no./row	Forage harvest index
control	51868[a]	18241[b]	14166[b]	9570[b]	4459[b]	823[c]	14.4[ab]	41[a]	27.3%[b]
seedling	57332[a]	19608[b]	18631[a]	11519[ab]	5892[b]	1270[ab]	15[a]	40[a]	32.4%[a]
flowering	50202[a]	31035[a]	14725[b]	10685[b]	5203[b]	1074[b]	14.1[b]	41[a]	29.3%[c]
Seedling with flowering	54090[a]	28076[a]	21785[a]	13712[a]	7938[a]	1333[a]	14.4[ab]	42[a]	40.2%[b]

Means of at least one letter in common, do not have a significant difference in a level of 1% or 5 %.

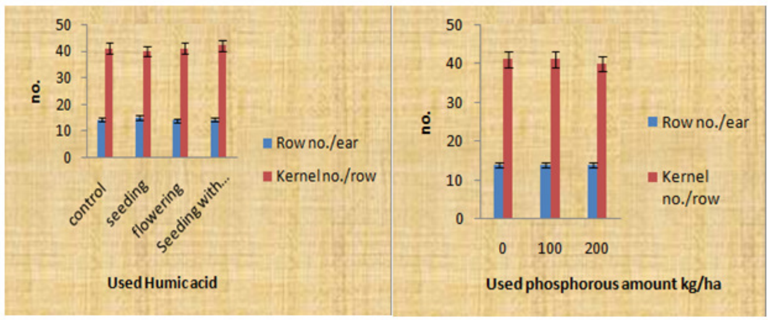

Fig 2. Phosphorous and Humic acid's impact on rows no./ear and kernel no./row.

100 and 200 kg of Phosphorous treatments. The lowest amount is for 100 kilogram phosphorous treatment. There was no significant difference between 0 and 200 kgs of Phosphorous. The results and variance analysis demonstrated that the phosphorous effect on maize cob weight is significant (as seen in Table 1).The mean comparisons demonstrated that the maximum amount of maize cob as shown is for the 200 kg treatment. There was no significant difference between 0 and 100 kg treatments. The lowest amount was as shown for the 100 kg phosphorous treatment case. Forage harvest index is one of the most determinant and important attributes for forage quality in a way that the harvest index of 30-50 % demonstrates forage high quality and below 30% demonstrates low forage quality. Results of ANOVA and mean comparisons showed that phosphorous had significant effect on forage harvest index (Table 1). Means comparison demonstrated that the maximum forage HI happened in the 0 kg treatment. There was no significant difference between 100 and 200 kg/ha phosphorous treatments. The lowest yield was for the 200 kg treatment.

Effects of humic acid

The results of ANOVA showed that humic acid's effect on forage yield was no significant (Table 2). The mean yield of forage maize in 3 repetitions was 53.373 tons/ha. Rezaei-Nezhad et al. (2001) resulted that the organic materials would be increased forage yield which is opposite to our results (Rezaei-Nejad et al., 2001). Mean comparisons showed that the humic acid's effect on dry material was significant especially in flowering stage (Table 2). There was significant difference among without humic acid (control), seedling and seedling with flowering. The minimum performance was related to the without humic treatment. There was no significant difference between flowering and seedling with flowering treatments; additionally, there was no significant difference between without humic and seedling treatments. In another study humic acid increased phosphorous and nitrogen in bentgrass plant, and increased dry material density (Rezvan-Talab et al., 1998). Our result is similar to Ghorbani et al. (2010) results for maize (Ghorbani et al., 2010). The analysis of variance results showed that humic acid's effect on maize's weight is significant (as seen in Table 2).The means comparison demonstrated that the maximum maize weight was seen in seedling with flowering treatment case. There was a significant difference between without humic treatments, seedling and flowering treatments. The minimum amount was related to control (without humic treatment). There was no significant difference between the without humic and flowering treatments; also, there is no significant difference between seedling and seedling with flowering treatments. The Mean comparison results showed that humic acid's impact on husk was significant (as seen in Table 2).The mean comparisons showed us the maximum amount of de-husked ear maize was related to seedling with flowering treatment. There was no significant difference among the without humic, flowering and seedling treatments and there was no significant difference between seedling and seedling with flowering treatments. The humic acid's impact on husk was significant (as seen in Table 2).The mean comparisons showed us that the maximum amount of maize husk was related to seedling with flowering treatment. There was no significant difference between without humic, flowering and seedling treatments. The minimum amount was related to without humic treatments. The variance analysis demonstrated that the humic acid's impact on the maize's cob weight was significant (as seen in Table 2). The mean comparisons showed us that the maximum amount of cob weight was related to the seedling with flowering treatment. There was a significant difference between without humic, flowering and seedling treatments. The minimum amount was related to the without humic treatment. There was no significant difference between flowering and seedling treatments. There is also no significant difference between seedling and seedling with flowering treatments. The number of rows in ear was affected by humic acid (Table 2). The means comparison showed that the maximum rows no./ear was related to the seedling treatments. There was significant difference between without humic, flowering and seedling treatments. The minimum amount is related to the flowering

