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Original article

Evaluation the effects of zinc and iron elements in nano form on grain yield and growth traits of pinto bean under water deficit stress

M. Fatollahpour Grangah[1], V. Rashidi[2*], B. Mirshekari[2], E. Khalilvand Behrozyar[2], F. Farahvash[2]

1. PhD student, Department of Agronomy and Plant Breeding, Faculty of Agriculture, Islamic Azad University Tabriz Branch, Tabriz, Iran

2. Faculty members, Department of Agronomy and Plant Breeding, Faculty of Agriculture, Islamic Azad University Tabriz Branch, Tabriz, Iran

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Abstract

In order to evaluate the effects of irrigation levels and foliar application with Zinc and Iron elements in nano form on grain yield and growth traits of pinto bean, an experiment was designed as a split factorial design based on randomized complete blocks with three replications in the experimental station of Faculty of Agriculture, Islamic Azad University of Tabriz, Iran during 2016-2017 and 2017-2018 growing seasons. Irrigation conditions (normal irrigation and water deficit stress in 50% flowering) were arranged in the main plots and experimental factors (nano-fertilizers and cultivar s) in the sub-plots. Factors experiment were included foliar application of nano-fertilizers in four levels [without foliar application (control), foliar application of nano Zn (1.5 g l^{-1}), foliar application of nano Fe (2 g l^{-1}) and foliar application of nano Fe+Zn (2+1.5 g l^{-1}] and four cultivars of pinto bean (Sadri, Coosha, Cos 16 and Ghaffar). The results showed that water deficit decreased grain yield, 100-seed weight, number seeds per pod and number pod per plant traits of pinto bean but, the application of Zinc and Iron elements in nano form could moderate the effects of water deficit stress. The highest of 100-Seed weight was observed in Saddri cultivar which had no significant difference with Ghaffar cultivar. Coosha and Cos 16 cultivars were after Sadri and Ghaffar cultivars. In both normal and water deficit conditions, the highest number of seeds per pod, grain yield and number of pods per plant were observed in Cos 16 cultivar. Also, the study of mean comparisons interaction showed that the application of Zinc and Iron elements in nano form had the great effect on number of seeds per pod, grain yield and number of pods per plant in all cultivar s in water deficit stress condition. Therefore, it was conducted that the foliar application of Zinc and Iron fertilizers can be useful in pinto bean cultivars under water deficit stress condition.

Keywords*:* Grain yield, Foliar application, Micro element, Pinto bean, Water deficit stress,

[*]Correspondent author: Varahram Rashidi; E-Mail: rash270@yahoo.com

Table1. Physical and chemical characteristics of the soil in studied farm

Total Neutralizing Value	Mn_{ava}	Cu_{ava}	K_{ava}	Organic Carbon	Fe_{ava}	Zn_{ava}	P_{ava}	ازت کل N total	Sand	Silt	Clay
%	---------- ppm ----------			%	---------- ppm ----------			---------- % ----------			
2.0	6.8	0.8	360	1.05	3.6	1.1	8.7	0.11	58	24	18

Table 2. Analysis of variance for some traits of pinto bean under water deficit stress and application of nano Zn-Fe fertilizers

		Mean Squares			
S.O.V	df	Grain yield	100-Seed weight	Number of seeds per pod	Number of pod per plant
Year	1	186.04^{**}	0.88^{ns}	854.29^{ns}	222.09^{ns}
Block (Year)	4	7.67	47.46	196.79	43.97
Irrigation condition (Irr)	1	5032.75^{**}	1121.34^{*}	17006.51^{ns}	1362.66^{ns}
Year× Block (Year)	1	0.046^{ns}	4.08^{ns}	656.38^{ns}	86.01^{*}
Irr × Block (Year)	4	3.61	5.52	261.05	8.82
Cultivar (C)	3	466.82^{*}	565.93^{ns}	22209.36^{**}	2748.15^{**}
Foliar application (F)	3	1220.41^{**}	221.32^{**}	6686.69^{**}	604.33^{*}
C × F	9	16.08^{ns}	20.91^{ns}	534.31^{**}	58.72^{**}
Year × C	3	46.42^{*}	114.07^{**}	197.13^{ns}	48.78^{ns}
Year ×	3	24.39^{ns}	3.91^{ns}	30.13^{ns}	28.82^{ns}
Irr × C	3	2.68^{ns}	25.18^{ns}	1144.22^{ns}	133.44^{ns}
Irr × F	3	80.32^{ns}	7.61^{ns}	72.33^{ns}	13.67^{ns}
Year × Irr × C	3	5.72^{ns}	19.12^{ns}	220.52^{ns}	62.47^{ns}
Year × Irr × F	3	17.47^{**}	15.85^{ns}	9.18^{ns}	8.37^{ns}
Irr × C × F	9	16.08^{**}	11.83^{ns}	298.83^{**}	14.63^{**}
Year × C × F	9	7.52^{*}	7.46^{ns}	62.63^{ns}	17.84^{**}
Year × Irr × C × F	9	5.85^{*}	11.34^{ns}	68.43^{ns}	10.21^{ns}
Error	120	3.04	14.28	99.82	5.58
CV (%)		*7.89*	*9.62*	*14.42*	*12.42*

