Fayoum Journal of Agricultural Research
and Development
ISSN:1110- 7790

Effect of soil and foliar application of humic acid on growth of grain sorghum (*Sorghum bicolcr* L Moench) grown in calcareous soil under different levels of phosphate fertilizer

Abd- El Samie,F.S.[1]*; Megawer,A.M.[1]; Abdel-Azim,A.A[2]; Hussein,M.U.[2]

[1] Agronomy Department, Faculty of Agriculture, Fayoum University
[2] Researches, Sorghum Res. Dept., FCRI, ARC, Giza

ABSTRACT

The current study was conducted to assess the main and interaction effects of humic acid with different levels of phosphate fertilizer on growth of grain sorghum {*Sorghum bicolor* (L) Moench} grown in calcareous soil. two field experiments were carried out consecutively at tamiya experiment station Agric. Res. center (A.R.C), Fayoum Governorate Egypt, during the during the summer growing seasons 2019 and 2020. The experimental layout was a split- split plot arranged in randomized complete block design with four replications.

At the vegetative growth results displayed that application of phosphorus fertilizers had a significant effect in all growth parameters plant height, stem diameter, number of green and dry leaves plant^{-1} and flag leaf area plant^{-1}, plant weight.

Soil application and Foliar spraying of humic acid reflected positive significant influences on growth parameters in both seasons. Soil application H_{20} followed by H_{10} and Foliar spraying F2 followed by F_1 were the potent treatment for increasing growth parameters compared with control treatments (without humic acid).

Key Words: sorghum (***Sorghum bicolcr L Moench***.), Humic acid, Phosphorus fertilizers, Reclaimed soils, Growth stage, Yield.

INTRODUCTION

Grain sorghum is an important annual cereal crop grown for both grain and palatable green forage production **Kumar and Chopra, 2013**. It comes at the fifth most important cereal crop in the world after wheat, maize, rice, and barley in terms of importance and production. The most important global countries for grain sorghum production are USA, Nigeria, Ethiopia, Sudan, Mexico and India, while Egypt has ranked nineteen in this respect **FAO, 2019.** In 2019 Grain sorghum cultivated area in Egypt was about 365439 feddan which producing about 792044 tons **(FAO, 2019).**

*Corresponding author: Email:maa22@fayoum.edu.eg
Received: 3/10/ 2021
Accepted:15/11/ 2021

Phosphorus is one of the most important nutrients for higher yield in larger quantity **(Chen, *et al.*, 1994).** Phosphorus is the second most crop- limiting nutrient in most soils. It is second only to nitrogen in fertilizer use. Plant growth behavior is influenced by the application of phosphorus. It is needed for growth, metabolism of sugar and starch photosynthesis, nucleus formation. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds for later use in growth and reproduction **Ayub et al., 2002.**

Calcareous soils cover more than 30% of the earth's land surface and they are the main soil of most of the arid and semi-arid climates. The calcareous soils in Egypt are estimated to be around 0.65 million feddans (feddan= 4200 m^2) **Hassan, 2012.** These soils contain different amounts of calcium carbonate (CaCO3) that affects the physical (such as soil water relations) and chemical (such as fertility, nutrient availability) soils properties related to plant growth. The excess of calcium carbonate increases soil pH, whereas a pH higher than 8 (up to 8.4) leads to reduced access to micronutrients, emissions of ammonium and reduced solubility and phosphorus uptake. In addition, calcareous soils in warmer regions are naturally low in organic matter due to high temperature **Leytem and Mikkelsen, 2005**. It is assumed that under calcareous soils, humic acid improves the growth and yield of sorghum and increase the absorption of nutrients as a result.

Humic substances play an important role in soil fertility and plant nutrition **Pettit, 2004.** Humic acid is known to be among the most bio-chemically active materials found in the soil. It's an affective agent to be used as a complement to synthetic or organic fertilizers. In many instances, regular humic acid presence will reduce the need of fertilization due to the soil's and plant's ability to make better use of it. In some occurrences, fertilization can be eliminated entirely if sufficient organic materials are present which lead to a self-sustaining soil as a result of microbial processes and humus production. In general, increasing certain levels of humic acid have a number of potential benefits for plants; the most important ones are increasing water and nutrients holding capacity, enhancing solubility of phosphorus **Selim et al., 2009.**

Plants suffer from phosphorus deficiency problem, in high **PH** soils especially when grown in calcareous soils because of formation of calcium phosphate and sub sequentially phosphorus becomes the in the non- concessional form. In lime soil, most likely found in Egypt reduction of available soil phosphorous is a common problem for plants due to phosphorous fixation into low level dissolved compounds e.g. calcium phosphate. This is considered nutrition for plants **Rezazadeh, et al., 2012.**

Hence this study was performed to investigate the effect of soil and foliar application of humic acid and different levels of phosphate fertilizer on growth of grain sorghum grown in calcareous soil.

MATERIALS AND METHODS

Tow field experiments were carried out at Tamiya experiment station Agric.Res.center (A.R.C), Fayoum Governorate Egypt, during the two successive seasons of 2019and 2020. The study was conducted in order to investigate the effect of phosphorous levels, soil application of humic acid, foliar spraying of humic acid and their interactions on growth and yield of grain sorghum grown in calcareous soil.

Each experiment included 27 treatments arranged in a split split plot design with 4 replicates. the experimental unit contained 5 ridges each of 3 m length and 0.٦m width, resulted an area of ٩ m^2 (1/4٦٦ fed) .

The treatments were the combinations of:

1-Three phosphorus levels (100, 200 and 300 kg/fed), occupied main plots. (P_{15}=100, P_{30} =200cm and P_{45} =300 kg/fed.).

2-Three levels of humic acid (HA) was applied as soil application i. e.

(0, 10 and 20 kg/fed), arranged in the sub plots.

3-Three foliar spraying of humic acid (0, 400 and 800 mg/L), arranged in the sub-sub plots.

