

EFFECT OF WATER-SUPERABSORBENT AND DROUGHT ON SEEDLING ESTABLISHMENT AND GROWTH IN SOME WARM SEASON PLANTS

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Abstract. Drought is one of the most important abiotic stresses in Iran's agriculture and annually causes many damages to plant productions. This study was designed to determine effect of water-superabsorbent polymer and drought on seedling establishment and growth in some warm season plants (foxtail millet, dill and fenugreek). This experiment was conducted as a pot experiment at Campus of Agriculture and Natural Resources, Razi University. In the pot experiment, effect of water-superabsorbent polymer (0, 0.02, 0.04 and 0.08 grams per kilogram of soil) and drought (favorable and long-term irrigation) on warm season plants were investigated. Results showed that by increasing water-superabsorbent polymer application, seedling fresh weight, seedling dry weight, seedling height, emergence percentage and rate were increased. Drought reduced mentioned traits, but water-superabsorbent was able to reduce drought negative effects partially. Regarding results, for high emergence in foxtail millet, fenugreek and dill, application of 0.08 g of superabsorbent per kilogram of soil is usefull, especially under drought condition.

Keywords: dill, emergence percentage, fenugreek, foxtail millet, limited irrigation, water-superabsorbent

INTRODUCTION

Drought is one of the important problems in arid and semiarid area. Iran's average annual rainfall is 273 mm. This rainfall is one third of world's average annual rainfall (Abfaihan, 2010). Water-superabsorbent polymer is one of the materials that are able to store water in soil. This water can be absorbed by plant especially under drought. Superabsorbent polymer application in sport turf had positive effect on plant traits especially under drought (Sheikhmoradi *et al.*, 2011). Application of compost and acrylamide hydrogel on sandy soil improved soil properties such as CEC, organic carbon, soil structure, total nitrogen and bulk density (Elhadi and Abo-sedera, 2006).

El-Hady and Wanas (2006) reported that incorporating 2g of water-superabsorbent in the plant pit and reducing irrigation water volume by 15% produced the highest cucumber yield compared to other treatments. Seedling establishment is one of the plant critical stages. If seedling establishment is failed, crop loss will be unavoidable.

Rafiee (2010) reported that both compost and water-superabsorbent increased seedling establishment and emergence in *Haloxylon aphyllum* compared to control. Due to low seedling emergence of plant with small seed, especially in warm season, it is required to increase farm seedling emergence. Using water-superabsorbent may be usefull for high seedling emergence.

So, the goal of the experiment was to determine effect of water-superabsorbent on seedling establishment in some warm season plants under drought condition.

MATERIALS AND METHODS

Experimental design and agronomical practices

The research was conducted as a factorial experiment based on randomized complete block design at Research Greenhouse, College of Agricultural Science and Engineering, Razi University in 2014. Studied factors included water-superabsorbent (0, 0.02, 0.04 and 0.08 g per kg of soil) and drought (favorable irrigation interval of 2-day and long term irrigation interval of 4-day). Irrigation intervals were determined as a pre-experiment at the greenhouse. This experiment was conducted on warm season plants (foxtail millet, fungreek and dill). Ten seeds of warm season plants with water-superabsorbent were sown in pots (7 cm in diameter and 7.5 cm in depth). Foxtail millet, fungreek and dill were cut when they had five leaves.

Measuring traits and data analysis

Plant height was measured from ground level to the latest leaf by ruler. Five plants were harvested per each pot and transferred to laboratory. Immediately, in laboratory, seedling fresh weight was recorded. Then samples were kept in oven (75°C and 72 h) to measure seedling dry weight. Seedling emergence percentage was computed according to Ellis and Roberts (1981) equation:

$$(1) \quad FEP = \left(\frac{S}{T}\right) \times 100$$

Where FEP, S and T are emergence percentage, emerged seeds number and total seed number, respectively. Emergence rate was calculated by equation 2.

$$(2) \quad AVE = \frac{\sum Nt}{\sum t}$$

Where AVE, $\sum Nt$ and $\sum t$ are emergence rate (number per day), total number of emerged seed per time (t) and total time (day), respectively. Data for each plant per each experiment was analyzed by MSTATC and SAS software. Duncan's multiple range test was used to compare means.

