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Original article

The effect of cytokinin foliar on morpho-physiological traits, yield and yield components of black cumin (*Nigella sativa* L.) under salinity stress conditions

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Extended abstract

Introduction

Salinity as one of the most important abiotic stress that reduce the growth, development and yield of crops and the use of plant growth regulator is one of the beneficial methods to reduce unfavorable effects of salinity stress. Black cumin (*Nigella sativa* L.) is an annual plant from the buttercup family that used widely in traditional and industrial pharmacology and seeds or their extracts contain anti-diabetic, antihistaminic, antihypertensive, anti-inflammatory, anti-microbial, antitumour, galactagogue and insect repellent effects.

Materials and methods

In order to investigate the effects of foliar application of cytokinin on morpho-physiological traits, yield and yield components of black cumin (*Nigella sativa* L.) a factorial experiment was conducted based on randomized complete block design with four replications at the greenhouse condition. The experimental factors included salinity at five levels of 0, 3, 6, 9 and 12 dS m^{-1} and foliar application of cytokinin at three concentrations of 0, 100 and 200 µM. This experiment was performed inside 5 kg plastic pots with a height 21 and openings diameter 23 cm under greenhouse conditions. The substrate composition consisted of a 2:1:1 ratio of arable soil, rotted and sifted manure and aerated sand. The average day and night temperatures of the greenhouse were 27±2 and 18±2°C with relative humidity between 65 and 80%, respectively. Four plants were kept inside each pot and the rest were thinned. Foliar application of cytokinin was performed one stage at the beginning of flowering and the second stage one week after the first foliar application. Physiological traits such as electrolyte leakage, relative water content, chlorophyll pigments and proline were measured one week after the second spraying. Plant height, number of number secondary branch and yield components traits were measured after complete plant maturity.

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Results and discussion

The results of analysis of variance showed that salinity treatment has significant effect on all traits. Salinity stress increases electrolyte leakage and proline, though it has a declining effect on other traits. Was not significant reduction in traits up to 3 dS m^{-1} of salinity. The highest grain yield with 2.42 g pl^{-1} was obtained in the control treatment and the lowest grain yield with 0.81 g pl^{-1} at a concentration of 12 dS m^{-1} of salinity. Cytokinin treatment has significant effect on all traits except chlorophyll a, proline and number of capsule in plant. Foliar application of cytokinin reduced unfordable of salinity stress in black cumin, and 100 µM concentration of cytokinin has high efficiency than 200 µM. The highest percentage of electrolyte leakage, proline and carotenoid content was observed at a salinity level of 12 dS m^{-1}. The lowest of plant height, relative water content, chlorophyll pigments, number seed in capsule, number secondary branch, number capsule in plant, weight of thousand seeds and biological yield observed in 12 dS m^{-1} of salinity level. The lowest grain yield (1.51 g pl^{-1}) was observed in the control treatment and the highest grain yield (1.83 g pl^{-1}) was observed in the concentration of 200 µM of cytokinin. Foliar Cytokinin was effective on all studied morpho-physiological traits under salinity stress. Under salinity stress, cytokinin application only affected the number of grains in capsule and had no significant effect on yield and other yield components traits.

Conclusion

The results obtained in this study showed that the black cumin can tolerate salinity up to 3 dS m^{-1} without any significant reduction in its yield. 1000-grain weight, number of grains per capsule and proline content were the least sensitive to different salinity levels. Biomass yield was also the most sensitive, so that it showed a significant decrease in all salinity levels. The concentration of 100 µM cytokinin was better than 200 µM. The results showed that foliar application of cytokinin under salinity stress may be improve some traits, however, this does not constitute a definite increase in yield and yield components under salinity stress conditions and may not result in a change in grain yield.

