Int. J. Agricult. Stat. Sci. Vol. 16, No. 2, pp.707-712, 2020 www.connectjournals.com/ijass
DocID: https://connectjournals.com/03899.2020.16.707 ISSN : 0973-1903, e-ISSN : 0976-3392

ORIGINAL ARTICLE

EFFECT OF POTASSIUM FERTILIZER APPLICATION METHOD AND IRRIGATION INTERVAL ON THE YIELD AND YIELD COMPONENTS OF SESAME (*SESAMUM INDICUM L.*) CROP

Bushra Sh. J. Alobaidy*, Jabbar Sh. E. Al-Esawi[1], Basheer Hamad Abdullah Aldulemy and Ahmed Shehab Abd-allah Ramadan

Department of Field Crops, College of Agriculture, University of Anbar - 310 01, Anbar, Iraq.
[1]Upper Euphrates Basin Developing Center, University of Anbar - 310 01, Anbar, Iraq.
E-mail: ag.bushra.shaker@uoanbar.edu.iq

Abstract: A field study was conducted during the summer season 2018, in Zekheikhah village west of Iraq to determine the effect of potassium application method and Water deficit stress on a number of quantitative and qualitative characteristics of sesame crop. Results revealed that application of potassium application method, dividing the recommended amount of potassium into two parts, the first is added to the soil when planting and the other part by spraying when flowering, led to a significant increase in the parameters of the oil quality in the seeds, the yield and its components. Low water availability (T_3) significantly decreased in oil% and seed yield. The seed yield reduction was mainly due to a reduction in seed weight and a reduction in seed number in capsules. Moderate shortage (T_2) of irrigation water availability (irrigation every 20 days) neither affected negatively improved oil percentage and weight of 1000 grains. In terms of the interaction between irrigation intervals and potassium application method, the evidence showed that the potassium plays a vital role in reducing the negative effect of water deficiency, as observed from the interaction in case of absence of the *K* fertilizer, where the results showed in the combination of with no potassium, less watering has led to a reduction in the most yield components and the oil content of seeds. To improve crop the resistance to drought, management practices should be considered for reducing drought-related issues in major sesame crop.

***Key words*:** Sesame, Potassium, Randomized complete block design, Irrigation intervals.

Cite this article

Bushra Sh. J. Alobaidy, Jabbar Sh. E. Al-Esawi, Basheer Hamad Abdullah Aldulemy and Ahmed Shehab Abd-allah Ramadan (2020). Effect of Potassium Fertilizer Application Method and Irrigation Interval on the Yield and Yield Components of Sesame (Sesamum Indicum L.) Crop. *International Journal of Agricultural and Statistical Sciences.* DocID: https:// connectjournals.com/03899.2020.16.707

1. Introduction

Sesame is considered one of the important oil crops and is cultivated as a basis for obtaining the seeds that are used in the production of some foodstuffs because its rich seeds contain oil, protein, phosphorus and calcium. It is high in raw fiber, mineral elements and oxalic acid. The economic importance of the sesame crop is its high yield and the increasing demand for its products, which made it a target for researchers. However, the shortage of water resources of the Tigris, Euphrates, lack of rainfall and the waste of water sources in agriculture considering the irrigation factor as determining the productivity of most summer and winter crops, which necessitated the need to reconsider the issue of water rationing and rationalization of its consumption. In agriculture and using it optimally and innovating new technologies that enable the plant to withstand water shortages, so many studies have suggested techniques to confront water stress, without affecting the quality of the crop, which is scheduling irrigation, and ways to add mineral nutrients to the soil and plants, which play a role in controlling stomata such as potassium (*K*), as it is the reason for a good nutritional balance between NPK elements in the soil, which is

