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Original article

Evaluation of the effects of glycine betaine and gibberellic acid application on physiological characteristics, yield and yield components of cowpea under drought stress conditions conditions

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Extended abstract

Introduction

Drought is one of the most important factors limiting growth and production in crops and therefore use of management methods to reduce the effects of drought is very important. Water deficit stress is one of the most important factors limiting the growth and survival of plants in arid and semi-arid regions of the world. Water is a major component of the fresh produce and significantly effects on weight and quality of plants. Also, water deficit may cause significant changes in the component yield and yield in plants. Iran with an average annual rainfall of 240 mm is included among arid and semi-arid regions of the world. Of the million hectares of cultivated region, only five millions are under irrigation because of intense water limitations. However, Iran is one of the world's cowpea producers. Cowpea has been cultivated for many years in different parts of Iran. Therefore, high production and development of cowpea is important in coriander. This research was conducted to evaluate the effects of foliar application of glycine betaine (GB) and gibberellic acid (GA) on physiological characteristics, yield and yield components under drought stress conditions in cowpea.

Materials and methods

To evaluate the effects of foliar application of glycine betaine (GB) and gibberellic acid (GA) on physiological characteristics, yield and yield components under drought stress conditions, a factorial split plot experiment based on randomized complete block design with three replications was conducted during the 2018 crop year. Experimental factors included irrigation regimes (50, 70 and 90 mm evaporation from Class A evaporation pan) in main plots and glycine betaine (no foliar application, 50 and 100 mM) and gibberellic acid (no foliar application, 60 and 120 ppm) were in factorial form in sub plots. Data were collected on relative water content, ion leakage, chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, pod number per plant, seed number per pod, hundred seed weight, seed yield and biological yield.

Results and discussion

The results of ANOVA indicated that the effects of irrigation regime, glycine betaine and gibberellic acid were significant for relative water content, ion leakage, chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, pod number per plant, seed number per pod, hundred seed weight, seed yield and biological yield. The results of comparison of means showed that by increasing drought stress the traits of relative water content, chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, pod number per plant, seed

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number per pod, hundred seed weight, seed yield and biological yield decreased but the ion leakage significantly increased. Nonetheless, exogenous application of glycine betaine and gibberellic acid increased relative water content, chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, pod number per plant, seed number per pod, hundred seed weight, seed yield and biological yield but the ion leakage significantly decreased. It seems that glycine betaine and gibberellic acid improved the growth indices of cowpea by reducing the adverse effects of drought stress. Therefore, exogenous application of glycine betaine and gibberellic acid can be used as a useful method for improving drought tolerance in cowpea.

Conclusion

Generally, the results indicated that glycine betaine and gibberellic acid improved the growth indices of cowpea by reducing the adverse effects of drought stress. Therefore, exogenous application of glycine betaine and gibberellic acid can be used as a useful method for improving drought tolerance in cowpea. Also, the results showed that concentrations of 100 mM glycine betaine and 120 ppm gibberellic acid were more effective than other levels and induces more water stress tolerance in cowpea

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***Keywords*:** Evaporation pan, Foliar application, Growth indices, Irrigation regimes, Ion leakage

Table 1. Some physical and chemical properties of field's soil

Soil type	pH	EC	Organic C	N	P	K	Cu	Zn	Mn	Fe
		dS m^{-1}	%	----------mg kg^{-1}----------			----------ppm----------			
Loam	7.7	1. 79	1.1	5.1	6.0	452	1.0	68.7	33.16	66.3

Table 2. Some weather parameters of the experimental site during growing season in 2018

	Month			
Weather parameter	**July**	**August**	**September**	**October**
Minimum Temperature (°C)	15.2	12.8	11.1	7.4
Maximum Temperature (°C)	42.1	40.0	37.4	31.3
Precipitation (mm)	0.0	0.0	0.0	4.0

Table 3. Abbreviations used in text for measured traits and the units for these traits in cowpea

Full	Abbreviation	Unit
Relative water content	RWC	%
Ion leakage	IL	%
Chlorophyll a	Chl. a	mg g^{-1}
Chlorophyll b	Chl. b	mg g^{-1}
Total chlorophyll	TChl	mg g^{-1}
Carotenoids	Car.	mg g^{-1}
Pod number per plant	PNPP	No.
Seed number per pod	SNPP	No.
Hundred seed weight	HSW	g
Seed yield	SY	kg ha^{-1}
Biological yield	BY	kg ha^{-1}

Table 4. Analysis of variance of the effects of gibberellic acid and glycine betaine on studied traits of cowpea under drought stress condition.

