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Yield and yield component quality of red bean (*Phaseolus vulgaris L.*) cultivars in response to water stress and super absorbent polymer application

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ABSTRACT

The effects of super absorbent polymer on plant under drought stress were studied in three bean cultivars (Derakhshan , D81083, Naz) at the two levels of irrigation and two different amounts of super absorbent (0 & 7%). field experiment was conducted in 2005 and the experimental design was randomized complete block in a split plot arrangement with three replications. In field experiments fallowing characters were studied seed yield, Harvest index, seed 100 weight, Relative water content and leaf cell membrane stability. Result experiments showed that, stress decreases yield and its components, but using 7% super absorbent in field situation increases agricultural characters.

Key words : Drought stress, Super absorbent, Red bean, Yield

INTRODUCTION

Drought stress is one of the several environmental factors greatly limiting crop production and plant distribution world wide [16,17].water is very important for growth and development of plants. [12]. Application and mixture of super absorbent polymer can reserve different amounts of water in itself and so increases the soil ability of water storing and preserving, and at last in water deficiency, produce plant water need and approve its growth. They increase the ability of soil to preserve the water and with decreasing drought stress approve growth of plant[11]. Polyacrylate polymer could be used to improve the quality of a copper-contaminated soil. Growth of annual medic (*Medicago polymorpha L.*) was stimulated in the polymer-amended soil, such that total biomass produced was three times that of plants from unamended soil. Roots of plants cultivated in the polymer-amended soil had a concentration of copper that was 73% of that in plants from the unlamented soil[14].

MATERIALS AND METHODS

The experiments were carried out at experimental farm of Islamic Azad University in Karaj-Iran during 2005 growing season. The region has a semi-arid climate. The site is located at 35º 48′ N latitude, 51º 59′ E longitudes and an altitude of 1313 meter above the sea level. The soil experimental site was sand loam with low in nitrogen (0.06%), low in organic matter (0.83-0.72) and alkaline in reaction with a PH of 7.8.The experimental design was a RCBD arranged in split plot with three replications. Each replication was divided into three main plots, which differed in severity of imposed water shortage. Bean Cultivars included V_1 , V_2 , V_3, that were arranged in sub plots. Before planting, the soil surface was ploughed during autumn and then disked twice in the spring (at the beginning of April and middle of May). Then 7% concentration of super absorbent for each plot was noticed. After calculation super absorbents were poured in necessary amount on each pail separately and sufficient water was applied. then 30 minutes was left till super absorbents absorb water completely and then were poured on the whole plot monotonously and accurately. After settling each plot was covered with soil. Irrigation was initiated on 16^{th} Sep

2005 exactly after culturing with acquaint method. For inducing stress electrical soil moisture meter system and plaster blocks were used. In this way before starting the experiment a plot with a 2*3 area was made beside the farm and plaster blocks was settled in it in 40 cm depth and were irrigated. Then with daily electrical humidity measuring and the percent of humidity calibration carve was made. According to this curve when the electrical humidity measurement reaches zero, the soil weight humidity was 8%. Plaster block although was used in the main experiment, and according to electrical humidity rate and amount of soil humidity percent and using the calibration curve water stress was performed. That was when the electrical humidity measurement system reaches 60, the herb dejection appearance was revealed and the soil humidity in this stage was 12%. Triple super phosphate fertilizer was applied before sowing at a rate of 150 kg ha^{-1}. The nitrogen fertilizer (15 kg ha^{-1}) in the form of urea was applied before planting (one third of the application). The rest of nitrogen fertilizer, distributed before starting the first stress treatment. Plots were 5-m long and consisted of 4 rows, 0.6 m apart. Between all main plots, a 3-m wide strip was left bare to eliminate all influences of lateral water movement. Soil surface of cultivated area was thoroughly irrigated 6 days before planting. The bean seeds were inoculated with Rhizobium japonicum before planting and were hand-planted on 24^{th} May 2005 at the rate of 20 seeds per m^2 of row and then were thinned to achieve a density of approximately 333,333 ha^{-1}. During the whole growth season, weeds and insects were effectively controlled. Agronomic traits (grain yield and it component) and some physiological (relative water content, leaf cell membrane leakage) was determined in farm conditions.

