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Effect of skip irrigation and nano potassium treatments on maize yield

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ABSTRACT

A field experiment was carried out in Maamirah area, located at 33-32 north latitude and 45-42 east longitude, 10 km south of Hilla, Iraq, in loam clay soil at fall 2018 season to study the effect of water stress and Potassium fertilizer treatments on maize yield. Split plot arrangement within randomized complete block design with three replications was used. The main plots included three irrigation treatments (control, skip one irrigation at eight leaves-stage (S8) and or at silk stage S silk), while sub plots included 5 potassium treatments, control without adding fertilizer (K0), adding potassium fertilizer recommendation of 50 kg $K.ha^{-1}$ (as N-P-K :15-15-25, 200 $kg.ha^{-1}$) to the soil (K1), spraying 200 mg of nano potassium (K2), spraying of 1500 mg of nano potassium + 50$kg.L^{-1}$ potassium fertilizer (K3)), spraying 1000 $mg.L^{-1}$ of nano potassium + 100 kg ha^{-1} potassium fertilizer (K 4), and spraying 500 $mg.L^{-1}$ of nano potassium + 150 $kg.ha^{-1}$of potassium fertilizer (5K). The fertilizer quantity of phosphorus and nitrogen were adjusted to 30 kg P_2O_5 ha^{-1} and 100 kg N ha^{-1} uniformly for all experimental units by adding super phosphate (46% P_2O_5) and Urea (46% N). The results indicated that spraying 500 $mg.l^{-1}$ of nano potassium + 150 $kg.ha^{-1}$ of potassium fertilizer (K5) was superior in grain yield and biological yield (7.07 $t.ha^{-1}$ and 19.29 $t.ha^{-1}$, respectively), while spraying of 1500 mg of nano potassium + 50 $kg.L^{-1}$ potassium fertilizer (K3) gave the highest weight of 100 grains weight (32.3 g). It is clear that spraying of nano-K fertilizer contributed to reduce the plants need for soil potassium fertilizer.

Key words: *Maize, Mineral K fertilizer, Nano K fertilizer and Skip one irrigation.*

Introduction

Maize (*Zia maize* L.) occupies an important place in human and animal life, and most varieties of corn in the world grow under rainy conditions and it is one of the more sensitive crops to drought than other cereal crops except rice (Xiao *et al.*, 2005). Water stress is caused by a decrease in the content of soil available water due to the constant water loss by transpiration-evaporation (Jaleel *et al*., 2009). The effect of water stress on the plant depends on several factors, including the severity of water stress, the time it occurs and its length, and the stages of plant growth. Potassium is one of the elements that maize needs in high quantities for its primary role in stimulating enzymes related to many vital activities within the plant (Mengle and Kirkiby, 1989). Nano-fertilizers are distinguished from the traditional ones for their easy absorption and reducing losses due to the increase of the surface-to-volume ratio, which increases its connection with the parts of the plant that come into contact with it, and also due to its molecules which contains high surface energy and stimulating properties (Lei *et al*., 2008, Feizi *et al*., 2012) as well as its easy to penetrate cell wall area, which ranges between 5-50 nanometers and its passage easily to the plasma membrane, which enhances the absorption of nanoparticles (Navarro *et al*., 2008). Nano fertilizers have many other benefits as they contribute to reducing environmental pollution, achieving sustainable agriculture in addition to low prices and easy storage (Guru *et al.,* 2015 and Hasaneen *et al.,* 2016).

Materials and Methods

Maize grain of Hybrid Euphrates was planted at 7/22/2015 in hills 25 cm apart on lines 75 between one another by putting three grains and after 30 days thinned to one plant per hill. NPK fertilizer was adding at seeding according to the treatments. The fertilizer quantity of phosphorus and nitrogen were adjusted to 30 kg P_2O_5 ha^{-1} and 100 kg N ha^{-1} uniformly for all experimental unitsby adding super phosphate (46% P_2O_5) and Urea (46% N) and phosphorus was completed to 30 kg ha^{-1} in all experimental unit by addingtriple superphosphate (46% P_2O_5) at seeding too. N fertilizer was completed to 100 $kg.ha^{-1}$ in all experimental unit by adding urea (46% N) as three doses (at seeding 8 leaves stage and male flowering respectively). Nano-potassium was sprayed at morning. The soil was prepared and divided according to split-plot arrangement within randomized complete block design (RCBD) with three replications. Each replicate contained 18 experimental units, each one (5 m × 3 m) included four lines 75 cm apart and the distance between the hills was 25 cm. The main plots included three treatments, which are normal irrigation (control S0), skip irrigation at 8 leaves stage (S8) and skip irrigation at silk stage (S silk). The sub-plots included six treatments as follows: 1-Control (without K fertilizer 2-add 50 $kg.ha^{-1}$ of K as soil chemical fertilizer. 3-spraying of nano K fertilizer (2000 mg/L). 4- Spraying 1500 mg of nano potassium + soil K fertilizer of 12.5 $kg.ha^{-1}$. 5- Spraying 1000 mg of nano potassium + soil K fertilizer of 25 $kg.ha^{-1}$. 6- Sprinkle 500 mg per liter of nano potassium + soil K fertilizer of 27.5 $kg.ha^{-1}$. At maturity, average of rows per ear, grains number per row and weight of 100 grains (g) were taken (from randomized ten ears from each experimental unit), total grain yield ($t.ha^{-1}$), biological yield ($t.ha^{-1}$) were taken. The data were analyzed statistically using the Genstat statistical program, and the averages were compared according to the least significant difference (LSD) test at a probability level of 0.05.

