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Original article

Effect of nitrogen and phosphorus fertilizers on yield and nutrient efficiency indices in maize under drought Stress

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Extended abstract

Introduction

Reduced use efficiency of important elements such as phosphorus and nitrogen has led to higher costs for corn production, reduced economic efficiency of fertilizers and greater environmental impacts due to increased use of these fertilizers. The use of nitrogen-stabilizing biological fertilizers is a potential alternative that can minimize these negative effects.

Materials and methods

For this purpose, a split factorial layout with 4 replications based on randomized complete block design was conducted two consecutive years (2016 and 2017) at the Agricultural Research Station of Mehran in East of Ilam province. The studied factors included irrigation in 3 levels including non-stress, drought stress based on 75% and 50% field capacity. In sub-plots, two factors were factorial. The first sub-factor included nitrogen fertilizer at 100% fertilizer requirement (Net nitrogen) through urea, control and Azotobacter biological fertilizer. Another sub-factor included 100% phosphorus fertilizer (Net phosphorus) in the form of triple superphosphate, control and Pseudomonas biological fertilizer applied.

Results

The results of this study showed that interaction of stress, nitrogen and phosphorus on seed yield were significant. The highest seed yield (11932 kg ha^{-1}) was obtained in irrigation with Azotobacter and Pseudomonas. However, there was a significant difference at the same level of stress associated with Azotobacter and triple superphosphate (11873 kg ha^{-1}) and irrigation treatment with Pseudomonas and urea (11318 kg ha^{-1}). Furthermore, at all levels of stress and consumption of Azotobacter and triple superphosphate, grain yield increased compared to control treatment. The interaction of stress, nitrogen and Phosphorus had significant effect on nitrogen productivity. The highest nitrogen productivity was obtained in non-stress treatment and inoculation of Azotobacter and Pseudomonas with 54.04 kg kg -1. At all irrigation levels, Azotobacter inoculation along with Pseudomonas aeruginosa increased nitrogen productivity.

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Conclusion

The results of this study showed that Pseudomonas and Azotobacter bacteria, both low (100% capacity) and severe (50% capacity) water stress conditions, possibly by increasing food absorption caused to increased the quantitative and qualitative yield of maize.

Keywords: Azotobacter, Absorption and consumption nitrogen efficiency, Nutrient Productivity, Protein, Pseudomonas fluorescens

Table 1. Physical and chemical properties of soil experiment site (2015, 2016)

Year	Depth	Soil texture	pH	EC	Organic carbon	Available N	Available P	Available K
	cm			dS/m	-------------%------------		-------------ppm-------------	
2015	0-30	Loam-clay	7.2	1.1	0.91	0.06	10	150
2016	0-30	Loam-clay	7.3	1	0.89	0.05	11	148

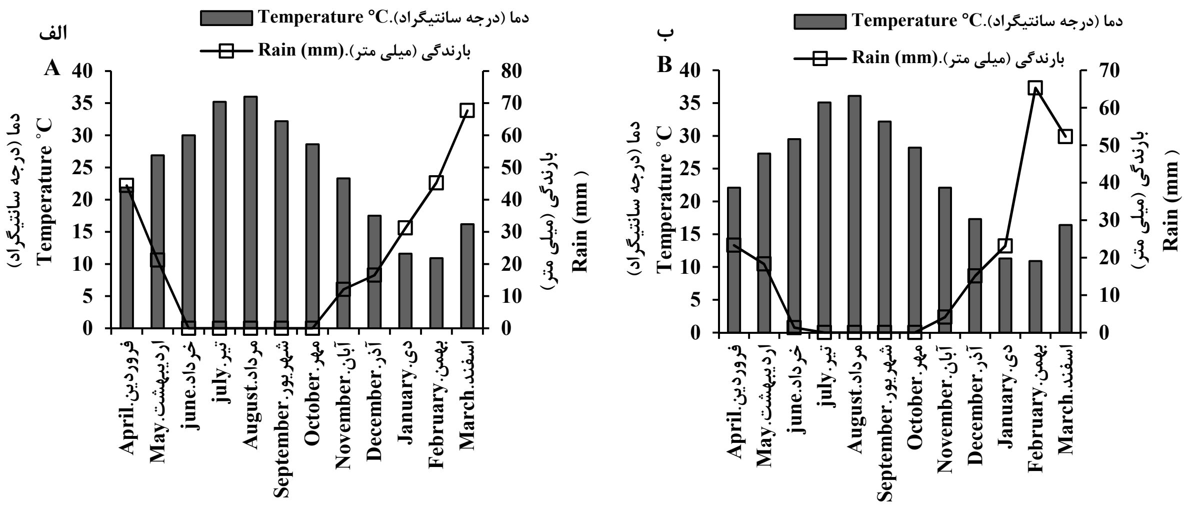

Fig. 1. Rainfall (mm) and mean temperature of Mehran city (ºC) in two years 2015 (A) and 2016 (B)

Table 2. Analysis of variance (mean squares) of traits under maize under two crop years