RESULTS

Field Experiments

Analysis of variance for Seed yield indicated significant differences ($P < 0.01$) among irrigation regimes, varities and super absorbent polymer concentration (table-1). Seed yield highly decreased in drought stress conditions. (Seed yield in drought stress condition decreased by 53% compared with control condition). Derakhshan produced by 48% less seed yield (795 kg ha^{-1}) compared with Naz. (table-1). Results also indicated that Derakhshan and Naz had highest and lowest 1000 seeds weight, respectively (table-1). Means comparison of interactions of cultivar × superabsorbent polymer indicated that application of the polymer can increase seed weight in all of cultivars. In this study, application of the polymer (7%) increased seed weight by 19% compared with control (table-1). Means comparison also showed that harvest index in drought stress condition decreased by about 14% compared with normal condition. Cultivars also had significant differences ($P < 0.01$) (table-1). Investigation of means comparison indicated that Naz and Derakhshan had highest and lowest harvest index, respectively (table-1). Results showed superabsorbent polymer increased harvest index from 40.42% to 42.92% in the non-application and application condition, respectively (table-1). Analysis of variance for interaction effects of cultivar × irrigation treatments showed significant difference ($P < 0.01$) for HI.

Drought stress also increased membrane leakage but superabsorbent polymers decreased damage of membrane.(table-1). Relative water content decreased under drought stress but superabsorbent polymers increased RWC (table-1).

Table 1: Investigated agronomical parameters in different varieties of drought treatments (control and stress) under superabsorbent polymer (field). W1, W2 irrigation, v1,v2,v3: variaties (Derakhshan, D8183 and Naz), S1, S2: superabsorbent polymer (0 , 7%)

Treatments	Grain Yield ($kg.he^{-1}$)	Harvest Index (%)	Seed 1000 Weight (gr)	Relative WaterContent (%)	Electerical Conductivity ($\mu s\ cm^{-1}$)
W1	1553a	44.70a	37.66a	56.43a	948.8b
W2	725b	38.65b	21.07b	49.45b	1059.3a
V1	795c	38.66c	35.08a	46.72c	1057a
V2	1084b	41.71b	30.83b	52.75b	1010b
V3	1538a	44.65a	22.20c	59.36a	944c
S1	955b	40.42b	26.55b	50.76b	1085a
S2	1323a	42.92a	32.19a	55.13a	923b

Means within each column of each category followed by the different letters are significantly different (P < 0.05) according to Duncan test.

Means investigations also indicated that superabsorbent polymer (7%) had significant effect on seed yield. There was significant differences ($P < 0.01$) for interaction effects of cultivar × superabsorbent polymer and There was significant differences ($P < 0.01$) for interaction effects of irrigation × superabsorbent polymer too.(table-2). Means comparison of these interaction effects indicated that Naz had highest seed yield both in stress and control condition. Interaction effects of irrigation × superabsorbent polymer showed that application of super absorbent polymer has increased seed yield in both condition (control and stress). These results also showed that superabsorbent polymer increased seed yield in all cultivars but had better effects on cultivar of Naz (table-2). Means comparison of superabsorbent polymer treatments showed that application of this polymer (7%) increased 1000 seeds weight from 26.55 g to 32.19 g (without or with polymer application). In drought stress conditions, seed weight decreased in all of cultivars (table-2).

Table 2. Mean comparison of interaction effects on measured variable under farm condition
W1, W2 irrigation, V1, V2, V3: varieties (Derakhshan, D8183 and Naz), S1, S2: superabsorbent polymer (0 , 7%)

Treatments		Grain Yield ($t\ ha^{-1}$)	Seed1000 Weight (gr)	Harvest index (%)
W1	V1	1120.25c	46.37 a	42.08 c
	V2	1537.9 b	40.42 b	44.86 b
	V3	2002.31a	26.20 c	47.16 a
W2	V1	471.17 e	23.78 d	35.23 e
	V2	630.31 d	21.23 e	38.57 d
	V3	1074.95c	18.21 f	42.13 c
W1	S1	1323.61 b	38.89 a	43.50 a
	S2	1783.35 a	40.44 a	45.90 a
W2	S1	587.61 d	18.20 a	37.34 a
	S2	863.34 c	23.95 a	39.95 a
V1	S1	1323.61 b	31.76 c	37.36 a
	S2	1783.35 a	38.40 a	39.96 a
V2	S1	587.61 d	27.71 d	40.46 a
	S2	863.34 c	33.95 b	42.97 a
V3	S1	649.60 d	20.17 f	43.45 a
	S2	941.82 c	24.23 e	45.85 a

Means within each column of each category followed by the different letters are significantly different ($P < 0.05$) according to Duncan test.