Results and Discussion

Table 2 shows that the irrigation factors caused significant effect on ear rows number, and the two stress treatments (S8 and S silk) caused a significant decrease (12.6 and 12.7) compared to control irrigation treatment (S0) which gave the highest average of 14.5 $rows.ear^{-1}$. This may be due to the fact that skip one irrigation negatively affected vegetative growth (Jasim *et al.,* 2015) and photosynthesis process that reflected in decreasing rows number per ear (Jasim *et al*., 2017). This results was agreed with Babakhaani *et al.* (2013) and Khaksar *et al*. (2013). Fertilizer treatments caused a significant effect on ear rows number, and all K addition treatments were significantly superior compared to control treatment that gave the lowest average of 12.2 rows. Adding soil fertilizer only (K1) was superior by giv-

Table 2. Effect of irrigation and potassium treatments on rows number

K treatments	Irrigation treatments			Average of K fertilizer
	Control (S0) at 8 leaves stage (S1)	Skip irrigation at silk stage (S2)	Skip irrigation	
K0	13.4	11.3	11.9	12.2
K1	15.0	13.4	13.5	14.0
K2	14.5	13.0	12.1	13.3
K3	14.8	12.6	12.3	13.2
K4	14.4	12.6	13.2	13.4
K5	15.1	12.6	13.4	13.7
Irrigation average	14.5	12.6	12.7	
LSD $_{0.05}$	Irrigation=0.53		interaction=n.s	0.75

ing the highest average of 14.0 rows compared to K0 and K3. This increase is due to the role of K fertilizer in promoting vegetative growth, increasing the process of representation and nutrient transport, and in increasing reactions and enzymatic activities and rates that reflect positively in providing the raw materials necessary for cell division, growth and development. As for nano-fertilizer , it is due to reasons related to the nature of nano-materials, such as their small size and large surface area that help them penetrate the added plant tissue to it and increase their absorption rates to a very large extent. This is consistent with Abdel-Aziz *et al*., (2016). The interference between factors had no significant effect on this trait.

Table 3 showed that water stress significantly affected the number of grains per row and skip irrigation at eight leaves (S8) and silk stage (Ssilk) significantly reduced the number of grains per row to 30.2 and 30.6 grains per row^{-1}, respectively compared to normal irrigation treatment (S0) which gave 33.2 grains. This may be due to that water stress negatively effect on nutrients, enzymatic and hormonal activity within the plant, which was reflected in the fertilization process and the number of grains, or perhaps the reason is due to the fact that irrigation with holding negatively in determining the number of seed origin because water tightening inhibits the products of photosynthesis and thus a lack of it moved to the grain sites, which caused the abortion of pollinated grains. This result was consistent with Babakhaani *et al*. (2013) and Khaksar *et al*., 2013). Adding K fertilizer significantly increased the number of grains per row compared to control treatment (K0), which gave the lowest average of 25.9 grains per row. This increase was due to the role K in delaying plant leaves aging and maintaining leaf activity that prolonged photosynthesis for a longer period and greater efficiency, which increased the amount of materials manufactured in the leaves and the transfer of their products to the grains, that reflected positively in reducing competition between them and reducing abortion (Mesbah, 2009 and Aown, 2012). The interaction caused significant effect and (SOK1) gave the highest average of 36.2 grains per row compared to (S0K0) which gave the lowest average of 23.60 grains. All fertilizer additions resulted in an increase in the number of grains per row in the case of normal or skip irrigation treatments. This result was attributed to the response of

Table 3. Effect of irrigation and potassium treatments row grains number

K treatments	Irrigation treatments			Average of K fertilizer
	Control (S0)	Skip irrigation at 8 leaves stage (S1)	Skip irrigation at silk stage (S2)	
K0	23.6	26.4	27.8	25.9
K1	36.2	28.6	31.3	32.0
K2	32.3	29.5	30.0	30.6
K3	35.9	32.4	30.6	33.0
K4	35.5	31.1	31.8	32.8
K5	35.2	33.0	31.9	33.4
Irrigation average	33.2	30.2	30.6	

Table 4. Effect of irrigation and potassium treatments on 100 grains weight (g)

K treatments	Irrigation treatments			Average of K fertilizer
	Control (S0)	Skip irrigation at 8 leaves stage (S1)	Skip irrigation at silk stage (S2)	
K0	29.03	28.13	27.33	28.17
K1	34.67	31.17	29.37	32.08
K2	33.67	30.37	29.77	31.27
K3	35.33	30.77	29.80	32.30
K4	33.00	31.37	31.03	32.02
K5	35.03	29.33	29.87	31.32
Irrigation average	33.86	30.19	29.53	
LSD $_{0.05}$	Irrigation=0.29		interaction=n.s	0.41

maize crop to Kelement in increasing photosynthesis, improving nutrient absorption and increasing root spread and efficiency (Abu-Dhahi, 2009).