Cultural practices

The grains of sorghum {*Sorghum bicolor* (L) Moench } were sown in April 17 and15 in the 1st and 2nd seasons respectively after fallow in both seasons. Each sub –sub plot was fertilized with NK fertilizers. Nitrogen fertilizer was added in the form of ammonium nitrate (33.5 % N) at the rate of 90 Kg N/fad, splatted into two equal doses , one half after thinning (before 1st irrigation), and the other half (before 2 nd irrigation). Potassium fertilizer was added in the form of potassium sulphate (48% k_2o) at the rate of 24 kg k_2o/fed., added during the field preparation.

The plants were thinned to two plants per hill before the first irrigation. The first irrigation was applied after 21 days after sowing and the following irrigation was applied at 15 days intervals during the growing seasons. Hand hoeing twice was applied after 20 and 35 days after sowing. The other agricultural practices were kept the same as normally practices in sorghum field according to the recommendation s of ministry of agriculture and land reclamation, except for the factors under study. The preceding winter crop in the first and second seasons of the study was wheat.

Soil characteristics

The soil texture of the sites was clay loam in both seasons; mechanical as well as chemical analysis of the experimental sit was presented in table (1).

Table (1) some Physical and chemical analysis of the experimental site" tamiya experimental station" in 2019 and 2020 seasons.

Soil analysis	2019	2020
	A: Mechanical analysis	
Sandy %	38.00	34.92
Silt %	21.20	22.50
clay%	40.80	42.58
Textural grade	Clay loom	Clay loom
	B: chemical analysis	
PH	8.12	8.20
E.C(ds/m) at 25^0C	4.00	3.96
Organic matter %	1.68	1.72
CaCo3%	11.18	11.14
Available N ppm	8.0	8.2

Data recorded:

Arandom sample of 5 plants from each plot was taken At harvest, in order to determine the following vegetative characters:

1. Plant height (cm): The length of the plant was measured by a strip from the soil surface to the top of the plant**.**
2. Stem diameter (cm).
3. Number of fresh leaves plant^{-1}.
4. Number of dry leaves plant^{-1}.
5. Plant weight (g).
6. Flag leaf area plant^{-1} (cm^2)

All data obtained in both seasons were subjected to analysis using ANAOVA table in GenStat Statistical computer software (edition12). Treatment means were compared using the least significant difference (LSD) test according to **Gomez and Gomez, (1984)** at the 5% level of significance.

RESULTS AND DESCUSSION

1. Plant Height (cm):

Table (2) displays the main and interaction impacts of phosphorous fertilization, humic acid soil application, humic acid foliar application and their interactions on plant height at harvest as average of the combined analysis for 2019 and 2020 seasons. Results showed that soil application of phosphorus fertilization at different rates reflected positive significant influences on plant height in comparison with the untreated control. Soil application of phosphorus fertilization (P_{45}) 300 kg P_2O_5 fed^{-1} resulted in the best average of mean values of plant height. Increased plant height was recorded at higher levels of phosphorus application treatments resulted in the availability of higher energy in the form of ATP molecules which would have helped in cell elongation in turn resulted in taller plants. Similar results were suggested by several investigations, i. e. **Al- Taher et al, 2005; Roy and Khandaker 2010; Baghdady 2016 and El-Mahi and Salih2019.**

Soil application humic acid had a significant effect on plant height (cm) of sorghum plants combined analysis for 2019 and 2020 seasons Table (2). Soil application humic acid caused significant increases in plant height as compared with control treatment (without humic acid). The tallest sorghum plants (143.0 cm) were achieved by using 20 kg/fed humic acid. Adversely, the shortest sorghum plants (135.0 cm) were resulted from control treatment (without humic acid).

Different levels of humic acid foliar application had a major effect on plant height. In this regard, adding 800 mg/L., give the highest mean values of plant height, followed by 400 mg/L, as compared to control treatment (0 mg/L).That could be related to the fact that humic acid soil and foliar application to grain sorghum plant will increase cell membrane permeability and may have hormone-like activity. These results are in good agreement with those obtained by **El-Sagheer and Mohamed 2017; Al-Beiruty et al, 2018; Al-Bawee et al, 2019 and Ali et al, 2020** reported that plant height was affected significantly, by humic acids rates.

Regarding, the interaction between phosphorous treatment and soil application of humic acid (P x H) had a significant effect on plant height. Grain sorghum plants grown under phosphorous treatment (P_{45}) with applying 20 kg fed^{-1} humic acid (P_{45} x H_{20}) were recorded the highest plant height (146.1cm) followed by (142.5cm) was achieved by plants grown under (P_{30} x H_{10}). Whereas the shortest plant (132.2cm) was obtained from (P_{15} x H_0). Also, the interaction between phosphorous treatment and foliar spraying of humic acid (P x F) was significant for plant height. Applying 300 kg P_2O_5 fed^{-1} a combined with 800 mg/L of foliar spraying of humic (P_{45} x F_2) recorded the best values of plant height (147.3cm), while the lower values of plant height (135.1cm) was achieved by (P_{15} x F_0). Also the interaction between 20 kg fed^{-1} soil application of humic acid and 800 mg/L of foliar application of humic, (H_{20} x F_2) achieved the highest value of plant height. The interaction between phosphorous treatment (P), soil application of humic acid (H) and foliar spraying of humic acid (F) had significant effect on plant height. Applying of phosphorus fertilization at 45 kg P fed^{-1} a combined with soil application of humic acid at 20 kg fed^{-1} and foliar spraying of humic acid at 800 mg/L (P_{45} x H_{20} x F_2) was recorded the highest value of plant height (151.3cm).

2. Stem diameter (cm):

Data given in (Table 3) obviously show the average of stem diameter of sorghum plants as a result of phosphorous fertilizers levels, soil application of humic acid, foliar spraying of humic acid and their interactions.

Soil application of phosphorus fertilization treatments had significant effect on stem diameter. Phosphorus fertilization at 300 kg P_2O_5 fed^{-1} (P_{45}) gave the highest value of stem diameter (2.71 cm). On the other hand, the lowest value of stem diameter (2.55 cm) was resulted by phosphorus fertilization 100 kg P_2O_5 fed^{-1} (P_{15}). Overall improvement in growth of sorghum plants under the influence of increasing rate of phosphorus levels could be ascribed due to the potential role of P fertilizer in modifying soil and plant environment conducive for better development of both morphological and biochemical components of the growth. A similar result was observed by **Al-Taher et al, 2005**.

