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Original article

Improvement of soybean physiological traits and yield under the end season drought stress conditions through the foliar spray of nutrient elements and polyamine

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Extended abstract

Introduction

Soybean is one of the most important products in Iran, due to the production of high-quality oil and protein-rich meal. Soybean is highly sensitive to water deficit stress at the flowering and grain filling stages, so the end-season drought stress can have negative effects on soybean yield and yield components. Therefore, increasing soybean tolerance to drought stress is very important. Due to the importance of the soybean plant and the existence of drought stress in Iran, Improving the agronomic characteristics and yield of this crop under drought stress as well as favorable conditions through agronomic treatments is essential. Considering the positive effects of nutrients availability on the plant's physiological traits and yield, this study aimed to investigate the effect of foliar application of nutrient elements and polyamine on agronomic and physiological characteristics of soybeans under the end-season drought stress.

Materials and method

To investigate the effect of fertilizer on physiological and yield characteristics of soybean (Glycine max) under the end-season drought stress, a split-plot experiment was conducted in a randomized complete block design (RCBD) with three replications at the Agricultural and Natural Resource Research Center of Ardabil in 2019. The treatments were irrigation (normal irrigation and omitting irrigation at the flowering stage) as main plots and foliar applications (control, nutrient elements containing polyamine, nutrient elements without polyamine) as sub-plots. Foliar application of nutrient elements without polyamine and nutrient fertilizer containing polyamine were applied one month after planting (at the vegetative stage). Drought stress was applied through irrigation stopping at the flowering stage (50% flowering). One week after drought stress, chlorophyll index, relative water content (RWC), and electrical conductivity (EC) were measured. Furthermore, the plant height, number of branches, pod per plant, grain per pod, 100-grain weight, biological and grain yield per unit area, harvest index, and oil percentages and oil yields were measured at the physiological maturity stage.

Results and discussion

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The results showed that drought stress decreased the chlorophyll index, leaf relative water content (RWC), and grain and oil yield of soybean seeds, and significantly increased the electrolyte leakage. Furthermore, plant height, the number of branches, pods per plant, grain per pod, biological yield, and 100-grain weight were significantly decreased under drought stress treatment compared to the normal condition. Under drought stress, foliar application of nutrient elements without polyamine caused an increase of about 43.05 percent in the number of branches, 45.11 percent in the number of pods per plant, 38.84 percent in biological yield, and 40.09 percent in grain yield, as compared to the control. Under normal irrigation conditions, foliar application of nutrient elements containing polyamine significantly increased the number of branches (23.6 percent), the number of pods per plant (11.45 percent), grain yield (24.88 percent), and biological yield (20.20 percent), as compared to the control. It seems that nutrient elements without polyamine improved the soybean yield and yield components through the provision of suitable nutritional conditions during the seed formation and filling period. Furthermore, under normal irrigation conditions, the application of polyamine with the nutrient fertilizer improved the growth characteristics and yield of soybeans compared to the nutrient fertilizer without polyamine, which indicates the synergistic effects of polyamine and nutrient element.

Conclusions

The results showed that drought stress during the flowering stage significantly reduced the chlorophyll index and relative water content (RWC) of the leaves and increased electrolyte leakage in soybean plants and finally reduced yield and yield components of soybean. Under drought stress, foliar application of nutrient elements without polyamine significantly increased the chlorophyll index, RWC, and reduced EC of the soybean leaves, which resulted in the improved agronomic and physiological characteristics and yield of soybean plants under end-season drought stress conditions. Therefore, foliar application of nutrient elements with or without polyamine under favorable and unfavorable environmental conditions had a positive and significant effect on the physiological traits and yield of soybean, through providing better nutritional conditions for soybean plants.

***Keywords*:** Chlorophyll index, Grain yield, Oilseed plant, Spraying, Water deficit

Table 1. Soil physical and chemical properties of experimental field

Soil texture	Sand	Silt	Clay	N	P	K	pH	EC
	----------%----------			----------mg kg^{-1}----------				dS m^{-1}
Clay loam	36	27	37	0.12	9.5	416.7	8.12	1.91

Table 2. Analysis of variance the effects of irrigation and foliar spray of nutrient elements treatments on chlorophyll index, RWC and EC of soybean leaves

