IOCAG 2022

Proceeding Paper

Effects of Superabsorbent Polymer on Yield and Yield Components of Sesame under Water Deficit Conditions †

Alireza Gilani [1], Ahmad Gholami [2], Hamid Abbasdokht [2] and Zahra Taghizadeh Tabari [1,*]

1 PhD Crop Ecology, Faculty of Agriculture, Shahrood University of Technology, Shahroud, Iran; Gilani-email@email.com
2 Associate Professor, Faculty of Agriculture, Shahrood University of Technology, Shahroud, Iran; email@email.com (A.G.); email@email.com (H.A.)
* Correspondence: Tabari-email@email.com
† Presented at the 1st International Online Conference on Agriculture—Advances in Agricultural Science and Technology (IOCAG2022), 10–25 February 2022; Available online: https://iocag2022.sciforum.net/.

Abstract: Water scarcity is the main cause of severe yield reduction in arid areas by creating harmful effects on the morphological, physiological and biochemical characteristics of the plant. The application of soil amendments is a profitable strategy to mitigate the adverse impact of drought stress. Superabsorbent polymers (SAPs) are eco-friendly materials, which have incredible water absorption ability and water holding capacity in the soil, because of their unique biochemical and structural properties. This study aimed to investigate the effects of superabsorbent on some characteristics of sesame under different irrigation intervals. This experiment was performed in a three replicated-split plot factorial, arranged in RCBD with three drought factors as the main plot (Irrigation interval using cumulative evaporation from class A pan: 80 mm (I_1), 160 mm (I_2), and 240 mm (I_3), and superabsorbent (SAPs) Stockosorb in three levels (0, 100, 200 kg ha^{-1}) (Z_0, Z_1, Z_2) as the subplots. The results showed that the application of superabsorbent (200 kg ha^{-1}) increased the number of capsules per plant, the number of seeds per capsule, and grain yield by 15.8%, 27%, and 39% compare to control. Moreover, the application of superabsorbent mitigated the adverse effects of increasing the irrigation intervals in biological yield, thereby biological yields in severe stress conditions (I_3) was similar to which obtained in mild stress. Our results demonstrated that the application of superabsorbent could be a promising approach to improve plant yield, especially under water deficit conditions.

Keywords: sesame; irrigation; yield components

Citation: Gilani, A.; Gholami, A.; Abbasdokht, H.; Tabari, Z.T. Effects of Superabsorbent Polymer on Yield and Yield Components of Sesame under Water Deficit Conditions. **2022**, *4*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s):

Published: date

1. Introduction

Water scarcity is an important limiting factor for agriculture, especially in arid and semi-arid regions. In the near future, global warming will exacerbate water scarcity. During drought stress, the decrease in plant water content leads to a decrease in cellular turbulence and leaf water potential. If the duration of stress increases, it will eventually lead to plant death by disrupting photosynthetic and metabolic activities [1]. In this regard, it is necessary to conduct some approaches to deal with the water deficit to produce high quality and quantity products and protect water resources. One of the approaches to cope with the adverse effects of water deficit is the application of advanced techniques to maintain soil moisture storage or adjust the acceptable irrigation intervals for the plant [2]. By adjusting irrigation scheduling through direct measurement of evaporation by evaporation pan, it is possible to determine the appropriate time and amount of water required by the plant. Thus, making available the required amount of water reduces the adverse effects of drought stress on it [3]. Another approach is optimal use of water resources and their preservation utilizing superabsorbent polymers. Superabsorbent polymers (SAPs) are organic compounds that can absorb and retain water quickly up to several times their volume, increase water holding capacity in the soil, and ultimately improve plant growth by reducing the effect of drought stress [4]. Positive impacts of superabsorbent in increasing soil water holding capacity, improving soil aggregate and soil stability, and improving soil aeration, increasing plant root access to available water, and mitigating the effects Negative drought on plants has been shown in several studies [5,6]. In addition, to obtain the optimum yield under drought stress conditions, a plant with suitable drought tolerance in these conditions is also needed. *Sesamum indicum* L.is considered an annual and thermophilic plant, drought-resistant, and short-day crop. Although this plant is drought tolerant, it is sensitive to drought stress during the flowering and grain filling stages [7]. Due to the nutritional contribution of sesame and also, according to previous studies on the positive effect of superabsorbent in reducing the adverse effects of the drought of different plants, this study aims to investigate yield and yield components of sesame (*Sesamum indicum* L.) under water deficit conditions.