Humic acid soil application i.e., 10, 20 kg fed.$^{-1}$, reflected positive significant influences on stem diameter in comparison with the untreated control. Plots treated with (H_{20}) 20 kg of humic acid fed^{-1} gave the highest average value of stem diameter (2.75 cm). The mentioned treatment increased stem diameter than the untreated control by 9.56 %.

Table (2): Effect of phosphorus fertilizers (P) levels, humic acid soil application (H), humic acid foliar application (F) and their interactions on plant height (cm) at harvest of sorghum plants (combined analysis for 2019 and 2020 seasons).

Phosphorus fertilizers (P)	**Humic Acid soil application (H)**	**Humic Acid foliar application (F)**			**Mean**
		F_0 (Control)	**F_1 (400 mg/L)**	**F_2 (800 mg/L)**	
100 k g P_2O_5 (P_{15})	**H_0** Control	131.7	132.9	132.0	132.2
	H_{10} 10 kg/fed.	134.4	136.0	139.2	136.5
	H_{20} 20 kg/fed.	139.3	140.9	140.8	140.3
	Mean	135.1	136.6	137.3	136.4
200 k g P_2O_5 (P_{30})	**H_0** Control	134.8	136.4	136.6	135.9
	H_{10} 10 kg/fed.	136.3	147.0	142.8	142.0
	H_{20} 20 kg/fed.	139.3	143.4	144.8	142.5
	Mean	136.8	142.3	141.4	140.2
300 k g P_2O_5 (P_{45})	**H_0** Control	128.7	137.2	144.5	136.8
	H_{10} 10 kg/fed.	145.2	143.6	146.2	145.0
	H_{20} 20 kg/fed.	140.2	146.7	151.3	146.1
	Mean	138.0	142.5	147.3	142.6
Means of humic acid soil application	**H_0** Control	131.7	135.5	137.7	135.0
	H_{10} 10 kg/fed.	138.6	142.2	142.7	141.2
	H_{20} 20 kg/fed.	139.6	143.7	145.6	143.0
	Mean	136.7	140.5	142.0	139.7

L.S.D. 5% for	
Super phosphate (P)	1.15
Humic Acid Powder (H)	1.46
Humic Acid foliar (F)	1.06
Interaction : (P x H)	2.80
: (P x F)	1.81
: (H x F)	N.S.
:(P x H x F)	3.43

Different levels of humic acid foliar application had a major effect on stem diameter. In this regard, adding 800 mg/L., give the highest mean values of stem diameter (2.70 cm), followed by 400 mg/L recorded (2.62 cm), as compared to control treatment (0 mg/L.,) gave (2.60 cm). The increase in growth characteristics in response to humic acid may be due to the presence of growth promoting substances like indole acetic acid (IAA), gibberellins and auxin in its structure that are directly involved in cell respiration, photosynthesis, oxidative phosphorylation, protein synthesis, and various enzymatic reactions. The findings obtained are comparable to those obtained by **Al-Bawee et al, 2019** reported that stem diameter was affected, significantly, by humic acids rates.

Combined analysis revealed significant differences between the interaction between phosphorus fertilization (P) and humic acid soil application (H). Phosphorous treatment (P_{45}) with applying 20 kg fed^{-1} humic acid (H_{20}) gave the highest value of stem diameter, while the lowest value of stem diameter was observed when applied (P_{45}) combined with the (H_0).

Data in **(Table 3)** indicated that the interaction between phosphorus fertilization and humic Acid foliar application **(**P x H) which was significant effect. The interaction between (P_{45} x F_2) achieved the highest average of value of stem diameter. On the other hand, the lowest value for this character was recorded by phosphorus fertilization (P_{15}) and humic acid foliar application (F_0). Also the interaction between humic acid soil application (H) and humic acid foliar application **(**H x F) had a significant effect on stem diameter. The highest stem diameter value (2.86cm) was obtained by the interaction between (H_{20} x F_2).

The interaction between phosphorous treatment (P), soil application of humic acid (H) and foliar application of humic acid (F) had a significant effect of stem diameter. Applying of phosphorus fertilization at 300 kg P_2O_5 fed^{-1}, soil application of humic acid at 20 kg fed^{-1} and foliar spraying of humic acid at 800 mg/L (P_{45} x H_{20} x F_2) was recorded the highest values of stem diameter (2.96cm). On the other hand, phosphorous treatment (P_{15}), soil application of humic acid (H_0) and foliar spraying of humic acid (F_0) gave the lowest value of stem diameter (2.33cm).

3. Number of green leaves plant^{-1}:

Table (4) displays the main and interaction impacts of phosphorous levels, soil application of humic acid, foliar application of humic acid and their interactions on number of green leaves/plant at harvest as an average of the (combined analysis) for two seasons of 2019 and 2020.

Soil application of phosphorus fertilization at the rates of 300 kg P_2O_5 fed^{-1}, (P_{45}) significantly resulted in higher mean values of number of green leaves plant^{-1} than the control treatment 100 kg P_2O_5 fed^{-1} (P_{15}). Phosphorus is an important element affecting the growth of plants right from the cellular to whole plant level. These growth parameters include plant height, leaf area, leaf number and shoot dry biomass. It plays an important role in cell division and cell enlargement**.** A similar result was observed by **Al-Taher et al, 2005.**

Soil application of humic acid reflected positive effects on number of green leaves plant^{-1} in comparison with the untreated control. The highest number of green leaves plant^{-1} (7.75) was recorded by humic acid at 20 kg fed^{-1}. While, the minimum values of this trait (6.56) was given by the control treatment (without humic acid).Similar findings on the enhancing impact of humic acid on number of leaves plant^{-1} of maize were obtained by **Daur and Bakhashwain, 2013.**

Table (3): Effect of phosphorus fertilizers (P) levels, humic acid soil application (H), humic acid foliar application (F) and their interactions on stem diameter (cm) at harvest of sorghum plants (combined analysis for 2019 and 2020 seasons).