RESULTS

Seedling height: Analysis of variance showed that effect of water-superabsorbent and drought on seedling height of all three plants was significant and interaction effect of water-superabsorbent and drought on fungreek seedling height was significant (Table 1). Under irrigation interval of 2-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill height by 33, 78 and 35%, respectively compared to no water-superabsorbent application. Under irrigation interval of 4-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill height by 46, 63 and 44%, respectively compared to no water-superabsorbent application (Figure 1).

Seedling fresh weight: Analysis of variance showed that effect of water-superabsorbent and drought on seedling fresh weight of all three plants was significant and interaction effect of water-superabsorbent and drought on seedling fresh weight of foxtail millet and fungreek was significant (Table 1). Under irrigation interval of 2-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill

seedling fresh weight by 98, 37 and 60%, respectively compared to no water-superabsorbent application. Under irrigation interval of 4-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill seedling fresh weight by 68, 84 and 86%, respectively compared to no water-superabsorbent application (Figure 1).

Table 1
Analysis of variance (mean square) of effect of water-superabsorbent (S) and drought (D) on warm season plants

Plants	Source of variation	DF	Seedling fresh weight	Seedling dry weight	Height	Leaf number	Emergence percent	Emergence rate
	D	1	1161.9**	714.9**	15.1**	0.37**	266.6**	4.63**
Foxtail millet	S	3	3333.1**	577.2**	16.9**	0.37**	944.4**	7.82**
	S × D	3	21.6**	1.9**	0.5 ^{ns}	0.37**	55.5 ^{ns}	1.32*
	Error	16	1.7	0.3	0.7	0.00	29.1	0.45
	D	1	15845.5**	912.6**	7.37**	0.00 ^{ns}	504.1**	1.89*
	S	3	7914.3**	851.6**	20.58**	0.00 ^{ns}	848.6**	6.77**
Fungreek	S × D	3	392.2**	0.5 ^{ns}	0.82**	0.00 ^{ns}	4.1 ^{ns}	0.20 ^{ns}
	Error	16	2.8	0.5	0.01	0.00	12.5	0.54
	D	1	240.6**	78.2**	2.69**	0.00 ^{ns}	816.6**	0.19 ^{ns}
	S	3	981.8**	324.2**	8.53**	0.00 ^{ns}	1000.0**	5.45**
Dill	S × D	3	2.0 ^{ns}	2.3 ^{ns}	0.02 ^{ns}	0.00 ^{ns}	16.6 ^{ns}	0.21 ^{ns}
	Error	16	15.7	6.0	0.27	0.00	8.3	0.33

** and *: significant at probably level of 1 and 5%, respectively. ^{ns}: non-significant

Seedling dry weight: Analysis of variance showed that effect of water-superabsorbent and drought on seedling dry weight of all three plants was significant and interaction effect of water-superabsorbent and drought on seedling dry weight of foxtail millet was significant (Table 1). Under irrigation interval of 2-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill seedling dry weight by 83, 72 and 97%, respectively compared to no water-superabsorbent application. Under irrigation interval of 4-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill seedling dry weight by 111, 111 and 140%, respectively compared to no water-superabsorbent application (Figure 1).

Seedling emergence percentage: Analysis of variance showed that effect of water-superabsorbent and drought on seedling emergence percentage of all three plants was significant (Table 1). Under irrigation interval of 2-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill seedling emergence percentage by 50, 36 and 36%, respectively compared to no water-superabsorbent application. Under irrigation interval of 4-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill seedling emergence percentage by 35, 42 and 58%, respectively compared to no water-superabsorbent application (Figure 2).