ns, * and **: non-significant difference, significant difference at the level of five and one percent probability, respectively.

Table 3. Mean comparisons of application of Zinc and Iron elements in nano form and water deficit stress on 100-Seed weight of pinto bean cultivars

Treatment	Level	Mean
Irrigation condition	Water deficit stress	36.84^{b}
	Normal Irrigation	41.68^{a}
Foliar application	Foliar application of nano Zn+Fe	41.53^{a}
	Foliar application of nano Fe	39.97^{b}
	Foliar application of nano Zn	39.14^{b}
	Without foliar application	36.41^{c}

.Non-similar alphabets in each treatment are significantly different at 1% probability level

Table 4. Mean comparisons cultivar and year interaction on100-Seed weight

	Cultivars			
	Sadri	Koosha	Cos 16	Ghafar
First year	41.79^{a}	39.58^{a}	33.33^{b}	42.08^{a}
Second year	43.04^{a}	35.91^{b}	36.95^{b}	41.41^{a}

Non-similar alphabets are significantly different at 1% probability level

Table 5. Mean comparisons of application of Zinc and Iron elements in nano form, cultivar and water deficit stress interaction on grain yield in two years

Irrigation condition	Foliar application	Year	Sadri	KooSha	Cos16	Ghafar
Normal Irrigation	Without foliar application	First year	11.33^{xyz}	22^{klm}	24^{j}	18^{qr}
		Second year	12^{wxy}	21^{mno}	20^{op}	22^{klm}
	Foliar application of nano Zn	First year	27.33^{fg}	25.33^{hi}	27.67^{f}	25.67^{hi}
		Second year	22.67^{kl}	26.33^{gh}	29^{e}	27^{fg}
	Foliar application of nano Fe	First year	25^{ij}	29.67^{e}	32.23^{d}	28^{f}
		Second year	29.33^{e}	29.67^{e}	37.33^{ab}	32.67^{d}
	Foliar application of nano Zn+Fe	First year	27^{fg}	34.33^{c}	37.67^{ab}	25^{ij}
		Second year	29.67^{e}	37.67^{ab}	38.33^{a}	36.67^{b}
Water deficit stress	Without foliar application	First year	8^{z}	13^{uvw}	15^{t}	10.67^{z}
		Second year	10^{z}	15^{t}	12.33^{vwx}	14^{tu}
	Foliar application of nano Zn	First year	11^{yz}	16^{s}	18^{qr}	14.67^{t}
		Second year	12.33^{vwz}	18^{qr}	19^{pq}	19^{pq}
	Foliar application of nano Fe	First year	13.33^{uv}	18^{qr}	21.67^{lmn}	25^{t}
		Second year	14.67^{t}	22.67^{kl}	22.67^{kl}	21^{mno}
	Foliar application of nano Zn+Fe	First year	17^{rs}	20.67^{no}	24.67^{ij}	19.33^{p}
		Second year	16.33^{s}	23^{k}	25.67^{hi}	22.33^{kl}

Non-similar alphabets in each column are significantly different at 1% probability level

Table 6. Mean comparisons of water deficit stress, application of Zinc and Iron elements in nano form and cultivar interaction in average two year on number of seed per pod