Phosphorus fertilizers (P)	Humic Acid soil application (H)	Humic Acid foliar application (F) F_0 (Control)	F_1 (400 mg/L)	F_2 (800 mg/L)	Mean
100 kg P_2O_5 (P_{15})	H_0 Control	2.33	2.36	2.36	2.35
	H_{10} 10 kg/fed.	2.50	2.58	2.56	2.55
	H_{20} 20 kg/fed.	2.68	2.66	2.92	2.76
	Mean	2.51	2.54	2.61	2.55
200 kg P_2O_5 (P_{30})	H_0 Control	2.55	2.52	2.69	2.59
	H_{10} 10 kg/fed.	2.66	2.64	2.76	2.69
	H_{20} 20 kg/fed.	2.70	2.65	2.69	2.68
	Mean	2.64	2.61	2.72	2.65
300 kg P_2O_5 (P_{45})	H_0 Control	2.62	2.55	2.64	2.60
	H_{10} 10 kg/fed.	2.70	2.69	2.75	2.71
	H_{20} 20 kg/fed.	2.62	2.90	2.96	2.83
	Mean	2.64	2.71	2.78	2.71
Means of humic acid soil application	H_0 Control	2.50	2.48	2.56	2.51
	H_{10} 10 kg/fed.	2.62	2.64	2.69	2.65
	H_{20} 20 kg/fed.	2.67	2.74	2.86	2.75
	Mean	2.60	2.62	2.70	2.64

L.S.D. 5% for	
Super phosphate (P)	0.051
Humic Acid Powder (H)	0.059
Humic Acid foliar (F)	0.038
Interaction : (P x H)	0.093
: (P x F)	N.S.
: (H x F)	0.078
:(P x H x F)	0.130

Foliar spraying of humic acid treatments was significantly superior to untreated plots. Foliar application of humic acid F_2 (800 mg/L) increased number of green leaves plant^{-1} of sorghum plants compared with control treatment by 12.43%. This is probably by protecting the photosynthetic pigments, the photosynthetic apparatus and increasing the metabolic activities relevant to growth through enhancing cell division and/or cell enlargement. Similar findings on the enhancing impact of humic acid on number of leaves plant^{-1} of sorghum were obtained by **El-Sagheer and Mohamed 2017 and Al-Bawee et al, 2019.**

Results in (Table 4) illustrated that the interaction phosphorous treatment and soil application of humic acid (P x H) had a significant effect on number of green leaves plant^{-1} value (8.15) were obtained by 200 kg P_2O_5 fed^{-1} of phosphorous treatment with 20 kg fed^{-1} of soil application of humic acid (P_{30} x H_{20}).

The interaction between phosphorous fertilizers treatment and foliar application of humic acid (P x F) had a significant effect on number of green leaves plant^{-1}. On the other hand the highest values of number of green leaves (8.26) were produced by applying of soil application of humic acid (H_{20}) combined with foliar application of humic acid (F_2).

Data presented in (Table 4), showed the effect of the interaction between phosphorous treatment (P), soil application of humic acid (H) and foliar application of humic (F) on number of green leaves were not significan.

4. Number of dry leaves plant^{-1}:

The average of mean number of dry leaves plant^{-1} as affected by phosphorus fertilization; humic acid and their interaction are given in the Table (5). The available results divulge that the impact of phosphorus fertilization treatments on number of dry leaves plant^{-1} was significant. P_{15} (control treatment) produced the highest value of number of dry leaves plant^{-1}, which increased number of dry leaves plant^{-1} than P_{45} (300 kg P_2O_5) by 10.29 %.

All humic acid soil application treatments were significantly superior to untreated plots. H20 and H10 treatments were the effective humic acid soil application treatments for decreasing number of dry leaves plant-1. The two mentioned treatments decreasing number of dry leaves plant-1 than control treatment H0 by 13.54, and 9.85 % respectively

All humic acid foliar application treatments were significantly superior to untreated plots. F_2 treatment was the effective humic acid foliar application treatments for decreasing number of dry leaves plant^{-1}. The mentioned previous treatment decreasing number of dry leaves plant^{-1} than control treatment F_0 by 14.17%.

Results in (Table 5) illustrated that the interaction between phosphorous fertilizers treatment and foliar application of humic acid (P x F) had a significant effect on number of fresh leaves plant^{-1}. The lowest values of number of dry leaves (5.21) were produced by applying of soil application of humic acid (H_{20}) combined with foliar application of humic acid (F_2).

Table (4): Effect of phosphorus fertilizers (P) levels, humic acid soil application (H), humic acid foliar application (F) and their interactions on number of green leaves/plant at harvest of sorghum plants (combined analysis for 2019 and 2020 seasons).

Phosphorus fertilizers (P)	Humic Acid soil application (H)	Humic Acid foliar application (F)			Mean
		F_0 (Control)	F_1 (400 mg/L)	F_2 (800 mg/L)	
100 kg P_2O_5 (P_{15})	H_0 Control	5.65	6.48	6.84	6.33
	H_{10} 10 kg/fed.	6.58	6.95	8.30	7.28
	H_{20} 20 kg/fed.	6.31	6.99	8.04	7.11
	Mean	6.18	6.81	7.73	6.91
200 kg P_2O_5 (P_{30})	H_0 Control	6.52	7.30	7.09	6.97
	H_{10} 10 kg/fed.	6.46	7.72	8.17	7.45
	H_{20} 20 kg/fed.	8.05	7.69	8.71	8.15
	Mean	7.01	7.57	7.99	7.52
300 kg P_2O_5 (P_{45})	H_0 Control	6.51	6.44	6.23	6.39
	H_{10} 10 kg/fed.	7.60	7.17	7.77	7.51
	H_{20} 20 kg/fed.	7.90	8.07	8.02	8.00
	Mean	7.34	7.23	7.34	7.30
Means of humic acid soil application	H_0 Control	6.23	6.74	6.72	6.56
	H_{10} 10 kg/fed.	6.88	7.28	8.08	7.41
	H_{20} 20 kg/fed.	7.42	7.59	8.26	7.75
	Mean	6.84	7.20	7.69	7.24

L.S.D. 5% for	
Super phosphate (P)	0.46
Humic Acid Powder (H)	0.17
Humic Acid foliar (F)	0.31
Interaction : (P x H)	0.493
: (P x F)	0.599
: (H x F)	0.462
:(P x H x F)	N.S.