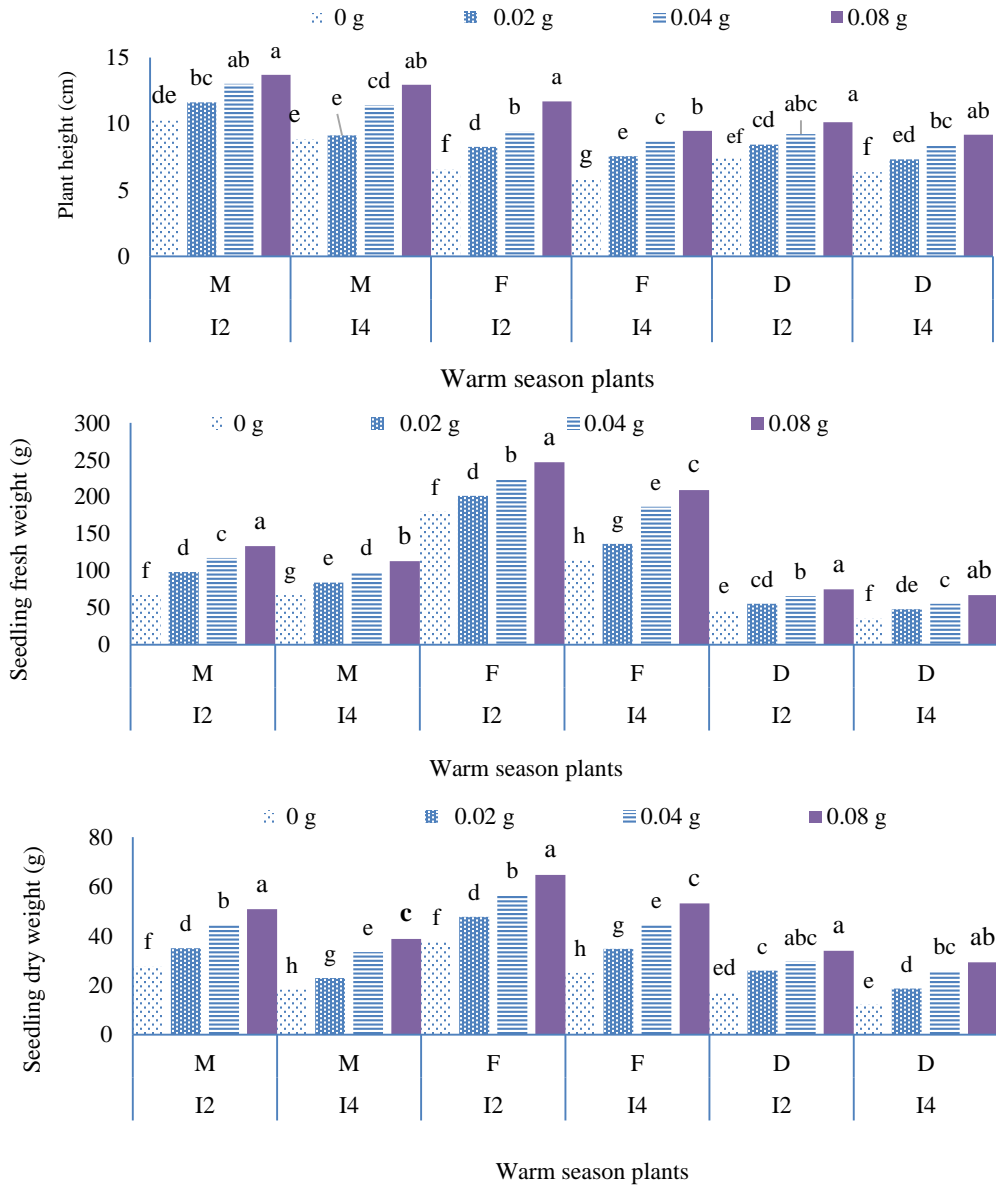


Fig. 1. Effect of water-superabsorbent and drought on plant height, seedling fresh weight and seedling dry weight. Means followed by the same letter within each plant are not significantly different at $P < 0.05$ as determined by Duncan's Multiple Range Test. M, F and D are foxtail millet, fenugreek and dill, respectively. I2 and I4 are irrigation interval of 2 and 4-day, respectively

