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-superabsornbent 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 annul rainfall (Abfairan, 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 sturucture, 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 yiled 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 *Haloxilon 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 eas 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 aven (75°C and 72 h) to mmeasure seedling dry weight. Seedling emergence percentage was computed according to Ellis and Roberts (1981) equation:

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

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

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

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-superabsornbent 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 (Fig. 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
Foxtail millet	D	1	1161.9**	714.9**	15.1**	0.37**	266.6**	4.63**
	S	3	3333.1**	577.2**	16. 9**	0.37**	944.4**	7.82**
	D × S	3	21.6**	1.9**	0.5ns	0.37**	55.5ns	1.32*
	Error	16	1.7	0.3	0. 7	0.00	29.1	0.45
Fungreek	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**
	D × S	3	392.2**	0.5ns	0.82**	0.00 ns	4.1ns	0.20ns
	Error	16	2.8	0.5	0.01	0.00	12.5	0.54
Dill	D	1	240.6**	78.2**	2.69**	0.00 ns	816.6**	0.19ns
	S	3	981.8**	324.2**	8.53**	0.00 ns	1000.0**	5.45**
	D × S	3	2.0ns	2.3ns	0.02ns	0.00 ns	16.6ns	0.21ns
	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

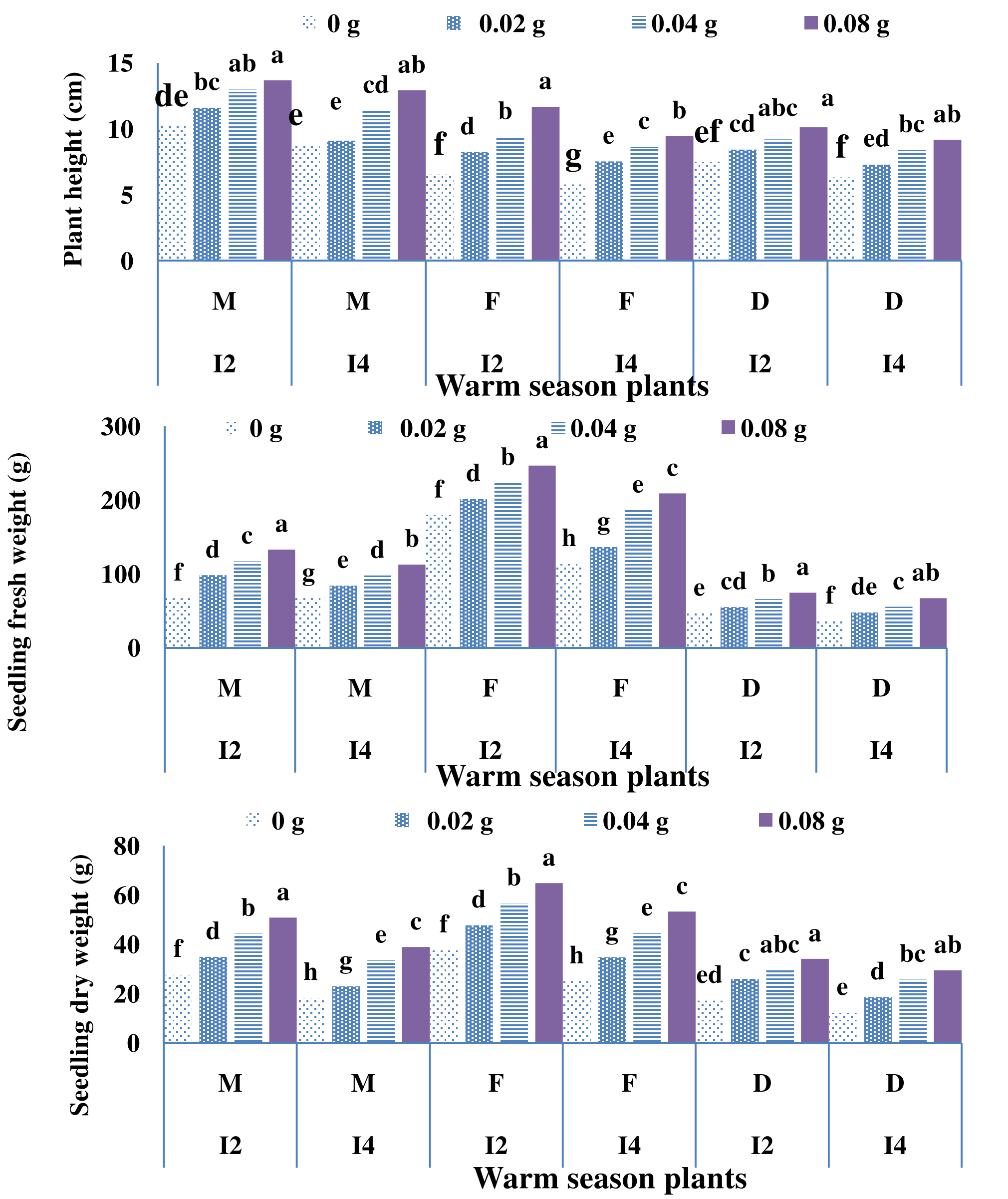

Fig. 1. Effect of water-superabsorbent and drought on plant height, seedling fresh weight and seedling dry weight. Means followed by the same letter within each plant are not significantly different at $P < 0.05$ as determined by Duncan's Multiple Range Test. M, F and D are foxtail millet, fenungreek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

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-superabsornbent 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 (Fig. 1).