S.O.V.	df	Mean of Squares		
		Chlorophyll index	RWC	EC
Block	2	0.57 ^{ns}	3.22 ^{ns}	3.97 ^{ns}
Irrigation (I)	1	203.01**	118.02*	827.95**
Error a	2	0.24	0.71	7.99
Spraying (S)	2	19.6**	123.72**	157.14 **
I× S	2	11.04**	12.77**	72.32 **
Error b	8	0.36	1.65	4.91
CV (%)		1.35	1.79	6.21

*, ** and ns: significant at a probability level of 5% and 1% and non-significant, respectively

Table 3. Mean comparison of chlorophyll index, RWC and EC of soybean leaves affected by irrigation and foliar spray treatments

Irrigation	Foliar application	Chlorophyll index	RWC	EC
			%	$\mu S\ cm^{-1}g^{-1}$
Normal irrigation	Control	45.47 c	70.52 b	31.23 b
	Nutrient elements containing polyamine	47.15 b	75.17 a	26.18 a
	Nutrient elements without polyamine	50.42 a	76.54 a	27.41 a
Drought stress	Control	39.05 f	62.08 c	52.03 d
	Nutrient elements containing polyamine	42.98 d	72.18 b	39.13 c
	Nutrient elements without polyamine	40.85 e	72.61 b	36.35 c

In each column, means which followed by the same letter(s) are not significantly different ($p \leq 0.05$)

Table 4. Analysis of variance the effects of irrigation and foliar spray treatments on agronomic traits of soybean

		Mean of Squares				
S.O.V	df	Plant height	Number of branch	Pad per plant	Grain per plant	100 grain weight
Block	2	11.85 ns	0.011 ns	5.55 ns	68.77 ns	0.1 ns
Irrigation (I)	1	837.62 *	6.12*	433.16**	3023.83**	422.18**
Error a	2	27.55	0.082	4.77	16.734	0.12
Spraying (S)	2	465.03 **	0.95 **	261.88 **	219.75**	4.64**
I× S	2	7.36 ns	0.33 **	89.8 **	5.82 ns	0.84**
Error b	8	9.55	0.02	7.85	10.78	0.05
CV (%)		*3.19*	*4.66*	*4.89*	*4.06*	*1.39*

Table 4. Continuation

		Mean of Squares			
S.O.V.	df	Biological yield	Grain yield	Oil percentages	Oil yield
Block	2	23440 ns	8526.4 ns	0.08 ns	821.22 ns
Irrigation(I)	1	16435555**	2070612.5 **	46.75 **	248798.81**
Error a	2	31894.4	1654.2	0.308	650
Spraying(S)	2	4900684.2 **	977526.4 *	2.94 **	54282.46 **
I× S	2	314033.6 ns	46404.2 ns	0.41 ns	1533.51 ns
Error b	8	33701	6023.6	0.17	412.06
CV (%)		*2.59*	*2.74*	*1.94*	*3.29*

*, ** and ns: significant at a probability level of 5% and 1% and non-significant, respectively

Table 5. Mean comparison of agronomic traits of soybean affected by irrigation and foliar spray of nutrient elements treatments

Treatments	Plant height	Grains per plant	Oil percentage	Oil yield
	cm		%	$kg\ ha^{-1}$
Normal irrigation	103.83 a	93.9 a	23.14 a	734.37 a
Drought stress	89.9 b	67.98 b	19.91 b	499.23 b
Control	87.08 c	74.33 b	20.99 b	507 b
Nutrient elements containing polyamine	99.37 b	82.27 a	21.26 b	672.6 a
Nutrient elements without polyamine	104.2 a	86.22 a	22.32 a	670.9 a

In each column, means which followed by the same letter(s) are not significantly different ($p \leq 0.05$)