Seedling emergence rate: Analysis of variance showed that effect of water-superabsorbent and drought on seedling emergence rate of foxtail millet and fungreek and water-superabsorbent effect on dill seedling emergence rate was significant (Table 1). Under irrigation interval of 2-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet, fungreek and dill seedling emergence percentage by 60, 33 and 28%, respectively compared to no water-superabsorbent application. Under irrigation interval of 4-day, water-superabsorbent application of 0.08 g per kg of soil increased foxtail millet,

fungreek and dill seedling emergence percentage by 30, 48 and 45%, respectively compared to no water-superabsorbent application (Figure 2).

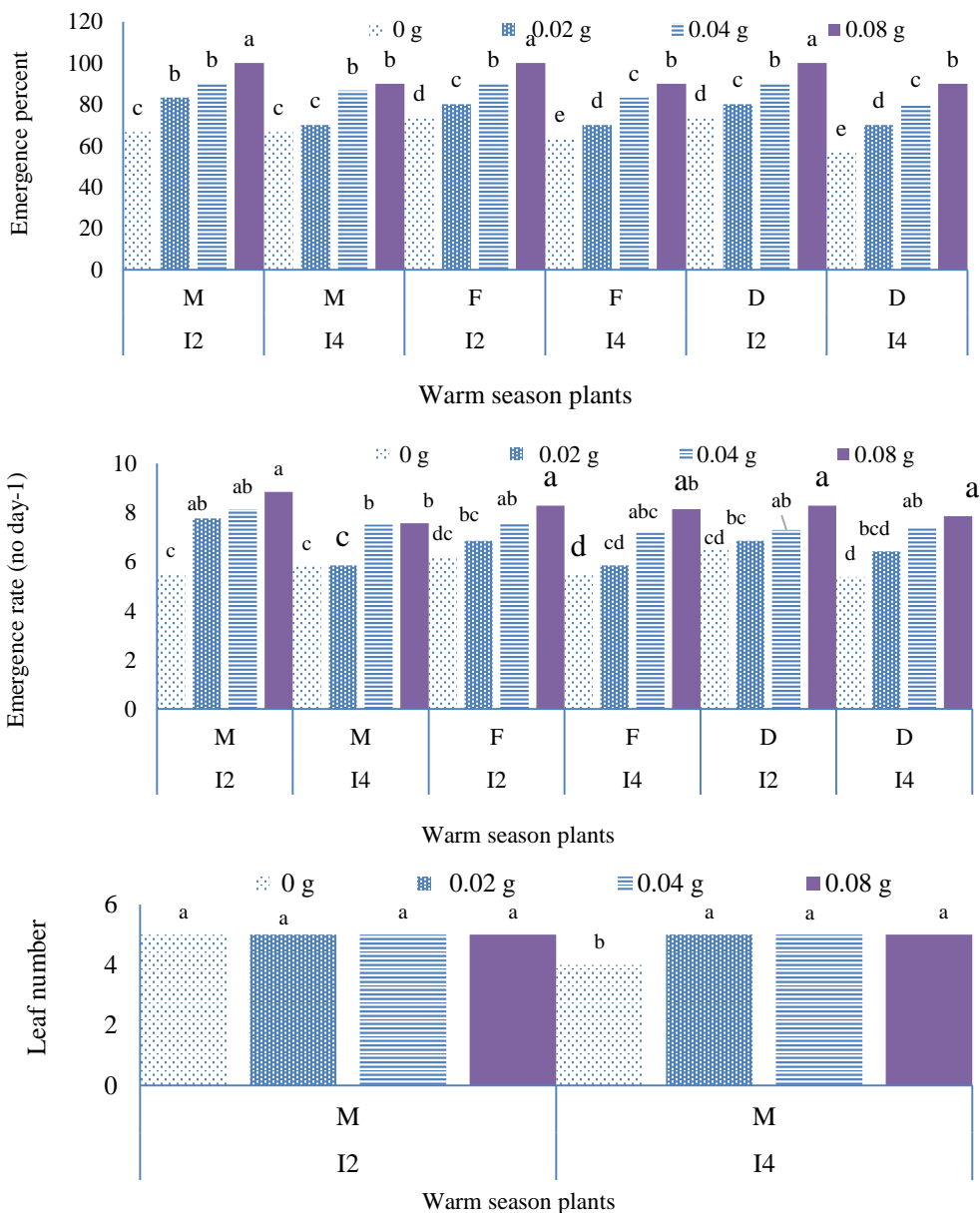


Fig. 2. Effect of water-superabsorbent and drought on warm season plants emergence percentage, emergence rate and leaf number. Means followed by the same letter within each plant are not significantly different at $P < 0.05$ as determined by Duncan's Multiple Range Test. M, F and D are foxtail millet, fenungreek and dill, respectively. I2 and I4 are irrigation interval of 2 and 4-day, respectively

Leaf number: Analysis of variance showed that effect of water-superabsorbent and drought on leaf number of fungreek and dill was not significant, but interaction effect of

water-superabsorbent and drought on leaf number of foxtail millet was significant (Table 1). Mean comparison showed that drought reduced leaf number in foxtail millet, but water-superabsorbent application could neutralize effect of drought on leaf number (Figure 2).

DISCUSSION

By increasing irrigation interval and decreasing water-superabsorbent, plant height trend was decreasing. Plant height reduction can be attributed to cell growth reduction and leaf senescence under drought. Nazarli *et al.* (2011) and Sheikhmoradi *et al.