***Author for correspondence** ***Received** May 16, 2020* ***Revised** August 28, 2020* ***Accepted** September 10, 2020*

reflected in the formation of a strong and branched root system that increases the efficiency of the plant in absorbing nutrients from the soil solution as well as regulating water absorption and the mechanism of closing and opening the stomata, thus ensuring the reduction of the resulting harmful effect on water stress on plants. The combination of the irrigation period and the potassium fertilizer may make them a more effective system, by maintaining the osmotic system and the swelling of plant cells and its role in activating the enzymes and transporting and storing the substances that have been represented by the plant [Cakmak (2005)]. The response of plants to hydrophobic stress is complex because it depends on both the intensity and duration of stress and the efficiency of nutrient synthesis in the photosynthesis process when stress occurs. Hence, this study was conducted to produce an integrated system that combines potassium fertilizer and irrigation scheduling to determine the effect of the irrigation period and the method of applying potassium fertilizer on the growth characteristics and quality of sesame crop production.

2. Materials and Methods

2.1 Experimental treatments and design

A field experiment was conducted during the summer season 2018, in Zekhakhah village west of Iraq. The soil was classified as a silt clay loam. Soil samples were collected (0-30 cm) before planting to determine some physical and chemical soil properties (Table 1).

A split factorial experiment based on randomized complete block design with 3 replications was carried out. The irrigation interval, namely (T_1) = 10, (T_2) = 20, (T_3) = 30 day represents the main plots. While the subplots were occupied by the fertilizer application methods, namely K_0= no fertilizer, K_1=soil fertilizer application once per season at planting, K_2 soil fertilizer application 50% of fertilizer at planting and 50% supplied before the flowering stage, K_3 soil fertilizer application 50% of fertilizer at planting and 50% supplied as a foliar application with 15 days' intervals at flowering and 15 days after. The two-meter distance was left between plots to avoid the interaction between treatments. The plots dimensions were 2 × 3 m with 6 rows of plants per plot, the distance between rows per plot and the adjacent plants were 40 and 20 cm respectively. The fertilizer application rate was 200 $kg.ha^{-1}$ for each of the Nitrogen, Phosphor, and potassium (*N*, *P*, *K*). The urea was applied in split applications (50% at planting and 50% before flowering), while triple superphosphate (TSP) was applied once at planting. The source of *K* was the potassium sulfate.

2.2 Irrigation method

The irrigation water requirements for the sesame in the study were 698mm [Pereira *et al.* (2017)]. A water tank was used with dimensions of 3 × 3 × 2 m, length, width, and height respectively. The tank covered by a transparent polyethylene, the water was provided from the source to the tank by using a 2 inches' pipe, the irrigation water was supplied to experimental treatments by plastic pipes provided with a flow meter to supply equal amount of water for each treatment. Initially, equaled water depth was supplied to all treatments at planting to rise up the soil moisture (to 30cm soil depth) to the field capacity limits, to support the seed germination.

2.3 Measurements of plant growth and yield

At the end of the season, the sesame crop was harvested on 20 October 2018. 10 plants have been randomly collected from each plot to determine the plant height (cm), branches $plant^{-1}$, number capsules $plant^{-1}$, 1000 grains weight (g), grain yield $plant^{-1}$ (g), root dry weight and the amount of chlorophyll was measured using chlorophyll Meter SPAD-502. The data were analyzed statistically at P = 0.05 by an analysis of variance, F test and least significant difference (LSD) by GenStat (2005).

3. Results and Discussion

3.1 Effect of potassium application method on growth traits

The results in Table 2 show that the all potassium treatments increased in growth characteristics compared to non-potassium treatment K_0. That add potassium in one go to the soil before planting, it achieved a significant increase in all the traits under study. Plant acquisition of sufficient *K* was probably the reason behind the increment, due to potassium (*K*) role in plant growth and metabolism, and its contribution to the survival of plants cultivated under various biotic and abiotic stresses [Wang *et al.* (2013)]. A treatment of fertilizer K_2, which means splitting the potassium fertilizer and adding it to the soil in two stages, the first before planting and the second at the flowering stage times had achieved the highest content of chlorophyll

Table 1: Physical, chemical and hydraulic characteristics of soil under study.