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-superabsornbent 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 (Fig. 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 (Fig. 2).

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 (Fig. 2).

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 comparision showed that drought reduced leaf number in foxtail millet, but water-superabsorbent application could neutralize effect of drought on leaf number (Fig. 2).

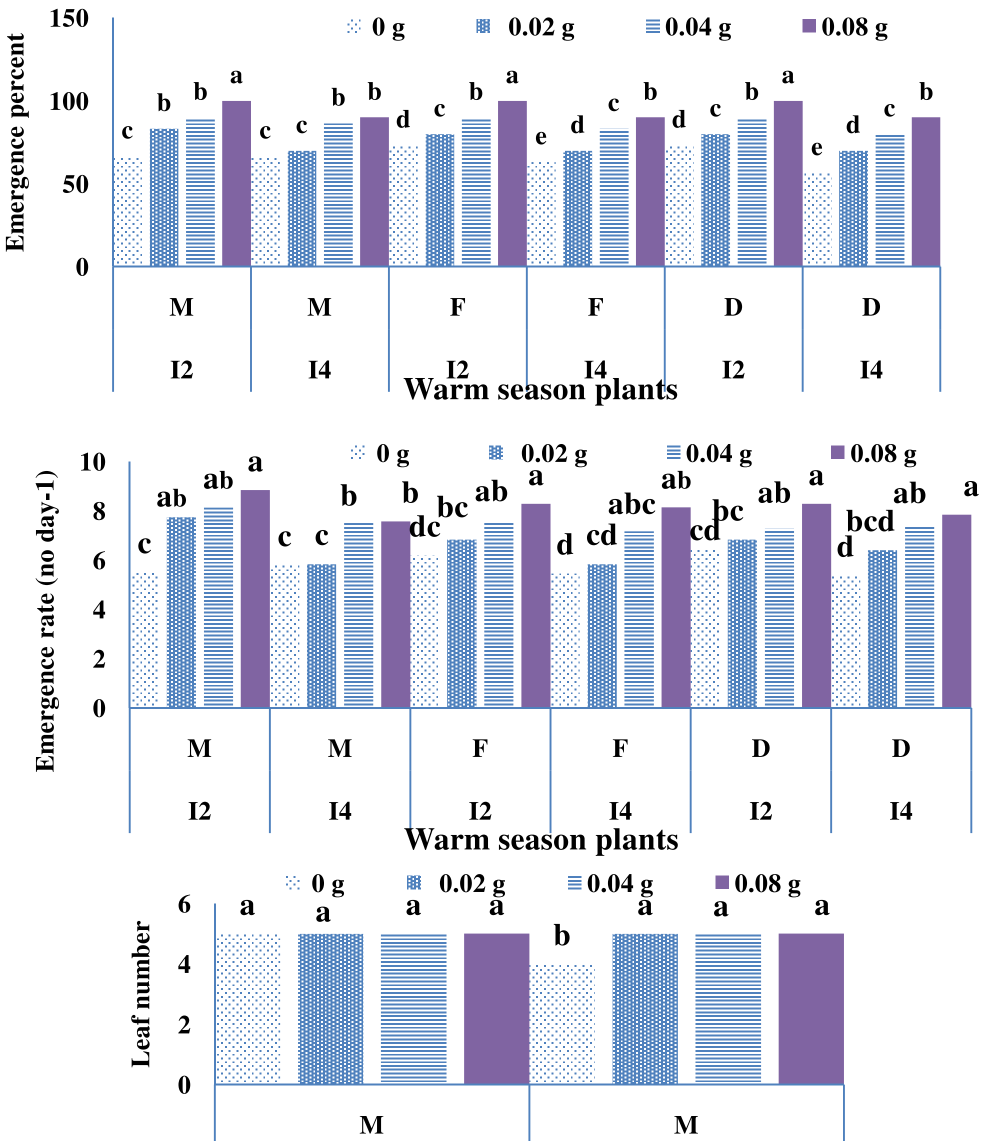

Fig. 2. Effect of water-superabsorbent and drought on warm season plants emergence percentage, emergence rate and leaf number. Means followed by the same letter within each plant are not significantly different at $P < 0.05$ as determined by Duncan's Multiple Range Test. M, F and D are foxtail millet,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

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 wtersuperabsorbent had significant effect on plant height. These results are in agreement with our results. Seedling fresh and dry weight had increasing trend by increasing wate-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 irrigaton. 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 icreased seedling length, plant fresh and dry weight and conserved soil and water. Overall, water-superabsorbent application could increase plant dry matter under drough. 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 (Bewely, 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 establishmen of foxtail millet, fungreek and dill, especially under drought, water-superabsorbent application of 0.08 g per kg of soil is usefull. It is suggested to test severe drought than that of the experiment for the next experiments.

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