Source of variation	df	RWC	EC	Chl. a	Chl. b	Total Chl.	Car.
Replication (R)	2	1.37^{ns}	5.71^{ns}	0.00003^{ns}	0.000001^{ns}	0.0000012^{ns}	0.000011^{ns}
Irrigation (I)	2	175.79^{**}	642.28^{**}	0.97074^{**}	0.247472^{**}	2.0684333^{**}	115.614959^{**}
Error (a)	4	7.50	3.68	0.00645	0.000107	0.0057278	0.025020
Glycine Betaine (GB)	2	162.96^{**}	43.54^{**}	0.06747^{**}	0.028112^{**}	0.1825148^{**}	11.127737^{**}
Gibberellic Acid (GA)	2	69.81^{**}	26.09^{**}	0.01581^{**}	0.006727^{**}	0.0424333^{**}	3.307878^{**}
GB × GA	4	1.56^{ns}	0.23^{ns}	0.00096^{ns}	0.000129^{ns}	0.0012593^{ns}	0.237004^{**}
I × GB	4	1.27^{ns}	0.81^{ns}	0.00251^{**}	0.000240^{*}	0.0038926^{**}	0.027396^{ns}
I × GA	4	3.02^{ns}	0.08^{ns}	0.00078^{ns}	0.000138^{ns}	0.0010167^{ns}	0.015437^{ns}
I × GB × GA	8	3.02^{ns}	0.52^{ns}	0.00023^{ns}	0.000135^{ns}	0.0001370^{ns}	0.040149^{ns}
Error	48	4.49	3.78	0.00077	0.000079	0.0008991	0.047584
C.V (%)		*2.49*	*2.12*	*5.21*	*3.45*	*3.80*	*5.38*

Table 4. Continued

Source of variation	df	PNPP	SNPP	HSW	SY	BY
Replication (R)	2	0.32^{ns}	4.9×10^{-6ns}	0.23^{ns}	201000^{*}	2937499^{ns}
Irrigation (I)	2	637.58^{**}	29.405^{**}	230.67^{**}	4837668^{**}	84445199^{**}
Error (a)	4	4.13	2.509	5.78	49156	2536407
Glycine Betaine (GB)	2	32.97^{**}	8.321^{**}	15.74^{**}	702611^{**}	7261018^{**}
Gibberellic Acid (GA)	2	16.99^{**}	2.441^{**}	12.49^{**}	107745^{*}	2910703^{**}
GB × GA	4	1.68^{ns}	0.174^{ns}	2.87^{ns}	11177^{ns}	49061^{ns}
I × GB	4	3.99^{ns}	0.097^{ns}	0.91^{ns}	92128^{*}	173617^{ns}
I × GA	4	6.72^{**}	1.551^{**}	2.46^{ns}	47885^{ns}	436674^{ns}
I × GB × GA	8	1.66^{ns}	0.200^{ns}	0.48^{ns}	21628^{ns}	75122^{ns}
Error	48	1.91^{ns}	0.301	1.17	33361	373710
C.V (%)		*7.27*	*6.08*	*6.33*	*13.31*	*11.11*

^{ns}, * and ** non-significant and significant at the 0.05 and 0.01 probability level, respectively

Table 5. Mean comparison of the effects of irrigation regimes, the concentrations of glycine betaine and gibberellic acid on traits in cowpea