2. Materials and Method

This study was carried out in the research field of Shahrood University of Technology, Shahrood, Iran in 2019 (Longitude 54°59′58″, Latitude 36°29′08″, Height 1349 m). This experiment was performed in a three replicated-split plot factorial, arranged in RCBD with three drought factors as the main plot (Irrigation interval using cumulative evaporation from class A pan: 80 mm (I_1), 160 mm (I_2), and 240 mm (I_3), and superabsorbent (SAPs) STOCKOSORB in three levels (0, 100, 200 kg ha-1) (Z_0, Z_1, Z_2) as the subplots. Each experimental plot includes four planting rows with a length of 4 m, and row spacing was 7cm (plant to plant) and 50 cm (row to row). For applying drought factors, an empirical equation model was used to calculate the desired evaporation from the evaporation pan by using five years of weather data. Daily meteorological data obtained from a weather station located at the experimental site were used to calculate ETO. In the beginning, all plots were irrigated equally to ensure full germination and favor seedling initial growing, and Irrigation treatments were applied after the complete establishment of seedlings. For SAP application, the top 5 cm of the soil was removed and mixed with soil in the top 15 cm depth of the sandy soil before cultivation. Plant samples for yield and components, including grain yield, 1000-seed weight, number of capsules per plant, number of seeds per capsule, and plant height, were randomly taken at the ripening stage from each plot and left to dry for two weeks. Seed counter and a digital scale were used for the determination of the number of seeds and seed weights. Dry matter yield was measured after oven-dried at 75 °C to a constant weight. Data analysis was performed by Statistical Analysis variance (SAS 9.4) (SAS Institute, Cary, NC, USA), and treatments means were compared by using the least significant difference (LSD) test ($p < 0.05$).

3. Result and Discussion

3.1. The number of Capsules per Plant

The effect of the irrigation regime on the number of capsules per plant was significant ($p \leq 0.01$) (Table 1). Comparison of means showed that water deficit stress had a negative effect on the number of capsules per plant in sesame (Table 2). I_1 Irrigation treatment had the highest number of capsules per plant (48.02) and the lowest amount belonged to I_3 irrigation treatment (35.19). The number of capsules per plant decreased by 13.43% and 26.71%, respectively, when I_2 and I_3 were applied. Behzadnejad (2020) also reported that the number of the capsule in sesame was decreased by 66% due to increments in water deficit from 100 to 40% [8]. A similar observation was reported by Jahan et al. (2021) [9]. The number of capsules per plant can be considered as an indicator of the number of fertile flowers per plant. And since the number of fertile flowers is strongly influenced by soil and plant moisture, water stress has reduced the number of capsules per plant [9]. The number of capsules per plant also were significantly affected by superabsorbent ($p \leq 0.01$)

(Table 1). The results showed that the increase in the superabsorbent application led to an increase in the number of capsules per plant compared to the control. This increment is probably due to the high water absorption capability of the superabsorbent, thanks to its specific structure. The highest number of capsules was obtained from the treatment of 200 kg ha^{-1} superabsorbent with the production of 44.33 capsules per plant (Table 2). This result is similar to the result of [10].

Table 1. Results of analysis of variance (mean squared) different levels of irrigation and Superabsobents of yield and yield components of sesame.

		Mean Squared				
Source	**D.F**	**1000 Seed Weight**	**Dry Matter Yield**	**Seed Yield**	**The Number of Seeds in the Capsule**	**The Number of Capsules**
Replication	2	0.13	518,401.02	1799.08	422.72	1.65
Irrigation (I)	2	2.2 **	23,527,600.79 **	896,974.26 **	1156.96 *	741.13 **
Error a	4	0.08	43,172.44	7520.01	19.97	98.81
Superabsorbent (Z)	2	1.19 **	4,562,995.74 **	295,011.4 **	1023.96 **	169.01**
(I×Z)	4	0.05 ^{ns}	669,881.00 **	4466.41 ^{ns}	42.35 ^{ns}	2.47 ^{ns}
Error a	12	0.1	130,057.44	5083.10	26.88	11.16

**, * Significant at the 1% and 5% probability levels, respectively.

Table 2. Comparison of the mean of main effects of Irrigation, and Superabsorbents on yield and yield components of sesame.