5. Plant weight (g):

Table (6) displays the main and interaction impacts of phosphorous levels, soil application of humic acid, foliar application of humic acid and their interactions on plant weight (g) at harvest as an average of the two experimental seasons of 2019 and 2020.

Results showed that soil application of phosphorus fertilization at different rates reflected positive significant influences on plant weight in comparison with the untreated control. Soil application of phosphorus fertilization (P_{45}) 300 kg P_2O_5 fed^{-1} resulted in the best average of mean values of plant weight (454.91 g). Adversely of that, the lowest values of dry weight of sorghum plants (386.98g) was proceeded from fertilizing sorghum plants with the lowest phosphorus level (P_{15}) 100 kg P_2O_5 fed^{-1}. A similar set of findings was also published by **Camacho et al, 2002; Abou-Amer and Kewan 2014; Roy et al, 2015 and Pritam et al, 2019.**

Table (5): Effect of phosphorus fertilizers (P) levels, humic acid soil application (H), humic acid foliar application (F) and their interaction on number of dry leaves $plant^{-1}$ at harvest of sorghum plants (combined analysis for 2019 and 2020 seasons).

Phosphorus fertilizers (P)	Humic Acid soil application (H)	Humic Acid foliar application (F) F_0 (Control)	F_1 (400 mg/L)	F_2 (800 mg/L)	Mean
100 kg P_2O_5 (P_{15})	**H_0** Control	7.90	6.28	5.66	6.61
	H_{10} 10 kg/fed.	6.57	5.84	5.40	5.94
	H_{20} 20 kg/fed.	6.34	6.52	6.03	6.30
	Mean	6.94	6.21	5.70	6.28
200 kg P_2O_5 (P_{30})	**H_0** Control	6.44	6.11	6.49	6.34
	H_{10} 10 kg/fed.	6.20	6.43	5.38	6.00
	H_{20} 20 kg/fed.	5.98	6.10	5.06	5.71
	Mean	6.21	6.21	5.64	6.02
300 kg P_2O_5 (P_{45})	**H_0** Control	6.94	5.88	6.78	6.54
	H_{10} 10 kg/fed.	6.10	6.10	4.69	5.63
	H_{20} 20 kg/fed.	5.30	5.08	4.14	4.84
	Mean	6.11	5.69	5.21	5.67
Means of humic acid soil application	**H_0** Control	7.09	6.09	6.31	6.50
	H_{10} 10 kg/fed.	6.29	6.12	5.16	5.86
	H_{20} 20 kg/fed.	5.88	5.90	5.07	5.62
	Mean	6.42	6.04	5.51	5.99

L.S.D. 5% for	
Super phosphate (P)	0.47
Humic Acid Powder (H)	0.31
Humic Acid foliar (F)	0.43
Interaction : (P x H)	N.S.
: (P x F)	0.73
: (H x F)	N.S
:(P x H x F)	N.S.

Soil application and foliar spraying of humic acid was responsible for producing significantly, heaviest plants than the untreated control. the average of mean values of plant weight showed that soil application of humic acid at 20 kg fed^{-1} seems to be suitable and recorded the heaviest mean values of plant weight. Also, foliar spraying of humic acid at 800 mg/L resulted in the best mean values of plant weight. On the other side, the lowest values of dry weight of sorghum plants (379.50 and 394.92g) were given by using the control treatment (without humic acid) in both two addition methods soil and foliar application, respectively. Humic acid stimulate plant growth by the assimilation of major and minor elements, enzyme activation and /or inhibition, changes in membrane permeability, protein synthesis. The obtained findings are consistent with those previously published by **Eyheraguibed et al, 2008; Hamad and Manal Taantawy 2018 and Al-Bawee et al, 2019.**

Regarding, the interaction between phosphorous treatment and soil application of humic acid (P x H) had a significant effect on plant weight. Grain sorghum plants grown under phosphorous treatment (P_{45}) with applying 20 kg fed^{-1} humic acid (P_{45} x H_{20}) were recorded the heaviest plant weight (494.30g). As well, the interaction between phosphorous treatment and foliar spraying of humic acid (P x F) was significant for plant height. Applying 300 kg P_2O_5 fed^{-1} a combined with 800 mg/L of foliar spraying of humic (P_{45} x F_2) recorded the best values of plant weight , while the lower values of plant height was achieved by (P_{15} x F_0). Also the interaction between 20 kg fed^{-1} soil application of humic acid and 800 mg/L of foliar application of humic, (H_{20} x F_2) achieved the highest value of plant weight (497.06 g).

The interaction between phosphorous treatments (P), soil application of humic acid (H) and foliar spraying of humic acid (F) had significant effect on plant weight. Applying of phosphorus fertilization at 45 kg P fed^{-1} a combined with soil application of humic acid at 20 kg fed^{-1} and foliar spraying of humic acid at 800 mg/L (P_{45} x H_{20} x F_2) was recorded the highest value(529.66g).

Table (6): Effect of phosphorus fertilizers (P) levels, humic acid soil application (H), humic acid foliar application (F) and their interactions on plant weight (g) at harvest of sorghum plants (combined analysis for 2019 and 2020 seasons).