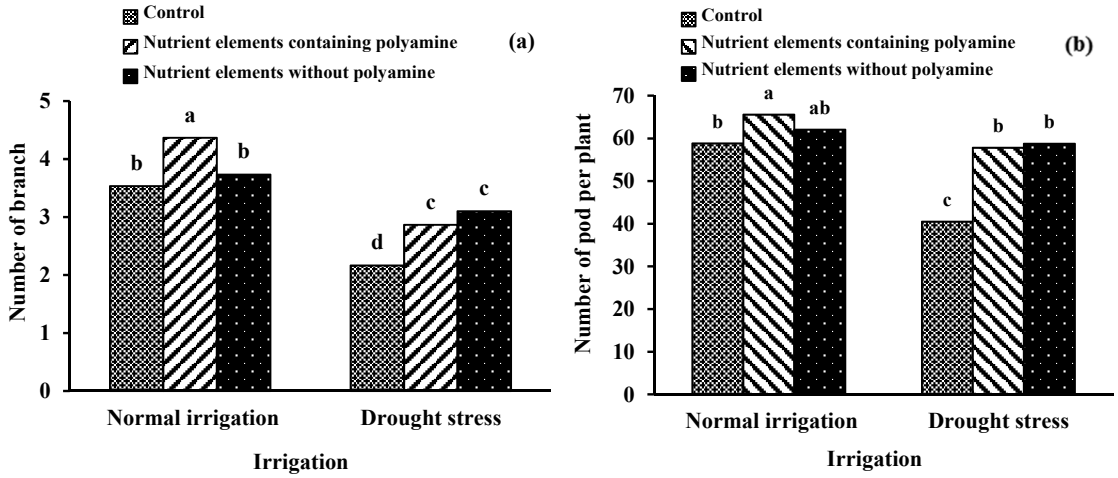

Fig. 1. The effects of foliar spray of nutrient elements treatments on Number of branches (a) and number of pods per plant (b) of soybean.

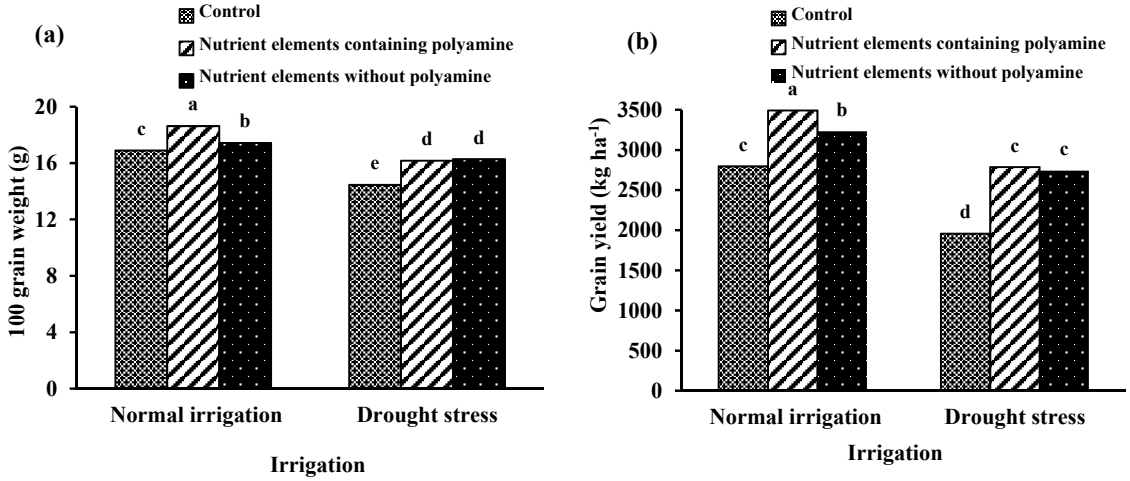

Fig. 2. The effects of foliar spray and irrigation treatments on 100 grain weight (a) and grain yield (b) of soybean

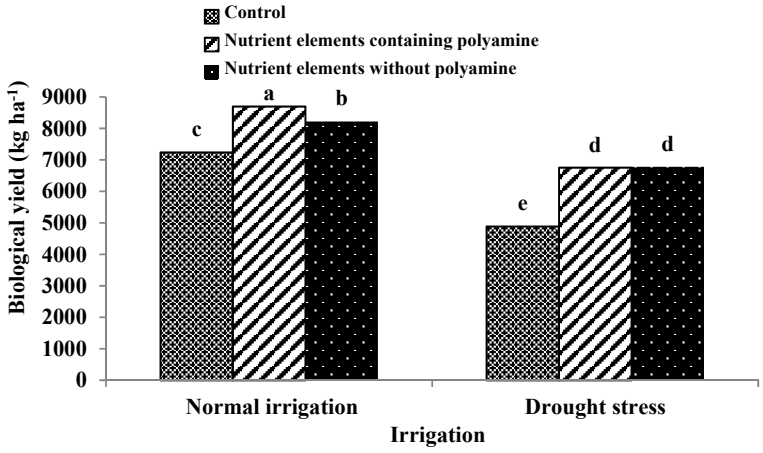

Fig. 3. The effects of foliar spray and irrigation treatments on biological yield of soybean