Parameter	Unit	Value	Parameter	Unit	Value
EC	ds/m	5.12	Sand	%	16
pH	-	7.14	Silt	%	49
OM	$g.kg^{-1}$	22.13	Clay	%	35
Available potassium	$mg.kg^{-1}$		**Soil Texture**		**Silty Clay Loam**
			bulk density	$g.cm^{-3}$	
			Soil Hydraulic Characteristics		
			VOC (33 kPa)	$cm^3.cm^{-3}$	0.38
			VOC (1500 kPa)	$cm^3.cm^{-3}$	0.20
			Available water	$cm^3.cm^{-3}$	0.18

EC = electrical conductivity; pH = Log (hydrogen concentration); OM = organic matter; VOC = volumetric moisture content; kPa = kilopascal.

Table 2: Effect of potassium treatments on Sesame crop components.

Treatment	plant height (cm)	branches $plant^{-1}$	No. of capsules	Weight of 1000 seeds (g)	Grain $yieldplant^{-1}$ (g)	Root dry Weight (g)	chlorophyll	Oil (%)
K_0	92.22	9.89	142.8	2.778	121	31.89	38.09	34.81
K_1	107.44	11.33	187.7	3.244	172.86	46.44	46.56	43.6
K_2	104.11	11	206	3.8	164.64	44.33	48.54	44.44
K_3	97.33	10.89	175.9	3.4	174.96	42.67	48.04	45.78
F test	*	*	*	*	*	*	*	*
L.S.D(0.05)	5.604	0.78	9	0.132	4.99	3.455	1.803	0.574

to 48.54. Table 2 shows that there is no difference between the treatments K_2 and K_3 (Which means splitting the potassium, one adding it to the soil, and the second part sprinkling it on the leaves during the flowering period) in terms of chlorophyll content, in which, in both treatments, the fertilizer was split. Therefore, the potassium was available for the plant for all growth period, which plays a crucial role in stomatal regulation. Potassium insufficiency (K_0) eventually results in reduced stomatal conductance, thereby increased the mesophyll resistance and lowered the ribulose-1, 5-bisphosphate carboxylase/oxygenase (Rubisco) activity in plants, which ultimately decreased the total photosynthesis rate and consequently reduce the chlorophyll content in the leaves [Zhao *et al.* (2001)]. The appropriate application of potassium in the critical stages of plant growth was reflected positively in the studied traits, since potassium contributes to increasing the efficiency of leaves to carry out photosynthesis as well as stimulating many enzymes that have reflected in increasing activities of vital processes in the plant, that leads to increase photosynthesis products used by the roots to increase their depth and lateral capillary roots which is reflected in the increase of the dry weight of the root.

3.2 Effect of potassium application method on grain yield per $plant^{-1}$ and seed oil content

It appears from the results of Table 3 that the method of potassium fertilizer application significantly affected all traits under study. The treatment K_2 recorded the highest average number of capsule per $plant^{-1}$ and 1000 grains weight reached to 206.0 capsules per plant-1 and 3.80 gm respectively. Whereas the control treatment gave the lowest average for the aforementioned traits, namely 142.8 capsules per $plant^{-1}$ and 2.77gm respectively. The supremacy of K_2 treatment in terms of a number of capsules $plant^{-1}$ and 1000 grains weight was possibly due to split the amount of potassium has led to continuing to provide the plant with nutrients during all growth stages.

Table 3: Effect of irrigation treatments on Sesame crop components.