* (2012) reported that increasing irrigation interval reduced plant height and application of water-superabsorbent had significant effect on plant height. These results are in agreement with our results. Seedling fresh and dry weight had increasing trend by increasing water-superabsorbent application and reducing irrigation interval. This is probably due to that superabsorbent application retains soil moisture so fresh and dry weight increased. Water and nutrients store in water-superabsorbent channels, so nutrients leaching reduces. Additionally, water-superabsorbent acts as water storage in soil and retains soil moisture during drought. Soil wetting around root also increased after irrigation. In the experiment, it was observed that superabsorbent application reduced negative effect of drought. Findings of Li *et al.* (2013), Kaydan and Yagmur (2008), Afsharmanesh, 2009, El-Hady *et al.* (2002) and Johnson and Woodhouse (1990) showed that drought reduced plant fresh and dry weight, but water-superabsorbent application increased seedling length, plant fresh and dry weight and conserved soil and water. Overall, water-superabsorbent application could increase plant dry matter under drought. Seed germination and seedling establishment are of the critical stages in plant life cycle. Seed germination initiates by water uptake and terminates by embryo elongation and radicle emergence (Bewley, 1997). Drought is one of the factors affecting seed germination (Mos *et al.*, 2007). Seed germination greatly reduces by moisture limitation (Khan, 1980; Kochaki *et al.*, 1991). Seedling emergence percentage and rate trend was increasing by increasing water-superabsorbent application and reducing irrigation interval. Probably, it is due to that water-superabsorbent retains soil moisture. Dexters and Miyamoto (1995) reported that water-superabsorbent polymer application increased germination, emergence and plant growth in sugarbeet.

CONCLUSION

It is concluded that water-superabsorbent increased seedling weight and seedling emergence percentage and rate. Drought reduced dry matter production and seedling emergence percentage, but water-superabsorbent reduced negative effect of drought. Regarding results, for high seedling establishment of foxtail millet, fennel and dill, especially under drought, water-superabsorbent application of 0.08 g per kg of soil is useful. It is suggested to test severer drought than that of the experiment for the next experiments.