Table 3. Mean comparison of interaction effects on measured variable under farm condition. W1, W2 irrigation, v1,v2,v3: variaties (Derakhshan, D8183 and Naz), S1, S2: superabsorbent polymer (0 , 7%)

Treatments			Grain yield ($t\ ha^{-1}$)	Seed1000 Weight(gr)	Harvest index (%)
W1	v1	S1	931d	43a	40d
		S2	1309c	49a	43c
W1	v2	S1	1331c	37b	43c
		S2	1744b	43a	46b
W1	v3	S1	12.73 a	7.26 a	37.28 ab
		S2	13.07 a	8.25 a	41.00 a
W2	v1	S1	33h	20e	367g
		S2	36g	27c	574f
W2	v2	S1	37f	18f	504f
		S2	39e	24d	756e
W2	v3	S1	40d	16g	890d
		S2	43c	20e	1259c

Means within each column of each category followed by the different letters are significantly different ($P < 0.05$) according to Duncan test.

DISCUSSION

Under water deficit conditions , seed yield, harvest index (HI), seed 1000 weight and Relative Content (RWC) decreased but electrical conductivity (EC) increased that shows leaf cell membrane damage.

The decrease in seed yield under water deficit conditions is largely due to the reduction in the number of pods per plant [10]. However, when soil moisture reaches the lower values of available soil water, the number of seeds per pod and the weight of individual seeds may play an important role in diminishing the harvest index and final yield [8]. Reductions in yield of bean cultivars were also reported to take place under drought stress [9]. In present study, cultivar of V3 showed the highest seed and yield as well as smaller reduction in this parameters during the drought stress period with compared to the other cultivars. The result of decrease in yield and yield components during stress is compatible with [13] result. They concluded that due to stress and water deficiency certainly the transmission of photosynthetic substances to air organs decrease and in the end yield components reduce.

This study showed that Superabsorbent polymer increased yield and yield components, and Results showed superabsorbent polymer increased harvest index from 40.42% to 42.92% in the non-application and application condition, respectively and polymer indicated that application of the polymer can increase seed weight in all of cultivars. In this study, application of the polymer (7%) increased seed weight by 19% compared with control. This is important in dry region because it can help roots to absorb water easily and it can absorb and holds water and fertilizers. When polymer added to soil, plant grow directly into the water- swollen particles, tapping the water and nutrients as needed. Therefore, super absorbent polymer increases available water for use of plant resulted in increase seed yield and yield components [3]. also reported that application of superabsorbent polymer increased seed weight. Relative water content (RWC) decreased under drought stress but superabsorbent polymers increased RWC. Drought also increased membrane leakage but superabsorbent polymers decreased damage of membrane. The result of decrease in Rwc, during stress is compatible with [7] result. The result of increase in Electrical Conductivity (Ec) during stress is compatible with [15] result. Lettuce also showed the greatest response to polymer addition in terms of dry weight yield. Our study showed that Polymer 7% seemed to have the best range of binding tensions, and good water availability for all species was found with this polymer. Water deficit stress is one of the most common adverse environmental stresses, and plants can respond and adapt to the stress by altering their cellular metabolism and invoking various defense mechanisms under the stress conditions[1]. in tolerance to water deficit stress in higher plants has been supported by research on banana plantlets, maize and pea[4,5,2].

Results showed using superabsorbent polymers can increase interval between irrigations and it can decrease drought stress effect on plants.

CONCLUSION

In conclusion this study has shown that cultivar of V3 (NAZ) is more suitable than other cultivars for sowing and application of super absorbent polymer can increase the survial capacity of red bean under conditions of drought stress. This study showed that Superabsorbent polymer increased yield and yield components.

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