Treatments	plant height (cm)	Branches plant^{-1}	Capsules plant^{-1}	Weight of 1000 seeds (g)	Grain yield plant^{-1} (g)	Root dry Weight (g)	Chlorophyll	oil (%)
T_1	122.17	11.17	239	3.417	206.53	57.83	48.09	45.87
T_2	103.58	11.25	212.5	3.642	211.57	45.25	47.72	42.05
*T*3	75.08	9.92	82.8	2.583	57.00	20.93	40.11	38.56
F test	*	*	*	*	*	*	*	*
L.S.D(0.05)	4.66	0.75	24.90	0.06	4.18	3.64	0.91	0.74

Table 4: Effect of the interaction between irrigation and potassium application method treatments on growth traits.

Treatment		High (cm)	No.	No. Tilling	W. of 1000 Box	Yield of seed	W. of plants (gm)	Chlo. root (gm)	Oil (%)
T_1	K_0	111.67	11.00	188.30	2.967	157.67	46.67	41.20	36.00
	K_1	132.67	11.33	251.00	3.500	225.47	68.67	50.57	46.70
	K_2	124.67	11.00	257.30	3.800	195.20	56.67	49.10	51.20
	K_3	119.67	11.00	249.00	3.400	247.77	59.33	51.50	49.56
T_2	K_0	95.00	9.67	171.00	3.033	154.67	35.33	41.73	35.10
	K_1	112.00	11.67	226.70	3.533	237.43	51.33	52.00	42.42
	K_2	107.33	12.00	259.30	4.200	231.07	46.00	49.77	45.39
	K_3	100.0	12.00	193.00	3.800	220.10	48.35	47.40	45.27
T_3	K_0	70.00	9.00	69.00	2.333	50.67	13.67	33.30	33.33
	K_1	77.67	11.00	75.30	2.700	55.67	19.33	37.11	41.66
	K_2	80.33	10.00	101.30	2.800	64.67	30.33	46.77	36.73
	K_3	72.33	9.67	85.30	2.500	57.00	20.33	45.23	42.50
F- test		*	*	*	*	*	*	*	*
LSD (5%)		9.002	1.286	25.11	0.209	8.030	5.795	2.771	0.995

Applying *K* in a proper way considerably increased photosynthesis during the grain filling stage, moreover, it has a positive role in increasing the number of grain per plant^{-1} [Pettigrew (2008)]. With regard to the yield of kernels, plant^{-1} and the content of seed oil, the K_3 treatment achieved the highest grain yield of 174.96 g plant^{-1} and the highest oil content was 45.78%, respectively, compared to other potassium addition methods. The control treatment gave the lowest average for the above mentioned traits, it reached 121.00 g vegetable^{-1} and 34.81% respectively. The evidence indicated that the potassium fertilization is an indispensable mineral constituent, intrinsically playing a vital role in plant growth and development processes in addition to the potassium has a vital role to limit of water stress effect on the plant through controlling the stomata behavior in addition to its effect on many enzymes, increasing the shoot and root growth consequently, nutrients absorption [Coskun *et al.* (2017)]. Probably the major cause of K_3 treatment superiority in terms of oil content was due to the application method and potassium role in reducing the negative effect of drought.

3.3 Effect of irrigation treatments on growth traits

The result of Table 3 indicated the reduction of plant height, the number of branches plant-1 and oil content associated with the spacing the crop irrigation intervals due to the exposure of the plant to water stress, which was negatively reflected in the inhibition of cell division and elongation, and then reducing the height of the plant and the branches plant^{-1}. Also, the low content of chlorophyll leaves was observed under the conditions of water stress, due to stomata behaviors in response to drought stress causes a reduction in the level of photosynthetic as a consequence of chloroplast dehydration [Cakmak (2005)].