***Keywords*:** Benzylaminopurine, Chlorophyll pigment, Hormone, Proline, Relative water content

Table 1. Analysis of variance of the effect of salinity and cytokinin hormone on morpho-physiological traits of black cumin

S.O.V	d.f	Length of plant	Number secondary branch	RWC	EL
Repeat	3	20.48 ^{ns}	2.01 ^{ns}	17.62 ^{ns}	9.90 ^{ns}
Salinity (S)	4	503.91**	159.04**	1386.23**	1990.21**
Cytokinin (C)	2	262.41**	110.71**	583.71**	247.79**
S × C	8	16.76**	2.34 ^{ns}	38.19*	175.64**
Error	42	5.14	2.95	16.72	8.17
C.V%	--	*6.85*	*13.31*	*5.93*	*6.48*

Table 1. Continued

S.O.V	d.f	Chlorophyll a	Chlorophyll b	Total Chlorophyll (a+b)	Carotenoid	Proline
Repeat	3	0.004 ^{ns}	0.01 ^{ns}	0.005 ^{ns}	0.005 ^{ns}	1.91 ^{ns}
Salinity (S)	4	0.222**	0.11**	0.64**	0.07*	73.39**
Cytokinin (C)	2	0.012 ns	0.12 **	0.15 **	0.02 **	1.68 ^{ns}
S × C	8	0.016*	0.01 ^{ns}	0.03 ^{ns}	0.01**	7.78**
Error	42	0.27	0.68	0.67	0.18	1.24
C.V%	--	*11.91*	*22.36*	*10.15*	*19.07*	*16.09*

*,**, and ^{ns} represent significant at of 5% and 1% probability level and not significant, respectively.

Table 2. Mean comparisons of the interaction effect of investigate traits in black cumin under salinity stress and cytokinin application

Salinity	Hormone	Length of plant	RWC	EL	Chlorophyll a	Carotenoid	Proline	Number seed in capsule
ds m^{-1}	µM	cm	----------%	----------	--------mg g^{-1} FW----------		µg g^{-1} FW	
	0	35.42±2.6 ^{de}	76±4 ^{ab}	28.75±2.2 ^{g}	0.84±0.06 ^{ab}	0.03 ^{fg}±0.24	4.52±0.4 $^{d-f}$	75.5±4.1 ^{a}
0	**100**	42.05±3.8 ^{ab}	81.75±3.6 ^{a}	32.40±3.1 ^{fg}	0.72±0.06 ^{bc}	0.04 ^{g}±0.21	5.92±0.5 ^{de}	71±5.3 ^{a}
	200	43.77±3.6 ^{a}	81.50±2 ^{a}	33.50±1.8 ^{f}	0.86±0.07 ^{a}	0.07 $^{d-g}$±0.27	4.51±1.2 ^{ef}	74.25±2.8 ^{a}
	0	32.95±1.6 ^{ef}	73±2.9 ^{bc}	35.71±2.3 ^{ef}	0.78±0.05 $^{a-c}$	0.04 $^{d-g}$±0.26	5.13±0.7 ^{ef}	72.25±3.8 ^{a}
3	**100**	42.20±3.7 ^{ab}	76±3.9 ^{ab}	36.05±2 ^{ef}	0.79±0.08 $^{a-c}$	0.08 $^{c-g}$±0.31	5.95±0.1 ^{de}	71.75±2.9 ^{a}
	200	37.52±2.5 ^{cd}	80.25±5.5 ^{a}	35±1.2 ^{ef}	0.78±0.11 $^{a-c}$	0.02 $^{e-g}$±0.25	3.94±0.8 ^{f}	71.75±2.9 ^{a}
	0	39.60±1.5 ^{bc}	68.50±3.4 ^{cd}	36.46±2.2 ^{ef}	0.66±0.05 ^{cd}	0.09 ^{b}±0.44	4.67±0.9 ^{ef}	69.75±6.5 ^{a}
6	**100**	39.65±2.7 ^{bc}	72.25±1.7 ^{bc}	36.95±1.4 ^{ef}	0.74±0.12 $^{a-c}$	0.05 $^{b-f}$±0.34	4.25±1.1 ^{ef}	72.50±3.8 ^{a}
	200	32.92±1.4 ^{ef}	77±3.1 ^{ab}	38.90±1.8 ^{e}	0.72±0.11 ^{bc}	0.06 $^{b-e}$±0.35	7.17±1 ^{cd}	71.75±4.7 ^{a}
	0	24.01±0.8 ^{g}	54.50±4.5 ^{fg}	70.69±2.1 ^{a}	0.50±0.07 ^{e}	0.04 ^{bc}±0.39	11.65±2.2 ^{a}	42.75±2 ^{ef}
9	**100**	32.05±1.6 ^{ef}	58.50±3.2 ^{ef}	54.32±3.1 ^{c}	0.68±0.08 ^{cd}	0.09 ^{bc}±0.39	8.84±1.6 ^{bc}	58.25±3.5 ^{b}
	200	30±3.3 ^{f}	71.50±1.7 ^{bc}	46.67±1.8 ^{d}	0.52±0.09 ^{e}	0.10 ^{bc}±0.40	7.80±1.1 ^{c}	53.25±2.2 ^{bc}
	0	23.05±1.4 ^{g}	47.75±2.7 ^{h}	67±2.9 ^{a}	0.44±0.04 ^{e}	0.08 ^{a}±0.59	9.79±1 ^{b}	38.75±2 ^{f}
12	**100**	25.82±1.7 ^{g}	51.50±1.7 ^{gh}	60.07±4.2 ^{b}	0.56±0.06 ^{de}	0.04 $^{c-f}$±0.32	10.08±1 ^{ab}	46.5±2.6 ^{de}
	200	24.72±1.51 ^{g}	63±4.39 ^{de}	49.37±5.28^{d}	0.49±0.01 ^{e}	0.03 $^{b-d}$±0.36	9.56±1.2 ^{b}	49±1.4 ^{cd}