Irrigation condition	Foliar application	Sadri	Koosha	Cos16	Ghafar
Normal irrigation	Without foliar application	35.83^{jkl}	68.33^{fgh}	75^{defg}	74.17^{defg}
	Foliar application of nano Zn	44.5^{ijkl}	76.83^{def}	94^{bc}	80.33^{bcdef}
	Foliar application of nano Fe	45.33^{ijk}	86.33^{bcde}	128.33^{a}	80^{bcdef}
	Foliar application of nano Zn+Fe	53^{hij}	96.5^{b}	131.17^{a}	88.33^{bcd}
Water deficit stress	Without foliar application	28.17^{i}	45^{ijkl}	58.33^{ghi}	50.67^{ijk}
	Foliar application of nano Zn	34^{kl}	51.5^{ij}	76.33^{def}	70.5^{efg}
	Foliar application of nano Fe	38.83^{jkl}	67.5^{fgh}	78.5^{cdef}	72.33^{defg}
	Foliar application of nano Zn+Fe	44^{ijkl}	68.17^{fgh}	96.83^{b}	76.67^{def}

Non-similar alphabets are significantly different at 1% probability level

Table 7. Mean comparisons water deficit stress and year interaction on number of pods per plant

	Irrigation condition	Number of pods per plant
First year	Normal irrigation	19.95^{a}
	Water deficit stress	15.96^{b}
Second year	Normal irrigation	23.44^{a}
	Water deficit stress	16.77^{b}

Non-similar alphabets in each column are significantly different at 1% probability level

Table 8. Mean comparisons of application of Zinc and Iron elements in nanoform, cultivar and year on pods per plant

		Foliar application			
	Cultivars	**Without foliar application**	**Foliar application of nano Zn**	**Foliar application of nano Fe**	**Foliar application of nano Zn+Fe**
First year	**Sadri**	7.58^{r}	10^{pq}	10.58^{op}	12.83^{mn}
	Koosha	11.66^{no}	13.33^{m}	17.16^{ijk}	16.83^{ijk}
	Cos16	22.66^{h}	25^{efg}	25.16^{efg}	25.33^{efg}
	Ghafar	15.16^{kl}	21.33^{efg}	25.83^{ef}	28.83^{d}
Second year	**Sadri**	8.75^{qr}	9.66^{pq}	10.66^{jkl}	16.37^{jkl}
	Koosha	13.16^{m}	15^{l}	16.16^{jkl}	17.5^{ij}
	Cos16	21^{h}	26.5^{e}	30.66^{c}	37.33^{a}
	Ghafar	18.33^{i}	24.16^{gh}	27^{d}	33.16^{b}

Non-similar alphabets are significantly different at 1% probability level

Table 9. Mean comparisons of application of year, cultivar and water deficit stress on pods per plant

		Cultivars			
	Irrigation condition	**Sadri**	**Koosha**	**Cos16**	**Ghafar**
First year	**Normal irrigation**	11.12^{gh}	16.75^{e}	27^{b}	24.91^{c}
	Water deficit stress	9.33^{h}	12.75^{fg}	23.66^{cd}	18.08^{e}
Second year	**Normal irrigation**	11.41^{gh}	17.25^{e}	33.08^{a}	32^{a}
	Water deficit stress	9.41^{h}	13.66^{f}	22.33^{d}	21.66^{d}

Non-similar alphabets are significantly different at 1% probability level

Table 10. Mean comparisons of water deficit stress, application of Zinc and Iron elements in nano form and cultivar interaction in average two year on number of pod per plant

Irrigation condition	**Foliar application**	**Sadri**	**Koosha**	**Cos16**	**Ghafar**
Normal irrigation	**Without foliar application**	8.75^{gh}	14.5^{fgh}	19.17^{defg}	24.17^{bcdef}
	Foliar application of nano Zn	11.17^{gh}	16.33^{efgh}	27.5^{bcd}	28.17^{abcd}
	Foliar application of nano Fe	11.5^{gh}	17.83^{defg}	33.67^{ab}	30.5^{abc}
	Foliar application of nano Zn+Fe	13.67^{fgh}	19.33^{defg}	37.83^{a}	33^{abc}
Water deficit stress	**Without foliar application**	6.63^{h}	10.33^{gh}	14.5^{fgh}	19.33^{defg}
	Foliar application of nano Zn	8.5^{gh}	12^{gh}	18^{defg}	23.33^{cdef}
	Foliar application of nano Fe	9.67^{gh}	15.5^{efgh}	19.17^{defg}	23.33^{cdef}
	Foliar application of nano Zn+Fe	12.5^{gh}	15^{fgh}	27.83^{bcd}	26^{bcde}

Non-similar alphabets are significantly different at 1% probability level