Under drought stress, the photosynthetic rate decreases mainly as a consequence of inadequate of intracellular carbon dioxide levels due to reduced stomatal conductance [Boureima *et al.* (2012)] due to accumulation of abscisic acid ABA where it is mainly managed regulating the stomatal opening. Consequently, indirectly regulates plant growth by increasing stomatal resistance to CO_2 uptake In addition to the lack of movement and absorption of nutrients, especially the elements that participate in the formation of the chlorophyll molecules, and water stress leads to an increase in the formation of free radicals. Accumulation high levels of reactive oxygen species (ROS) became extremely harmful to cellular membranes and other cellular components when its concentrations reached the level of phytotoxicity, which leads to oxidative stress and, ultimately, cell death [Mittler (2002)]. The negative effect of spacing the crop irrigation intervals during the season on the previously mentioned traits reflected, also on the dry weight of the root, where the reduced rate of the dry weight of the root at treatment T_3 63.81% compared with treatment T_1. Water shortage reduces the concentration of nutrients in the soil solution. The transferred nutrients from the soil to plant root cells reduced with increasing the water stress, water deficiency causes a lack of energy supplied by photosynthesis moreover lowered transpiration rates consequently, shorten nutrient absorption potential of roots [Farooq *et al.* (2012)].

3.4 Effect of irrigation treatments on grain yield and oil content

Table 3 shows that the irrigation treatment T_2 had achieved the highest average of traits of the number of branch (12.00) branch, number of capsules (259.30 capsules) and weight of 1000 grains (4.20gm), significantly superior to treatments T_1 and T_3. This superiority was probably due to physiological adaptations, which results as a response to drought stress occurs, thereby expansion growth in the shoot arrested and accumulated photosynthetic are translocated to the root force it to search for more soil water. Consequently, consume more nutrients and increase biomass partitioning to roots to maximize the water absorption capacity [Karcher *et al.* (2008)]. So, the percentage of oil, in the treatment, T_2 was significantly superior to treatment T_3 with the highest rate of 42.05%. Its value converged with the T_1 treatment, which was 45.80%. The results indicated that the soil moisture in the T_1 was sufficient to support the plant growth thus, achieved the highest grain yield (247.77gm per plants^{-1}). Since the plant behavior can be changed based on the biosynthesis of bioactive compounds when exposed to abiotic limitations thereby changing their normal physiological and molecular processes, consequently amend the crop yield chemical composition [Ozkan *and* Kulak (2013)]. The decreased weight of 1000 grains and grain yield plant^{-1} in the treatment T_3 probably was due to the exposure of the plant to water stress caused an imbalance in the physiological processes in the plant consequently, reflected in the lack of photosynthetic products that support the fullness of the seed.

3.5 Effect of the interaction between irrigation and potassium application method treatments on growth traits.

Table 4 shows that the interaction between the two factors (irrigation *x* fertilizer application) significantly affected all traits under study. The application of adding all the amount of potassium fertilizer at planting with the irrigation every 10-day (T_1 K_1) has achieved the highest average height of the plant (132.67 cm), the weight of the dry root (68.67 g), grain yield (247.77 gm per plant^{-1}) and oil in the seeds (51.20%). Whilst moderate deficiency in the T2 (irrigation every 20-day) with existing of potassium *K3 (soil* fertilizer application 50% of fertilizer at planting and 50% supplied as a foliar application with 15 days intervals at flowering and 15 days after) had increased the number of branch per plant^{-1} (12.00) branches, number of capsules per plant^{-1} (259.30 capsule) and weight of 1000 seeds (4.20g).

The combination of shortage moisture T_2 and the splitting of potassium added into two batches K_2 may lead to activate the ATP synthase enzyme, thereby support the photosynthesis process and consequently, increases the phonological development. The highest chlorophyll content recorded by T_2 combination with K_1 was 52.0, while the lowest chlorophyll content recorded by T_3 combination with K_0 was 33.30 (Table 4). The evidence showed that the chlorophyll affected by existing of potassium more than soil moisture, possibly owing to the sesame classified as tolerance drought stress crop. Therefore, the heights chlorophyll content was obtained from T_2 with presence of K while the chlorophyll has reduced with absence of K in spite of water availability in the T_1 treatment (41.20).