In each column, there is no significant difference between treatments with common letters according to Duncan test.

Table 3. Analysis of variance of the effect of salinity and cytokinin on yield and yield component of black cumin

S.O.V	d.f	Number capsule in plant	Number seed in capsule	Weight of thousand Seeds	Biological yield	Grain yield
Repeat	3	0.66 ^{ns}	2.28 ^{ns}	0.05 ^{ns}	0.48 ^{ns}	0.03 ^{ns}
Salinity (S)	4	65.10**	2198.80**	0.26**	75.99**	5.95**
Cytokinin (C)	2	3.95 ^{ns}	121.95**	0.11*	35.44**	0.53**
S × C	8	1.09 ^{ns}	66.40**	0.02 ^{ns}	0.72 ^{ns}	0.04 ^{ns}
Error	42	1.96	14.72	0.04	0.79	0.08
C.V%	--	*10.61*	*6.12*	*11.32*	*10.95*	*17.53*

*, **, and ^{ns} represent significant at of 5% and 1% probability level and not significant, respectively

Table 4. Mean comparisons of the investigate traits of black cumin under salinity stress and cytokinin application.

Treatment	Chlorophyll b	Total Chlorophyll	Number secondary branch	Number capsule in plant	Weight of thousand Seeds	Biological yield	Grain yield
	------mg g^{-1} FW--------				g	---------- g pl^{-1} --------	
Salinity (ds m^{-1})							
0	0.70 ^{a}	1.51 ^{a}	17.16 ^{a}	15.58 ^{a}	2.10 ^{a}	11 ^{a}	2.42 ^{a}
3	0.63 ^{ab}	1.42 ^{a}	15 ^{b}	15.50 ^{a}	2.04 ^{a}	9.79 ^{b}	2.29 ^{a}
6	0.55 ^{bc}	1.26 ^{b}	14.08 ^{b}	12.66 ^{b}	2.01 ^{a}	8.84 ^{c}	1.80 ^{b}
9	0.48 ^{c}	1.05 ^{c}	9.91 ^{c}	12.08 ^{b}	1.81 ^{b}	6.09 ^{d}	1.13 ^{c}
12	0.47 ^{c}	0.97 ^{c}	8.41 ^{d}	10.16 ^{c}	1.76 ^{b}	5.02 ^{e}	0.81 ^{d}
Cytokinin (µM)							
0	0.51 ^{b}	1.16 ^{b}	10.20 ^{b}	12.70 ^{a}	1.87 ^{b}	6.61 ^{b}	1.51 ^{b}
100	0.53 ^{b}	1.23 ^{b}	14.25 ^{a}	13.35 ^{a}	1.93 ^{ab}	8.85 ^{a}	1.72 ^{a}
200	0.65 ^{a}	1.33 ^{a}	14.30 ^{a}	13.55 ^{a}	2.02 ^{a}	8.98 ^{a}	1.83 ^{a}

In each column, there is no significant difference between treatments with common letters according to Duncan test.