REFERENCES

1. Abfairan (2010). Comprehensive portal of water industry and structure of water and sewage of Iran. News part. < Accessed 1 February 2010>. <http://www.abfairan.ir>
2. Afsharmanesh, G. (2009). Study of some morphological traits and selection of drought resistant alfalfa cultivars (*Medicago sativa* L.) in Jiroft, Iran. *Plant Ecophysiology*. 3: 109-118.
3. Bewley, J.D. (1997). Seed germination and dormancy. *Journal of Plant biology*. 9: 1055-1066.

4. Dexters, S.T. and T. Miyamoto. (1995). Acceleration of water uptake and germination of Sugarbeet seedballs by surface coatings of hydrophilic colloids. *Agronomy Journal*. 51: 388-389.
5. El-hadi O.A., and S.A. Abo-sedera. (2006). Conditioning effect of composts and acrylamide hydrogels on a sandy calcareous soil. *Physico-bio-chemical properties of the soil. International Journal of Agriculture and Biology*. 8(6): 876-884.
6. El-hadi, O.A., and Sh.A. Wanas. (2006). Water and fertilizer use efficiency by cucumber grown under stress on sandy soil treated with scrylamide hydrogels. *Journal of Applied Sciences Research*. 2(12): 1293-1297.
7. El-Hady, O. A., M.A. Safia, and A.A. Abdel- Kader. (2002). Sand-Compost-Hydrogel mix for low cost production of tomato seedlings. *Egyptian journal of soil science*. 42(4): 767-782.
8. Ellis, R.A., and E.H. Roberts. (1981). The quantification of ageing and survival in orthodox seeds. *Journal of Seed Science and Technology*. 9: 373-409.
9. Johnson, M. S., and J. Woodhouse. (1990). Effect of superabsorbent polymers on efficiency of water use by crop seeding. *Science of Food and Agriculture Journal*. 52: 431-434.
10. Kaydan, D., and M. Yagmur. (2008). Germination, seedling growth and relative water content of shoot in different seed sizes of triticale under osmotic stress of water and NaCl. *African Journal of Biotechnology*. 7 (16): 2862-2868.
11. Khan, A.A. (1980). *The physiology and biochemistry of dormancy and germination*. North Holland. Publishing Company, Oxford. 447 p.
12. Kochaki, A., H. Rashed Mohasel, M.Nasiri, and R. Sadrabadi. (1991). *Physiological basis for crop growth and development*. Astan Qods Razavi Press. 404 p.
13. Li, X., J.Z. He, Y.R. Liu, and Y.M. Zheng. (2013). Effects of super absorbent polymers on soil microbial properties and Chinese cabbage (*Brassica chinensis*) growth. *Journal of Soils and Sediments*. 13: 711-719.
14. Mos, M., A. Binek, A. Zielinski, and T. Wojtowicz. (2007). Effect of osmotic stress on vigor in naked and husked oat cultivars subjected to accelerated ageing. *American-Eurasian Journal of Agricultural and Environmental Sciences*. 5: 465-469.
15. Nazarli, H., F.Faraji, and M.R. Zardashti. (2011). Effect of drought stress and polymer on osmotic adjusment and pigment of sunflower. *Journal of Agronomical Research in Moldavia*. 145 (1): 35-41.
16. Rafiee, Z. (2010). Comparing effect of hydrogel and compost on establishment and growth properties of Haloxilon aphyllum. M.Sc. Thesis. College of Natural Resources, University of Tehran, Iran, 110 p.
17. Sheikmoradi, F., I. Argi, V. Abdodi, and A. Esmaeili. (2012). Evaluation the effects of superabsorbent on qualitative characteristics of lawn. *Journal of Ornamental and Horticultural Plants*. 2 (1): 55-60.
18. Sheikmoradi F., E. Arji, A. Esnaeili, and V. Abdosi (2011). Investigating effect of irrigation interval and superabsorbent polymer on some quality traits in sport turf. *Journal of Horticultural Science*. 25(2): 170-177.