The heights grain yield plant^{-1} was obtained from the interaction between $T_1 K_3$ reached to 247.77 (Table 3) probably due to the optimum soil moisture in addition to the K application method (foliar application), which is recognized as a significant method of fertilization, since foliar nutrients absorbed easily by the leaf cuticle and enter the cells, facilitating easy and rapid utilization of nutrients by the crop. Consequently, increasing the grain yield per plant$^{-1.}$ Table 4 also showed evidence that the seed oil content was affected by the absence of K, which has a vital role in the seed oil content, and perhaps the lack of K increased the negative effects on drought stress and thus reduced the seed oil content [Wang *et al.* (2013)].

4. Conclusion

Evidence the results that potassium fertilizer played a major role in reducing the negative impact of drought stress, especially when it was added in batches, whether it was added to the soil or sprayed on the leaves. The results show the reduced biological yield because of the distant irrigation times. Whilst moderate deficiency in the T_2 with existing of potassium K_3 had increased the number of branch per plant^{-1}, number of capsules per plant^{-1} and weight of 1000 seeds. Therefore, evidence indicated that potassium fertilizer is an indispensable mineral component, and plays a vital role in plant growth and metabolism.

Conflict interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The research was funded by Anbar University Grant No. 8443510. The authors would like to thank all, who presented the insight and expertise that greatly assisted in the research. The authors also appreciate the exert efforts of the academic and support staff of the Department of Field Crops, College of Agriculture and Upper Euphrates Basin Developing Center, University of Anbar in providing all the required assistance and materials in conducting this research.

References

Boureima, S., A. Oukarroum, Diouf, N. Cisse and P. Van Damme (2012). Screening for drought tolerance in mutant germplasm of sesame (Sesamum indicum) probing by chlorophyll a fluorescence. *Environmental and Experimental Botany*, **81**, 37-43.

Cakmak, I. (2005). The role of potassium in alleviating detrimental effects of abiotic stresses in plants. *Journal of Plant Nutrition and Soil Science*, **168(4)**, 521-530.

Coskun, D., D.T Britto and H.J. Kronzucker (2017). The nitrogen–potassium intersection: membranes, metabolism, and mechanism. *Plant Cell & Environment*, **40(10)**, 2029-2041.

Farooq, M., M. Hussain, A. Wahid and K.H.M. Siddique (2012). *Drought stress in plants: An Overview, in Plant Responses to Drought Stress*, ed. R. Aroca (Berlin: Springer-Verlag), 1-33.

Karcher, D.E., M.D. Richardson, K. Hignight and D. Rush (2008). Drought tolerance of tall fescue populations selected for high root/shoot ratios and summer survival. *Crop Science*, **48(2)**, 771-777.

Mittler, R. (2002). Oxidative stress, antioxidants and stress tolerance. *Trends in Plant Science*, **7(9)**, 405-410.

Ozkan, A. and M. Kulak (2013). Effects of water stress on growth, oil yield, fatty acid composition and mineral content of Sesamum indicum. *J. Anim. Plant Sci.*, **23(6)**, 1686-1690.

Pereira, J. E. R., H. O. C. Guerra, J. E. R. C. Bezerra, J. H. Zonta and W. E. P. Araujo (2017). Behavior and water needs of sesame under different irrigation regimes: Analysis of growth. African Journal of Agricultural Research, 12(20), 1756-1762.

Pettigrew, W.T. (2008). Potassium influences on yield and quality production for maize, wheat, soybean and cotton. *Physiologia Plantarum*, **133(4)**, 670-681.

Wang, M., Q. Zheng, Q. Shen and S. Guo (2013). The critical role of potassium in plant stress response. *International Journal of Molecular Sciences*, **14(4)**, 7370-7390.

Zhao, D., D.M. Oosterhuis and C.W. Bednarz (2001). Influence of potassium deficiency on photosynthesis, chlorophyll content, and chloroplast ultrastructure of cotton plants. *Photosynthetica*, **39(1)**, 103-109.