Treatment	RWC	EC	Chla	Chlb	TChl	Car	PNPP	SNPP	HSW	SY	BY
Irrigation regimes											
50 (mm)	87.66^{a}	86.95^{c}	-	-	-	5.68^{a}	-	-	20.12^{a}	-	7435^{a}
70 (mm)	84.83^{b}	92.17^{b}	-	-	-	4.76^{b}	-	-	16.90^{b}	-	5106^{b}
90 (mm)	82.57^{c}	96.70^{a}	-	-	-	1.73^{c}	-	-	14.28^{c}	-	3965^{b}
Glycine betaine											
0 (mM)	82.54^{c}	93.12^{a}	-	-	-	-	17.87^{c}	8.58^{b}	16.41^{b}	-	4978^{c}
50 (mM)	85.07^{b}	92.10^{a}	-	-	-	-	18.99^{b}	8.86^{b}	16.97^{b}	-	5513^{b}
100 (mM)	87.45^{a}	90.60^{b}	-	-	-	-	20.08^{a}	9.65^{a}	17.92^{a}	-	6015^{a}
Gibberellic acid											
0 (ppm)	83.32^{c}	92.93a	0.51^{b}	0.24^{c}	0.76^{c}	-	-	-	16.32^{b}	1321^{b}	5141^{b}
60 (ppm)	85.21^{b}	91.92^{ab}	0.53^{b}	0.26^{b}	0.78^{b}	-	-	-	17.46^{a}	1355^{ab}	5582^{a}
120 (ppm)	86.52^{a}	90.97^{b}	0.56^{a}	0.27^{a}	0.83^{a}	-	-	-	17.53^{a}	1443^{a}	5783^{a}

In each column, the values with same letters is not significantly different.

Table 6. Mean comparison of double interaction effects of glycine betaine and gibberellic acid on carotenoid content in cowpea

Glycine betaine	Gibberellic acid	CAR
mM	ppm	
	0	3.23^{b}
0	**60**	3.32^{b}
	120	3.66^{ab}
	0	3.77^{ab}
50	**60**	4.06^{ab}
	120	4.39^{ab}
	0	4.18^{ab}
100	**60**	4.67^{ab}
	120	5.22^{a}

In each column, the values with same letters is not significantly different.

Table 7. Mean comparison of double interaction effects of irrigation regime and glycine betaine on studied traits in cowpea.

Irrigation regime (mm)	Glycine betaine (mM)	Chla	Chlb	TChl	SY
	0	0.69^{c}	0.31^{c}	1.01^{c}	1697^{bc}
50	**50**	0.74^{b}	0.34^{b}	1.08^{b}	1768^{ab}
	100	0.81^{a}	0.38^{a}	1.19^{a}	1938^{a}
70	**0**	0.40^{f}	0.23^{e}	0.63^{f}	1066^{e}
	50	0.47^{e}	0.28^{d}	0.75^{e}	1525^{cd}
	100	0.51^{d}	0.31^{c}	0.82^{d}	1498^{d}
	0	0.35^{g}	0.12^{h}	0.48^{h}	807^{f}
90	**50**	0.40^{f}	0.16^{g}	0.56^{g}	1010^{e}
	100	0.42^{f}	0.18^{f}	0.60^{gf}	1047^{e}

In each column, the values with same letters is not significantly different.

Table 8. Mean comparison of double interaction effects of irrigation regime and gibberellic acid on studied traits in cowpea.

Irrigation regime (mm)	Gibberellic acid (ppm)	PNPP	SNPP
	0	22.48^{b}	9.63^{b}
50	**60**	24.69^{a}	10.31^{ab}
	120	25.93^{a}	10.62^{a}
	0	17.42^{c}	8.70^{c}
70	**60**	17.91^{c}	8.59^{cd}
	120	17.64^{c}	8.88^{c}
	0	14.33^{d}	7.71^{e}
90	**60**	15.32^{d}	8.82^{c}
	120	15.11^{d}	7.96^{de}

In each column, the values with same letters is not significantly different.

Table 9. Group comparisons of the foliar application of glycine betaine (GB) and gibberellic acid (GA) in cowpea under irrigation different regimes.

Irrigation regimes	Group comparisons	SY
50 mm	**GB vs GA**	0.05^{ns} (-2)
	The combination of GB and GA vs GB and GA separately	7.61^{**} (+14)
70 mm	**GB vs GA**	3.86^{ns} (+10)
	The combination of GB and GA vs GB and GA separately	11.19^{**} (+12)
90 mm	**GB vs GA**	2.45^{ns} (+10)
	The combination of GB and GA vs GB and GA separately	10.17^{**} (+15)

^{ns} and ** non-significant and significant at the 0.01 probability level, respectively. GB: glycine betaine, GA: gibberellic acid

Numbers in parentheses indicate the percentage increase (+) or decrease (-) of first group compare to second group.