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Interaction effect of potassium fertilizer, humic acid and irrigation intervals on growth and yield of wheat

ALAA HASAN FAHMI[1,*], MOHAMMED OBED SALLUME[2], ASWAD H. ASWAD[1], ABBAS L. ABDULRAHMAN[3], GHASSAN JAAFAR HAMDI[4] AND MOHAMMED ALI ABOOD[1]

[1]*Department of Soil Science and Water Resources*
College of Agriculture, University of Diyala, Diyala, Iraq
**(e-mail : alaahassen@agriculture.uodiyala.edu.iq)*

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ABSTRACT

Three-way factorial experiment in a randomized complete block design (RCBD) was designed and carried out to determine the effect of the interaction of potassium (K^+) fertilizer, humic acid and irrigation period on wheat production. Wheat variety IPA 99 was planted using two rates of potassium fertilizer as KCl (0 and 150 kg K^+/ha), two rates of humic acid (0 and 3 kg/ha) and three irrigation intervals (one week, two weeks and three weeks). The results showed that the interaction treatment of K and humic acid produced the highest number of internodes (7.00), for one and two weeks. However, for three weeks of irrigation intervals was (6.65). The highest plants were (145.00 cm) for two weeks of irrigation intervals. While the number of spikes/m^2 was 145.67 for one week irrigation period which was not significantly different with two weeks irrigation intervals (143.33). The heaviest spikes and the highest grain yield were 6.93 g and 9.933 t/ha for two weeks irrigation intervals, respectively. The findings of the present study exhibited that using the combination of fertilizer (K × humic acid) led to reduce the irrigation requirement. Therefore, the results of this study recommend using the combination of (K × humic acid) to save water irrigation and to produce high grain yield.

Key words : Humic acid, irrigation intervals, potassium fertilizer, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a group of the grass family (Gramineae or Poaceae). It is one of the most established crop plants across the world (Curtis and Halford, 2014) and it provides the staple nutrition for approximately 35% of the world population (Chandra *et al.,* 2014). It is easy to plant and grow; however, adjusting to diverse climate conditions is critical for producing a good wheat yield. In recent years, the production of wheat has decreased obviously because of the effect of different abiotic factors (Cheeseman, 2016).

Shahryari and Mollasadeghi (2011) reported that potassium humate had significant effects on a number of seeds per spike, the weight of seeds per spike, grain yield and biomass at 1% probability level. Mollasadeghi *et al.* (2011) displayed that the impact of potassium humate on drought stress declined and the difference between yields under stress and no stress condition decreased from 1 to 0.1 t/ha in wheat cultivars. In addition, Rafat *et al.* (2012) showed that drought reduced seed number in a single row, seeds per ear, seed weight per ear, seed length, seed weight, grain yield and harvest index. Potassium humate treatment improved the plant ability for drought tolerance. Grain yield under drought conditions was higher compared with control treatment, while reduction by using potassium humate was lower. Clay minerals of soils are fixed and adsorbed (K^+) nutrient (Binner *et al.,* 2017; Issenova *et al.,* 2018; Portela *et al.,* 2019). Consequently, it leads to reduce the efficacy of K fertilizers (Portela *et al.,* 2019). On the other hand, soil organic matter acts a significant part in controlling the availability of potassium and other nutrients by chelating mechanism

[2]Department of Soil Science and Water Resources, College of Agriculture, University of Anbar, Iraq.
[3]Agricultural Extension and Training Office, Ministry of Agriculture, Iraq.
[4]Department of Horticulture and Landscape, College of Agriculture, University of Diyala, Baqubah, Iraq.

(Binner *et al.,* 2017; Manga *et al.,* 2019). Studies showed that the humic acid adsorbed K^+ and nutrients. It provided an exchangeable site from their functional groups contained (Yin *et al.,* 2018; Goli *et al.,* 2019). Therefore, the objective of this study was to determine the effect of the interaction of K fertilizer, humic acid and irrigation intervals on wheat plant production.

MATERIALS AND METHODS

Plant Materials

This study was carried out at Diyala state during 2018-19 to determine the effect of K fertilizer, humic acid and irrigation intervals on wheat production. Seeds of wheat (*Triticum aestivum* L.) variety IPA 99 were supplied from the State Board of Agricultural Research, Baghdad, Iraq. Three-way factorial experiment in a randomized complete block design (RCBD) with three replications was implemented as 1 × 1 m the area of unit experiment and one-meter space between blocks. The physical and chemical properties of the soil are shown in Table 1. The seeding rate was 140 kg/ha in this experiment. For all treatments, the nitrogen fertilizer was added three times, as 60, 120 and 60 kg/ha during the tillering stage, elongation stage and the booting stage, respectively. Three treatments applied were potassium fertilizer (0 and 150 kg K^+/ha), humic acid (0 and 3 kg/ha) during preparation of the soil, and three irrigation intervals (one, two and three weeks) until maturity stage of plants.