Phosphorus fertilizers (P)	Humic Acid soil application (H)	Humic Acid foliar application (F) F$_0$ (Control)	F$_1$ (400 mg/L)	F$_2$ (800 mg/L)	Mean
100 kg P_2O_5 (P_{15})	**H_0** Control	314.01	328.22	341.12	327.79
	H_{10} 10 kg/fed.	383.01	383.00	447.01	404.34
	H_{20} 20 kg/fed.	373.61	434.54	478.29	428.81
	Mean	356.88	381.92	422.14	386.98
200 kg P_2O_5 (P_{30})	**H_0** Control	350.88	370.44	424.33	381.88
	H_{10} 10 kg/fed.	413.00	459.42	490.01	454.14
	H_{20} 20 kg/fed.	433.35	466.94	483.23	461.18
	Mean	399.08	432.27	465.86	432.40
300 kg P_2O_5 (P_{45})	**H_0** Control	430.77	399.83	455.88	428.83
	H_{10} 10 kg/fed.	395.88	431.57	497.30	441.58
	H_{20} 20 kg/fed.	459.73	493.53	529.66	494.30
	Mean	428.79	441.65	494.28	454.91
Means of humic acid soil application	**H_0** Control	365.22	366.16	407.11	379.50
	H_{10} 10 kg/fed.	397.30	424.66	478.11	433.36
	H_{20} 20 kg/fed.	422.23	465.00	497.06	461.43
	Mean	394.92	418.61	460.76	424.76

L.S.D. 5% for	
Super phosphate (P)	8.36
Humic Acid Powder (H)	11.09
Humic Acid foliar (F)	8.86
Interaction : (P x H)	17.16
: (P x F)	N.S.
: (H x F)	16.44
:(P x H x F)	27.29

6. Flag leaf area (cm^2):

Data given in (Table 7) obviously show the average of flag leaf area of sorghum plant as a result of phosphorous fertilizers levels, soil application of humic acid, foliar spraying of humic acid and their interactions.

Soil application of phosphorus fertilization treatments had significant effect on flag leaf area. Phosphorus fertilization at 300 kg P_2O_5 fed^{-1} (P_{45}) gave the highest value of flag leaf area (406.36 cm^2). On the other hand, the lowest value of flag leaf area (360.24cm^2) was resulted by phosphorus fertilization 100 kg P_2O_5 fed^{-1} (P_{15}).

Humic acid soil application i.e., 10 and 20 kg $fed.^{-1}$, reflected positive significant influences on flag leaf area in comparison with the untreated control. Plots treated with (H_{20}) 20 kg of humic acid fed^{-1} gave the highest average value of flag leaf area (406.74 cm^2).

Humic acid foliar application had a major effect on flag leaf area. In this side, adding 800 mg/L, give the higher values of flag leaf area (400.81 cm^2), followed by 400 mg/L, as compared to control treatment (0 mg/L,). Under calcareous soil conditions, foliar application of humic acid can be a good practice for improving plant growth and uptake of the nutrients studied **Çelik et al, 2011**.

Combined analysis revealed significant differences between the interaction between phosphorus fertilization (P) and humic acid soil application (H). Phosphorous treatment (P_{45}) with applying 20 kg fed^{-1} humic acid (H_{20}) gave the highest value of flag leaf area, while the lowest value of flag leaf area was observed when applied (P_{45}) combined with the (H_0).

Data in (Table 7) indicated that the interaction between phosphorus fertilization and humic acid foliar application **(**P x H) which was significant effect. The interaction between (P_{45} x F_2) achieved the highest average of value of flag leaf area. On the other hand, the lowest value for this character was recorded by phosphorus fertilization (P_{15}) and humic acid foliar application (F_0). Also the interaction between humic acid soil application (H) and humic acid foliar application **(**H x F) had a significant effect on flag leaf area. The highest flag leaf area value (444.05 cm^2) was obtained by the interaction between (H_{20} x F_2).

The interaction between phosphorous treatment (P), soil application of humic acid (H) and foliar application of humic acid (F) had a significant effect of flag leaf area. Applying of phosphorus fertilization at 300 kg P_2O_5 fed^{-1}, soil application of humic acid at 20 kg fed^{-1} and foliar spraying of humic acid at 800 mg/L (P_{45} x H_{20} x F_2) was recorded the highest values of flag leaf area (565.22 cm^2). On the other hand, phosphorous treatment (P_{15}), soil application of humic acid (H_0) and foliar spraying of humic acid (F_0) gave the lowest value of flag leaf area (311.31 cm^2).

The increase in growth characteristics in response to humic acid may be due to the presence of growth promoting substances like indole acetic acid (IAA), gibberellins and auxin in its structure that are directly involved in cell respiration, photosynthesis, oxidative phosphorylation, protein synthesis, and various enzymatic reactions. This increase may also be owing to the effect of HA on root development, stimulation of root hairs and enhancement of root initiation by HA may increase nutrients uptake that eventually affected the growth characteristics of plant**.** In addition, this increase might be due to the enhanced uptake of minerals through the stimulation of microbiological activity of soil **Arjumend, et al 2015**.

Table (7): Effect of phosphorus fertilizers (P) levels, humic acid soil application (H), humic acid foliar application (F) and their interactions on flag leaf area (cm^2) at harvest of sorghum plants (combined analysis for 2019 and 2020 seasons).

Phosphorus fertilizers (P)	Humic Acid soil application (H)	Humic Acid foliar application (F) F_0 (Control)	F_1 (400 mg/L)	F_2 (800 mg/L)	Mean
100 kg P_2O_5 (P_{15})	H_0 Control	311.31	336.01	346.20	331.17
	H_{10} 10 kg/fed.	398.53	336.78	328.20	354.50
	H_{20} 20 kg/fed.	431.97	355.28	397.86	395.03
	Mean	380.60	342.69	357.42	360.24
200 kg P_2O_5 (P_{30})	H_0 Control	318.05	336.53	367.14	340.57
	H_{10} 10 kg/fed.	436.30	325.14	424.41	395.28
	H_{20} 20 kg/fed.	378.67	377.66	369.09	375.14
	Mean	377.67	346.44	386.88	370.33
300 kg P_2O_5 (P_{45})	H_0 Control	431.64	328.33	328.70	362.89
	H_{10} 10 kg/fed.	330.93	407.11	480.44	406.16
	H_{20} 20 kg/fed.	363.02	421.89	565.22	450.04
	Mean	375.20	385.78	458.12	406.36
Means of humic acid soil application	H_0 Control	353.66	333.62	347.35	344.88
	H_{10} 10 kg/fed.	388.59	356.34	411.02	385.31
	H_{20} 20 kg/fed.	391.22	384.94	444.05	406.74
	Mean	377.82	358.30	400.81	378.98

L.S.D. 5% for	
Super phosphate (P)	21.83
Humic Acid Powder (H)	18.04
Humic Acid foliar (F)	25.77
Interaction : (P x H)	31.82
: (P x F)	N.S.
: (H x F)	40.24
:(P x H x F)	70.05

REFERENCES

Abou-Amer, A. I and. K. Z . Kewan 2014. Effect of NP Fertilization Levels on Sorghum (*Sorghum bicolor* L.) Yield and Fodder Quality for Animals. Alex. J. Agric. Res. Vol. 59, No.1, pp.51-59.