Table 4 showed that skip irrigation decreased 100 grains weight significantly compared to full irrigation treatment (S0) which gave the highest average weight of 33.86 g. Sip irrigation at silk stage (S silk) gave the lowest average of 29.53 g. The reason for this decrease is attributed to the negative effect of water stress on reducing the duration of carbonic representation due to its effect on the speed of aging of the tissues, which was negatively reflected in the lack of the material represented and transferred to the grain, which leads to its small size and shrinkage (El-Sahuki, 2006). The results are similar to Yang *et al*. (2018); Stutts *et al*. (2018) and Borras *et al.* (2018) who reported a reduced grain weight when sorghum subjected to water stress. Adding K fertilizer treatments led to a significant increase in the average weight of 100 grains compared to control treatment (without fertilizer), which gave the lowest average weight of 28.17 g. treatments of K1, K4 and K3 was superior. This is due to the effect of K elementin improving photosynthesis and transferring processed nutrients to the grains. These results are consistent with Aslam *et al.* (2013). The interaction between the two factors had no significant effect.

Table 5 showed that water stress (S8 and S silk) gave the lowest grain yield of 5.696 and 5.893 t/ha^{-1} respectively compared to normal irrigation (S0) which gave the highest grain yield of 7.527 t.ha^{-1}. The lower grain yield under water skipping is attributable to the significant decrease in yield components of ear rows number, row grain number and 100 grains weight (Table 2, 3 and 4). This result was consistent with Schlegel *et al.* (2018), Sweeney and Kirkham (2018), Stutts *et al.* (2018) and Yang *et al.* (2018) who found that maize plants exposure to water stress resulted in a lower grain yield.

Table 5 showed that grain yield was significantly affected by adding fertilization treatments, as the K5 and K1 treatments gave the highest averages of 7.079 and 6.978 t.ha^{-1}, while the control treatment (K0) gave the lowest average of 4.606 t.ha^{-1}. This increase was due to the role of K fertilizer in increasing ear rows number and grains per row as well as 100 grains weight (Table 2, 3 and 4). This result was consistent with Makinde and Ayoola (2009). The interaction caused significant effect and S0K1 gave

Table 5. Effect of irrigation and fertilization treatments on grain yield (t.ha^{-1})

K treatments	Irrigation treatments			Average of K fertilizer
	Control (S0)	Skip irrigation at 8 leaves stage (S1)	Skip irrigation at silk stage (S2)	
K0	4.872	4.238	4.708	4.606
K1	8.447	5.807	6.680	6.978
K2	7.610	5.627	5.391	6.209
K3	8.011	5.995	5.672	6.559
K4	7.959	6.006	6.435	6.699
K5	8.261	6.503	6.474	7.079
Irrigation average	7.527	5.696	5.893	
LSD $_{0.05}$	Irrigation=0.087	interaction=0.213		0.123

Table 6. Effect of irrigation and potassium treatments on biological yield (t.ha^{-1})

K treatments	Irrigation treatments			Average of K fertilizer
	Control (S0)	Skip irrigation at 8 leaves stage (S1)	Skip irrigation at silk stage (S2)	
K0	16.90	14.74	15.59	15.74
K1	22.55	17.08	17.91	19.18
K2	20.43	16.68	16.78	17.96
K3	21.44	17.80	16.93	18.62
K4	21.63	17.26	17.87	18.92
K5	22.39	17.81	17.68	19.29
Irrigation average	20.89	16.84	17.09	
LSD $_{0.05}$	Irrigation=0.28			interaction= n.s 0.40

the highest average of 8,447 t.ha^{-1}, while the combination (S8K0) gave the lowest average of 4,238 t.ha^{-1}. Adding soil + nano fertilizer (S8K5) improved the yield to 6.503 t.ha^{-1}. This result came in the same line ofBenzon *et al*. (2015) who obtained the highest grain yields when rice plants were sprayed with nano and conventional potassium fertilizer.

Table 6 showed that irrigation treatments caused significant effect on biological yield and skip irrigation treatments (S8 and S silk) gave less biomass (17.09 and 16 .84 t.ha^{-1}) compared to normal irrigation (S0)which gave 20.89 t.ha^{-1}. This may be attributed to that water stress decreased the total sum of the carbon representation materials produced in the tissue of the leaves. This is consistent with Jasim and Idan (2017). All potassium adding treatments caused significant increasing in the biological yield compared to control treatment that gave the lowest value of 15.74 t/ha^{-1}, and the treatment of K5, K1 and K4 were superior by giving the highest yield of 19.29, 9.181 and 18.92 t/ha^{-1}. This may be due to increasing vegetative growth and grain yield (Table 5). This results was agreed with Aslam *et al* (2013). The combinations of S0K1, and S0K5 were significantly superior by giving the highest averages of 22.55 and 22.39 t.ha^{-1}, compared to all other combinations, while the combination of S8K0 gave the lowest average of 14.74 t.ha^{-1}.

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