Treatment	1000 Seed Weight (g)	Seed Yield	The Number of Seeds in the Capsule	The Number of Capsules
Irrigation				
I_1	3.43^a	950^a	71.87^a	48.02^a
I_2	3.05^b	818.6^b	62.12^b	41.56^{ab}
I_3	2.73^c	514.8^c	55.97^c	35.19^b
Superabsorbent				
Z_0	2.83^b	643.8^c	55.38^c	38.28^b
Z_1	3.03^b	741.8^b	64.18^b	42.16^a
Z_2	3.34^a	897.7^a	70.39^a	44.33^a

Means with common letters show no significant difference in 5% probability level with LSD test.

3.2. The Number of Grains per Capsule

The irrigation regime had a significant effect on the number of grains per capsule ($p \leq 0.05$) (Table 1). The number of grains decreased from 71.87 grains per capsule at I_1 to 55.97 at I3 (Table 2). Heidari et al. (2011) [11] reported that the number of seeds per capsule was reduced by 12% compared to regular irrigation under stress. The effect of superabsorbent on the number of grains per capsule was also significant ($p \leq 0.01$) (Table 1). The mean comparison showed that increasing the amount of superabsorbent increased the number of grains per capsule. Therefore, the highest number of grains per capsule was observed in the superabsorbent treatments with 0, 100, and 200 kg ha^{-1}, respectively (Table 2). A similar result was reported by Biosci et al. (2014) [12]. Superabsorbent increases the soil's water holding capacity and releases water slowly, resulting in rapid drying of the soil around the roots and rapid loss of water via evaporation, as well as deep penetration into the root environment, so an increases yield components.

3.3. The Grain Yield

The effect of the irrigation regime on grain yield was significant ($p \leq 0.05$) (Table 1). Water deficit declines the grain yield. Grain yield under regular irrigation (I_1) was 46% higher than severe stress (I_3). The highest grain yield was observed in I_1 (950 kg ha^{-1} grain yield), and the lowest was in than severe stress (I_3) (514.8 kg ha^{-1} grain yield) (Table 2). shortening of grain filling period. Also, reducing carbohydrate transfer to grain (the most critical physiological sinks) is the major reason for these losses. Ayoubizadeh et al. (2018) [13] reported that grain yield under stress decreased by 13.72% compared to regular irrigation. The effect of superabsorbent on grain yield ($p \leq 0.01$) (Table 1). The results showed that increasing the superabsorbent application led to a significant increase in grain yield. The application of 100 kg ha^{-1} of superabsorbent increases the grain yield by 13.2% compared to the control. And increasing superabsorbent up to 200 kg ha^{-1} caused a 17.4% increment in grain yield compared to 100 kg ha^{-1} of superabsorbent (Table 2). This result is also consistent with a report by [14].

3.4. Dry Matter Yield

As can be seen in Table 1, the effect of irrigation regime, superabsorbent, and their interactions on dry matter yield were significant ($p \leq 0.05$). The results showed that increasing the superabsorbent amount under all irrigation levels led to an increase in dry matter yield. Superabsorbent application mitigated the negative effect of water deficit. So that, the dry matter yield under mild stress (I_2) with an application of 200 kg ha^{-1} of superabsorbent was similar to regular irrigation. (Figure 1).