Table 3. Correlation coefficients between yield and yield components of forage maize.

	Forage yield /ha	Dry material /ha	ear weight /ha	De-husked ear weight/ha	husk weight/ha	Cob weight /ha	Row no./ear
Dry material /ha	0.07375^{ns}						
ear weight /ha	0.35402^{*}	0.04991^{ns}					
De-husked ear weight/ha	0.28888^{ns}	0.34737^{*}	0.35012^{*}				
husk weight/ha	0.28125^{ns}	0.36911^{*}	0.42126^{*}	0.93252^{**}			
Cob weight /ha	0.41399^{*}	0.28050^{ns}	0.51144^{**}	0.78767^{**}	0.76395^{**}		
Row no./ear	0.45870^{**}	-0.12189^{ns}	0.21040^{ns}	0.32368^{ns}	0.31526^{ns}	0.32552^{ns}	
Kernel no./row	0.05928^{ns}	0.30810^{ns}	0.06400^{ns}	0.59427^{**}	0.58777^{**}	0.27784^{ns}	0.42840^{**}

treatment. There was no significant difference between without humic, seedling and seedling with flowering treatments. Studies showed that the humic acid's application to maize plant and the number of rows made no significant difference (Miyasaka et al., 1998). The results of ANOVA and means comparison showed that the humic acid's impact on the kernels no./ear is no significant (as seen in Table 2). The average number of kernel/ear was 41, that is similar to Rezvan-Talab result (Rezvan-Talab et al., 1998). The humic acid's impact on forage HI was significant (as seen in Table 2). The means comparison showed us that the maximum amount of forage harvest was related to seedling with flowering treatment. There were no significant difference between without humic, seedling and flowering humic acid usage. The minimum performance was of the without humic treatment.

Interaction of correlation coefficient

With respect to high correlation coefficient between forage yield and husked ear weight, husk pealed ear's weight and number of rows per ear, cob weight and pealed husk ear's weight, and finally between ear weight and number of rows /ear, we can state that an increase in one factor affects on others in an impressive way (as seen in Table 3).

Conclusion

Results of this study showed us the significance of phosphorous treatment impact on husk weight, cob weight and forage harvest index in a 5% level; it also showed that results from humic acid and various levels of its usage demonstrated its impact on dry material performance, ear weight/ha, de-husk ear weight/ha, husked ear weight/ha, rows no./ear and forage harvest index at 5% level, that can be addressed to low level of organic materials of soil and high level of pH and phosphorous in this region's soil. In one of our conducted studies, the application of humic acid in the nutritional compound caused an increase in the maize plant's Nitrogen content in its air system, and the growth in shoots and roots (Sanchez-Conde et al., 1972). This was achieved by hormone effects and its impact on plant cells, hence increasing its food absorption. Therefore, we can say that humic acid caused growth increase for the plant (MacCarthy, 2001) Wang et al. (1995) added humic acid and some Phosphorous fertilizers to soil in a farm laboratory and then observed that Phosphorous absorption percentage was 25 % higher than no humic acid usage (Wang et al., 1995).Hence the requirement of cutting down on chemical phosphate fertilizers is needed. The results of this study showed us positive impacts of organic materials especially humic acid in forage maize cultivation. One of the advantages of humic acid is having different nutritional substances like sodium, potassium, magnesium, zinc, calcium, iron, copper and some others that can be used to overcome the lack of these substances which are important for the roots' growth and enlargement (Aiken et al., 1985). It also proves that the application of humic acid twice in seedling usage and during the flowering period enhances performance as well as reducing the chemical pollution of the soil.

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