Table 1. Physical and chemical properties of the soil

Properties	Unit	Value
pH	-	7.58
EC	dS/m	1.43
OM	g/kg	7.8
Available N	mg/kg	24.67
Available P	mg/kg	28.58
Available K	mg/kg	133.45
Texture	%	Sandy clay loam

Measurement of Internodes (Number/Plant)

Ten plants from each treatment at maturity stage were selected randomly to measure the number of internodes/plant.

Determination of Plant Height (cm)

Ten plants from each treatment at maturity stage were selected to record the height of the plant.

Number of Spikes/m²

The spikes belonging to one square meter/experiment unit were collected to account 10 number of spikes.

Weight of Spike (g)

The weight of spike was determined by calculating the mean of 10 spikes weight, which was selected randomly from each treatment.

Grain Yield (t/ha)

Each treatment was harvested to determine the grain yield (t/ha).

Statistical Analysis

The analysis of variance (ANOVA) was used to analyze data using the SAS software package, version 9.4, as well as the Tukey's test, was employed to test the significant differences among treatment means at P?0.05 to compare among the means.

RESULTS AND DISCUSSION

Internodes Number/Plant

Table 2 displays the effect of potassium, humic acid and irrigation periods on the number of internodes/plant. For humic acid treatment, the highest number of internodes mean was (7.76) with one week intervals of irrigation. While the lowest number of internodes mean was (5.33) with control treatment with irrigation period two and three

Table 2. Effect of potassium, humic acid and irrigation intervals on the number of internodes/plant

Effect of K	Effect of humic acid	Irrigation intervals		
		One week	Two weeks	Three weeks
Control	Control	6.15bc	5.33c	5.33c
	With H	7.67a	6.33bc	6.00bc
with K	Control	6.56ab	6.32bc	6.33bc
	With H	7.00ab	7.00ab	6.65ab

Means followed by the same letters within a column are not significantly different at P=0.05.

weeks. For interaction treatments of potassium and humic acid was 7.00, 7.00 and 6.65 for one, two and three week periods, respectively. These results encourage us to use the combination of fertilizer (K × humic acid) in order to reduce the irrigation requirement and provide potassium for the plant. These results agree with the result of Joseph *et al.* (2013) who stated that the humic acid was considered to increase the permeability of plant membranes and enhance the uptake of nutrients. It also improves soil nitrogen uptake and encourages the uptake of K, Ca, Mg and P_2O_5 making these more mobile and available to plant root system.

Plant Length (cm)

The significant effect of potassium, humic acid and irrigation intervals on plant length (cm) is presented in Table 3. The highest length of the plant was shown in plants, which treated with potassium and humic acid for two weeks irrigation intervals (145.00 cm) which was not significantly different with one-week irrigation intervals (144.66 cm). The interpretation of this result was due to the superiority of this trait to produce an excellent number of internodes (Table 2). However, the shortest plants were registered in the control treatment (0 K and 0 humic acids) (116.00 cm) for three weeks irrigation intervals. The results of this trait were supported by the results of Fagbenro and Agboola (1993), Xue *et al.* (1994), Purchase *et al.* (1995) and Agegnehu *et al.* (2017) who reported that support plant by humic acid produced more plant height, number of spikes, number of grains and weight of 100 grains as compared to untreated plant.

Table 3. Effect of potassium, humic acid and irrigation intervals on plant length (cm)

Effect of K	Effect of humic acid	Irrigation intervals		
		One week	Two weeks	Three weeks
Control	Control	126.00de	125.33de	116.00f
	With H	127.40cde	131.33cd	122.00fe
with K	Control	132.00cd	143.33b	128.33cde
	With H	144.66a	145.00a	135.32bc

Means followed by the same letters within a column are not significantly different at P=0.05.