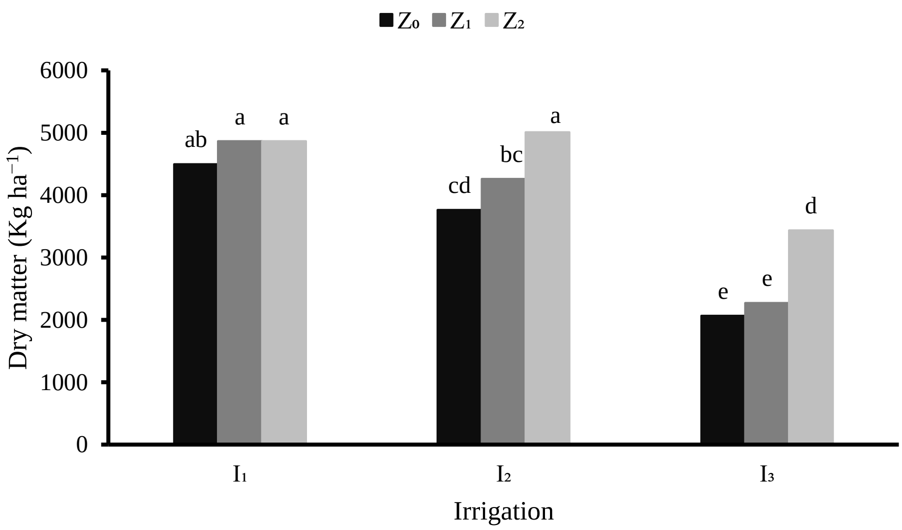

Figure 1. Interaction of irrigation × superabsorbent on dry matter yield (Kg ha^{-1}). (Means with common letters show no significant difference in 5% probability level with LSD test).

3.5. 1000-Seed Weight

The results of the analysis of variance showed that the irrigation regime had a significant effect on 1000-seed weight ($p \leq 0.01$) (Table 1). Comparison of the mean of irrigation regimes showed that water deficit stress caused a significant reduction in 1000-seed weight in sesame plants. 1000-seed weight under normal irrigation condition (I_1) was 11.02% higher than mild stress condition (I_2) and 20.5% more than severe stress condition (I_3) (Table 2). 1000-seed weight reduction under water deficit condition resulted from reduced grain filling period and loss of growing season [13] reported that the weight of 1000 sesame seeds decreased by 32.84% compared to the control under stress. Drought stress in the time after determining the number of seeds in the pod, reduces grain filling and thus reduces the weight of 1000 sesame seeds [15]. The effect of superabsorbent on 1000-grain weight was also significant ($p \leq 0.01$) (Table 1). The results showed that increasing the amount of superabsorbent led to an increase in 1000-seed weight due to enhancement of water availability for the plant, which alternating periods of wet and dry conditions and exposure of seeds to water deficit, and also the better transfer of nutrients to the seeds, which prevents the seeds from seed shriveling and coat wrinkling [16]. Comparison of the mean of different amounts of superabsorbent showed that 1000-grain weight in the application of 200 kg ha^{-1} superabsorbent was 10% higher than 100 kg ha^{-1} and 15.6% higher than non-application (Table 2).

4. Conclusions

The results showed that the application of superabsorbent due to increased water retention in the soil and its uniform distribution to the plant led to an increase in measured traits and thus can lead to increased yields in areas with water shortages problems.

Institutional Review Board Statement:

Informed Consent Statement:

Data Availability Statement:

References

1. El-Samad, H.M.A.; Shaddad, M.A.K.; Ragaey, M.M. Drought Strategy Tolerance of Four Barley Cultivars and Combined Effect with Salicylic Acid Application. *Am. J. Plant Sci.* **2019**, *10*, 512–535. https://doi.org/10.4236/ajps.2019.104037.
2. Jovanovic, N.; Pereira, L.S.; Paredes, P.; Pôças, I.; Cantore, V.; Todorovic, M. A review of strategies, methods and technologies to reduce non-beneficial consumptive water use on farms considering the FAO56 methods. *Agric. Water Manag.* **2020**, *239*, 106267. https://doi.org/10.1016/j.agwat.2020.106267.
3. Da Cunha Leme Filho, J.F.; Ortiz, B.V.; Balkcom, K.S.; Damianidis, D.; Knappenberger, T.J.; Dougherty, M. Evaluation of Two Irrigation Scheduling Methods and Nitrogen Rates on Corn Production in Alabama. *Int. J. Agron.* **2020**, *2020*, 8869383. https://doi.org/10.1155/2020/8869383.
4. Abrisham, E.S.; Jafari, M.; Tavili, A.; Rabii, A.; Zare Chahoki, M.A.; Zare, S.; Egan, T.; Yazdanshenas, H.; Ghasemian, D.; Tahmoures, M. Effects of a super absorbent polymer on soil properties and plant growth for use in land reclamation. *Arid Land Res. Manag.* **2018**, *32*, 407–420. https://doi.org/10.1080/15324982.2018.1506526.
5. Elshafie, H.S.; Camele, I. Applications of absorbent polymers for sustainable plant protection and crop yield. *Sustainability* **2021**, *13*, 3253. https://doi.org/10.3390/su13063253.
6. Wu, H.; Li, Z.; Song, W.; Bai, S. Effects of superabsorbent polymers on moisture migration and accumulation behaviors in soil. *J. Clean. Prod.* **2021**, *279*, 123841. https://doi.org/10.1016/j.jclepro.2020.123841.
7. Gholamhoseini, M. Evaluation of sesame genotypes for agronomic traits and stress indices grown under different irrigation treatments. *Agron. J.* **2020**, *112*, 1794–1804. https://doi.org/10.1002/agj2.20167.
8. Behzadnejad, J.; Tahmasebi-Sarvestani, Z.; Aein, A.; Mokhtassi-Bidgoli, A. Wheat Straw Mulching Helps Improve Yield in Sesame (*Sesamum indicum* L.) Under Drought Stress. *Int. J. Plant Prod.* **2020**, *14*, 389–400. https://doi.org/10.1007/s42106-020-00091-8.
9. Jahan, M.; Javadi, M.; Hesami, E.; Amiri, M.B. Nutritional Management Improved Sesame Performance and Soil Properties: A Function-Based Study on Sesame as Affected by Deficit Irrigation, Water Superabsorbent, and Salicylic Acid. *J. Soil Sci. Plant Nutr.* **2021**, *21*, 2702–2717. https://doi.org/10.1007/s42729-021-00557-2.
10. Jooyban, Z.; Moosavi, S.G. Seed yield and some yield components of sesame as affected by irrigation interval and different levels of N fertilization and superabsorbent. *Adv. Environ. Biol.* **2012**, *6*, 593–597. https://doi.org/10.5897/ajb12.505.
11. Heidari, M.; Galavi, M.; Hassani, M. Effect of sulfur and iron fertilizers on yield, yield components and nutrient uptake in sesame (*Sesamum indicum* L.) under water stress. *Afr. J. Biotechnol.* **2011**, *10*, 8816–8822. https://doi.org/10.5897/ajb11.854.
12. Biosci, I.J.; Namvar, H.; Asgharzade, A.; Babaeian, M.; Hosseinzade, E. The effects of superabsorbent polymer on yield and yield component of two grape varieties. *Int. J. Biosci.* **2014**, *6655*, 18–23. https://doi.org/10.12692/ijb/4.4.18-23.
13. Ayoubizadeh, N.; Laei, G.; Amini Dehaghi, M.; Masoud Sinaki, J.; Rezvan, S. Seed yield and fatty acids composition of sesame genotypes as affected by foliar application of iron nano-chelate and fulvic acid under drought stress. *Appl. Ecol. Environ. Res.* **2018**, *16*, 7585–7604. https://doi.org/10.15666/aeer/1606_75857604.
14. Islam, M.R.; Xue, X.; Mao, S.; Zhao, X.; Eneji, A.E.; Hu, Y. Superabsorbent polymers (SAPs) enhance efficient and eco-friendly production of corn (*Zea mays* L.) in drought affected areas of northern China. *Afr. J. Biotechnol.* **2011**, *10*, 4887–4894. https://doi.org/10.5897/AJB10.2152.
15. Farzi-Aminabad, R.; Ghassemi-Golezani, K.; Nasrullahzadeh, S. Grain and Oil Yields of Safflower (*Carthamus tinctorius* L.) Affected by Water Deficit and Growth Regulators. *Agriculture* **2021**, *67*, 87–94. https://doi.org/10.2478/agri-2021-0008.
16. Elshafie, H.S.; Camele, I. Applications of absorbent polymers for sustainable plant protection and crop yield. *Sustainability* **2021**, *13*, 3253. https://doi.org/10.3390/su13063253.