Al-bawee, A. Sh. H. and E. Kh. Aziz 2019. Effect of Potassium and Foliar Nutrition with Humic Acid on Growth and Yield of *Sorghum bicolor* (L.) Meonch. Plant Archives Vol. 19 No. 1, 2019 pp. 485-491.

Al-Beiruty, R. Z. ; B.M. Finekher and H. K.Khrbeet 2018. Foliar application of humic acid, it's components and effect on grain yield in Sorghum. Journal of Research in Ecology. 6(2):2032-2043.

Al-Taher, F. M.; Al-Refai, S. I., & Al-Abdulla, S. A. 2005. Effect of different levels of nitrogen and phosphorus fertilizers on growth and yield of sorghum. journal of university of babylon, 12(3):

Ali, E.A.; K.A. Abd El-Rahman ; I.A. El-Far and A.H. Mohamed 2020 Response of some Grain Sorghum Genotypes to Foliar Spray by Humic Acid. Assiut J. Agric. Sci., 51 (2): 54-63.

Arjumend, T.; Abbasi, M. K. and Rafique, E. 2015. Effects of lignite-derived Humic acid on some selected soil properties, growth and nutrient uptake of wheat (*Triticum Aestivum* L.) grown under greenhouse conditions. Pakistan J. Bot. 47, 2231–2238.

Ayub, M.; M.A. Nadeem; M.S. Sharar and N. Mahmood. 2002. Response of maize (*Zea mays* L.) fodder to different levels of

Baghdady, A.M.M.(2016) Response of some sorghum (Sorghum bicolor L.) cultivars to sowing dates and phosphorus fertilization under New Valley conditions. Middle East Journal of Applied 6(4): 1150-1159.

Camacho, R., E. Malavolta ; J. Guerrero-Alves & T. Camacho 2002. Vegetative growth of grain sorghum in response to phosphorus nutrition. Scientia Agricola, 59(4): 771-776.

Celik, H.; A. V.Katkat ; B. B.Aşık & M. A. Turan (2011). Effect of foliar-applied humic acid to dry weight and mineral nutrient uptake of maize under calcareous soil conditions. Communications in soil science and plant analysis, 42(1), 29-38.

Chen, M. L.; X. L. Jiang ; B.Y. Zoov and Z.Y. Zheri 1994 Mathematical models and best combination of high yield cultivation technique for rapeseed variety Zhenyouyoum. Acta Agric Zhejiiangenesis. 6:22-26.

Daur, I. & A. A. Bakhashwain (2013) Effect of humic acid on growth and quality of maize fodder production. Pak. J. Bot, 45(S1): 21-25.

El Mahi, Y. E. & T. M. Salih 2019 Response of Sorghum [Sorghum bicolor (L.) Moench] to Phosphorus and Nitrogen Fertilization under Rainfed Conditions, Blue Nile State–Sudan. University of Khartoum Journal of Agricultural Sciences, 20(2).

El-Sagheer, M. E. M. and E. I. Mohamed.2017 "Response Of Two Sorghum Hybrids To Foliar Application Of Some Activators Under Two Levels Of Nitrogen.". Alex. J. Agric. Sci., 62(6):443-455.

Eyheraguibel, B.; J.Silvestre & P.Morard 2008. Effects of humic substances derived from organic waste enhancement on the growth and mineral nutrition of maize. Bioresource technology, 99(10): 4206-4212.

F A O " Food and Agriculture Organization of the United Nations " 2019. Nations, Food and Agriculture Organization of the United /FAOSTAT Statistics Division. *http://www.fao.org/faostat/en/#home*

Gomez KA, Gomez AA 1984. Statistical procedures for agricultural research. 2nd Ed. An International Rice Research Institute Book. John Wiley and Sons pp. 321- 323, 467-469.

Hamad, M.M. and Manal F. A. Tantawy 2018. Effect of different Humic Acids Sources on the Plant Growth, Calcium and

Iron Utilization by Sorghum. Egypt. J. Soil. Sci. Vol. 58, No. 3, pp. 291-307 (2018).

Hassan, A. S. A. 2012. Effect of some characteristics of calcareous soils on available phosphorus in North Africa. M.Sc. Thesis, Institute of African Research, and Studies, Cairo University, Egypt.

Kambal, A.E. and O.J. Webester 1966 Manifestation of hybrid vigor in grain sorghum and the relation among the components of yield, weight per bushel, and height. Crop Sci., 6: 513-515.

Kumar, V. and A.K. Chopra 2013. Response of sweet sorghum after fertigation with sugar mill effluent in two seasons. Sugar Tech, 15 (3): 285-299 DOI: 10.1007/s12355-013-0226-9

Leytem, A.B. and R.L. Mikkelsen (2005). The nature of phosphorus in calcareous soils. Better Crops, 89 (2): 11-13.

Pettit, R. E. 2004. Organic matter, humus, humate, humic acid, fulvic acid and humin: their importance in soil fertility and plant health. CTI Research, 10: 1-7.

Pritam, O. Bhutada, RL. Aundhekar and Dr. SP Mehtre 2019. Effect of different fertilizer levels on yield of grain sorghum genotypes. International Journal of Chemical Studies 7 (3): 1872-1874.

Rezazadeh, H.; S.K. Khorasani and R.S.A. Haghighi 2012 Effects of humic acid on decrease of phosphorus usage in forage maize var. KSC704 (Zea mays L.). Australian Journal of Agricultural Engineering, 3(2): 34-38.

Roy, D.C.; N.K.Tudu ; M. Ray; M.C.Pakhira and H. Das 2015 Effect of phosphorus on yield and quality of multi cut sorghum (Sorghum bicolor) fodder in the new gangetic flood plains of West Bengal. Int. J. Bio-res. Env. Agril. Sci., 1(1): 13-20.