Number of Spikes/m²

Significantly maximum number of spikes/m² was recorded in the treatment of using potassium and humic acid within one week irrigation intervals (145.67) which was not significantly different with treatment of potassium × humic acid × two weeks irrigation intervals (143.33) and potassium × two weeks irrigation (142.00) (Table 4). Whereas the least number of spikes/m² was obtained by control treatment (0 K × 0 humic acid) within three weeks irrigation intervals. The humic acid had positive effect direct and indirect physiological processes of plant growth. The direct effects led to an increase in cell membrane permeability, respiration, nucleic acid biosynthesis, ion uptake, enzyme activity and sub-enzyme activity (Ghanifathi *et al.,* 2012). Humic acid decreased the amount of fertilizer consumption and encouraged the plant to be more tolerant against drought stress. Also, production of the great number of spikes and increasing of yield. In addition, drought reduced the grain yield and its components. Whereas using potassium humate application increased drought tolerance which increased the number of spikes per experimental unit. These findings are in agreement with the results of Cheng *et al.* (1995), Rafat *et al.* (2012) and Agegnehu *et al.* (2017).

Table 4. Effect of potassium, humic acid and irrigation intervals on the number of spikes/m²

Effect of K	Effect of humic acid	Irrigation intervals		
		One week	Two weeks	Three weeks
Control	Control	115.00cdef	110.00def	79.00g
	with H	121.33cde	128.33bc	101.67f
With K	Control	123.33cd	142.00ab	101.33f
	with H	145.67a	143.33ab	105.65ef

Means followed by the same letters within a column are not significantly different at P=0.05.

Spike Weight (g)

There existed significant variability for the spike weight. The highest spike weight was (6.93 g) within the treatment of interaction of potassium and humic acid with two weeks irrigation intervals. However, the least of spike was 0.67 g for the control treatment (0 K × 0 humic acid × three weeks irrigation intervals) (Table 5). These findings were obtained because

Table 5. Effect of potassium, humic acid and irrigation intervals on the spike weight (g)

Effect of K	Effect of humic acid	Irrigation intervals		
		One week	Two weeks	Three weeks
Control	Control	1.57c	1.17c	0.67c
	With H	4.17b	4.47b	4.23b
With K	Control	5.10ab	5.17ab	4.10b
	With H	6.20ab	6.93a	4.27b

Means followed by the same letters within a column are not significantly different at P=0.05.

Table 6. Effect of potassium, humic acid and irrigation intervals on grain yield (t/ha)

Effect of K	Effect of humic acid	Irrigation intervals		
		One week	Two week	Three week
Control	Control	1.806 c	1.287 c	0.529 c
	with H	5.060 b	5.736 b	4.301 b
with K	Control	6.290ab	7.341 ab	4.115b
	with H	9.032 ab	9.933 a	4.511 b

Means followed by the same letters within a column are not significantly different at P=0.05.

of increasing plant uptake and translocation of nutrients and total dry matter yield by using humic acid and potassium. The results of the current study coincide with the findings of Yang *et al.* (2004) and Vanitha and Mohandass (2014) who found that the humic acid could affect direct and indirect physiological processes of plant growth. Their direct effects included improved cell membrane permeability, respiration, nucleic acid biosynthesis, ion uptake, enzyme activity and sub-enzyme activity. Humic materials reduce the amount of fertilizer consumption and make plant tolerant against drought stress production of total plant weight and increase yield.

Grain Yield (t/ha)

Nutrient element and its availability for the plant in developing stages is one of the important inputs of enhancing the production of the crop. Nutrient management especially with recommended fertilizers dose of N, P and K as well as the addition of humic substances, potassium and other organic manures is one of the agronomic factors that significantly affect the grain yield (Shahryari and Mollasadeghi, 2011). In the current study, the highest grain yield was obtained after application of the interaction of potassium × humic acid × each two weeks irrigation intervals (9.933 t/ha) which was not significantly different with one week irrigation periods of the same treatment (9.032). However, the lowest grain yield was 0.529 t/ha within the control treatment (0 K × 0 humic acid × three weeks) (Table 6). The results of Purchase *et al.* (1995) and Patil *et al.* (2010) supported the results of the current study, when they stated that humic materials improved plant growth under irrigated conditions. Some of these stimulatory effects are increase in the length of roots and shoots. There have also been reports of increase in wheat grain yield.

CONCLUSION

The present study was conducted to improve the growing and development of wheat variety IPA 99 using humic acid to increase the availability of potassium ion and water of irrigation for the wheat plant. Findings indicated that combinations of humic acid with potassium fertilizer led to decrease in the water requirements for wheat plants during all developing stages as well as increase in grain yield. Therefore, the recommendation of authors is using this combination to increase wheat production.

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