Roy, P. R. S., & Z. H. Khandaker 2010. Effects of phosphorus fertilizer on yield and nutritional value of sorghum (Sorghum bicolor) fodder at three cuttings. Ban. J. Anim. Sci., 39(1-2): 106-115.

Salim, E. M., A. S. El-Neklawy and S. M. El-Ashry. 2009. Beneficial effects of humic substances fertigation on soil fertility to potato grown on sandy soil. Aust. J. Basic and Appl. Sci. (4): 4351-4358.

الملخص العربى

تأثير الإضافة الأرضية والرش لحامض الهيوميك على نمو وإنتاجية الذرة الرفيعة النامية فى أرض جيرية تحت مستويات مختلفة من التسميد الفوسفاتى

فوزى سيد عبد السميع*،إكرام علي مجاور* ، احمد عبد العظيم الرفاعي، محمد يوسف حسين****

*** قسم المحاصيل- كلية الزراعة – جامعة الفيوم**

****قسم بحوث الذرة الرفيعة - معهد المحاصيل الحقلية– مركز البحوث الزراعية**

الهدف من هذه الدراسة الحالية هو تقييم تأثير ثلاثة معدلات من التسميد الفوسفاتى (١٥، ٣٠، ٤٥ وحدة فوسفور للفدان) كإضافات أرضية، وثلاثة مستويات من حامض الهيوميك فى صورة هيومات البوتاسيوم (صفر، ١٠، ٢٠كجم للفدان) كإضافات أرضية، وثلاثة معدلات من الرش الورقى لحامض الهيومك فى صورة هيومات البوتاسيوم (صفر، ٤٠٠، ٨٠٠ ملليمول /لتر)، والتداخلات بينهما على النمو الخضرى لنباتات الذرة الرفيعة (هجين شندويل) النامية بالتربة الجيرية. لتحقيق الهدف من الدراسة الحالية نفذت تجربتان حقليتان بمزرعة محطة بحوث طامية التابعة لمركز البحوث الزراعية بالفيوم خلال الموسم الصيفي لعامى ٢٠١٩ و٢٠٢٠.

ولقد شملت كل تجربة ٢٧ معاملة تم التنفيذ فى تصميم القطع المنشقة مرتين (قطاعات كاملة العشوائية) بأربع مكررات أحتوت الوحدة التجريبية على ٥ خطوط بطول ٣ متر وعرض ٦٠ سم وكانت مساحة كل وحدة تجريبية ٩ متر مربع (٤٦٦/١ فدان).

اتبع فى التنفيذ الحقلى للتجارب استعمال تصميم القطع المنشقة مرتين (قطاعات كاملة العشوائية) بأربعة مكررات حيث ووزعت المعاملات عشوائيا لجميع مستويات العوامل الثلاثة ووضعت معدلات الفوسفور فى القطع الرئيسية، وزعت عشوائياً الإضافة الارضية لمعدلات حامض الهيوميك (هيومات البوتاسيوم) فى القطع المنشقة الأولى ، وتم التوزيع العشوائى للإضافة الورقية لمعدلات حامض الهيوميك (هيومات البوتاسيوم) فى القطع المنشقة الثانية .

الصفات المدروسة :

عند الحصاد تم الاختيار العشوائى لخمسة نباتات من القطع التجريبية فى كلا الموسمين لتقدير الصفات التالية:

ارتفاع النبات (سم)، قطر الساق (سم)، عدد الأوراق الخضراء/نبات، عدد الاوراق الجافة/نبات، وزن النبات (جم) ، مساحة ورقة العلم (سم^{٢})/نبات.

و يمكن تلخيص النتائج المتحصل عليها كما يلي:-

١- كانت الإضافة الأرضية للتسميد الفوسفاتى بمعدل ٣٠ و ٤٥ وحدة/فدان معنوية و حققت أطول ارتفاع للنبات (١٤٢.٦سم) ، أكبرقطر للساق (٢.٧١سم) وأكبر عدد للأوراق الغضة (٧.٣) ، أكبر مساحة ورقة العلم (٤٥٤.٩١سم٢) ، واقل عدد الاوراق الجافة كمتوسط للموسمين . بشكل عام كانت معاملة التسميد الفوسفاتى ٤٥ وحده/ فدان افضل المعاملات وأدت الى زيادة طول النبات وقطر الساق وعدد الاوراق الغضة ومساحة ورقة علم نبات الذرة الرفيعة بنسبة (٤.٥٥، ٥.٩١، ٥.٣٤ و١٣.٩٣%) على الترتيب بالمقارنة بمعاملة الكنترول ١٥ وحده/ للفدان.

٢- كانت الإضافة الأرضية لهيومات البوتاسيوم بمعدل ١٠ و ٢٠ كجم وحدة/فدان معنوية و حققت أطول ارتفاع للنبات ، أكبرقطر للساق وأكبر عدد للأوراق الغضة ، أكبر مساحة ورقة العلم ، واقل عدد الاوراق الجافة كمتوسط للموسمين . بشكل عام كانت معاملة هيومات البوتاسيوم ٢٠ كجم/ فدان افضل المعاملات وأدت الى زيادة طول النبات (١٤٣.٠٠سم) وقطر الساق(٢.٧٥ سم) وعدد الاوراق الغضة (٧.٧٥) ومساحة ورقة علم نبات الذرة الرفيعة (٤٠٦.٧٤ سم^{٢}) مقارنة بمعاملة الكنترول صفر/ كجم للفدان والتى أعطت أقل القيم للصفات السابق ذكرها .

٣- الرش الورقى لحامض الهيومك (هيومات البوتاسيوم) بمعدل ٤٠٠، ٨٠٠ ملجم/لتر أثر معنوياً على ارتفاع النبات وحقق المعدل ٨٠٠ ملجم/لتر، أطول ارتفاع للنبات (١٤٢.٠سم)، أكبرقطر للساق (٢.٧٠سم) وأكبر عدد للأوراق الغضة (٧.٦٩) ، أكبر مساحة ورقة العلم (٤٠٠.٨١ سم^{٢})، واقل عدد الاوراق الجافة (٥.٥١) كمتوسط للموسمين.