S.O.V	d.f	Seed yield	Biologic yield	Nitrogen productivity	Phosphorus productivity
Year	1	2679587 **	24837722 ns	781.03 **	5510.1**
Rep (Year)	6	145785	107604338.4	22.22	301.81
Water stress (W)	2	2305025125 **	325318870 *	2847.73 **	82281.6**
Year×W	2	30185 ns	9956360.7 **	14.6 ns	183.6ns
Residual a	12	466419	1053521.5	7.26	125.62
N fertilizer (N)	2	137051326 **	242178392ns	3436.4ns	45501.2ns
Year× N	2	31258 ns	218982892**	1421.7**	275851.2**
W × N	4	10591255 **	3822180ns	45.6ns	81.54ns
Year×W× N	4	86960 *	10901023.4*	18.02**	1939.6**
P fertilizer (P)	2	105152112 **	12585622.2ns	23.62ns	4762.4ns
Year× P	2	744283 **	2987539.2ns	75.11 **	4356.3**
W × P	4	577786 **	2374639.1ns	0.79ns	50.16ns
Year×W × P	4	30426 ns	2453359 ns	0.14ns	35.86*
N × P	4	10224950 **	72774272 **	204.11**	5687.1**
Year× N ×P	4	59197 ns	280736 ns	0.95*	23.05ns
W × N ×P	8	2968907 **	601463 ns	38.65**	1571.2**
Year×W × N ×P	8	19994 ns	1929029 ns	0.17ns	6.52ns
Residual b	144	580295	1638609	8.72	199.91
CV (%)	-	*9.8*	*12.7*	*8.9*	*10.1*

Table 2. Continued

S.O.V	d.f	Nitrogen Uptake efficiency	Phosphorus Uptake efficiency	Nitrogen physiologic efficiency	Phosphorus physiologic efficiency
Year	1	0.121 **	0.246 ns	19.57 ns	139751.8 ns
Rep (Year)	6	0.005	0.001	1.25	2376.4
Water stress (W)	2	0.656 **	0.815 **	330.1 **	64582.5 *
Year×W	2	0.003 ns	0.007 ns	0.186 ns	2327.5 ns
Residual a	12	0.012	0.021	214.2	20255.9
N fertilizer (N)	2	0.727 ns	0.406ns	1026.4 ns	8035.6 ns
Year× N	2	0.315 **	1.777 **	298.1 *	222336.8 *
W × N	4	0.007 ns	0.003 ns	8.58 ns	271.7 ns
Year×W× N	4	0.006 **	0.034**	29.96 **	21638.9 **
P fertilizer (P)	2	0.016 ns	0.039ns	142.2 ns	7122.9 ns
Year× P	2	0.019 **	0.036**	77.75 **	14394.4 *
W × P	4	0.001 *	0.001 ns	10.52 **	49.8 ns
Year×W × P	4	0.0001 ns	0.001 **	0.06 ns	1504.5 **
N × P	4	0.039 **	0.092 **	174.8 **	12598.5 **
Year× N ×P	4	0.0001 ns	0.001 **	0.192 ns	222.0 ns
W × N ×P	8	0.021 **	0.014 **	272.5 **	4019.6 **
Year×W × N ×P	8	0.0001 ns	0.0001 ns	0.137 ns	100.7 ns
Residual b	144	0.003	0.007	56.79	4187.6
CV (%)	-	9.7	12.1	8.1	14.1

*: Significant at 5%; **: Significant at 1%; ns: Non-significant

Table 3. Mean comparison of interaction effect of irrigation, nitrogen and phosphorus levels on nitrogen productivity, yield and nitrogen physiological efficiency

Irrigation levels (field capacity)	N fertilizer	P fertilizer	Seed yield	nitrogen productivity	nitrogen physiological efficiency
			----------kg kg^{-1}----------		
100	Control	Control	7180 hi	31.95 gh	83.39 abc
		psedomuna	8522 ef	38.63 de	82.77 abc
		Triple superphosphate	9427 d	41.68 cd	80.45 bcd
	Azetobacter	Control	8859 def	39.87 cd	77.49 bcde
		psedomuna	11932 a	54.04 a	71.91 def
		Triple superphosphate	11117 c	53.97 a	67.47 f
	Urea	Control	11400 b	31.66 ghi	66.96 f
		psedomuna	11234 bc	34.41 fg	70.6 ef
		Triple superphosphate	11490 b	34.56 fg	75.7 bcdef
75	Control	Control	6180 jkl	27.31 klmn	83.83 ab
		psedomuna	6612 hijk	30.36 hijk	73.52 def
		Triple superphosphate	6923 hij	30.84 hij	82.79 abc
	Azetobacter	Control	6399 ijkl	28.57 ijklm	68.22 f
		psedomuna	8945 de	40.46 cd	78.46 bcde
		Triple superphosphate	10802 c	47.63 b	73.28 def
	Urea	Control	7128 hi	19.49 p	83.98 ab
		psedomuna	9693 d	26.85 lmn	75.48 bcdef
		Triple superphosphate	10888 c	29.5 hijkl	72.15 def
50	Control	Control	5607 l	24.27 no	90.12 a
		psedomuna	6129 jkl	28.18 jklm	73.08 def
		Triple superphosphate	5795 kl	25.95 mn	82.95 abc
	Azetobacter	Control	5877 kl	26.31 lmn	78.46 bcde
		psedomuna	7356 d	42.24 c	74.91 bcdef
		Triple superphosphate	7298 ef	36.79 ef	78.19 bcde
	Urea	Control	5558 l	15.32 q	82.77 abc
		psedomuna	7058 fg	22.5 op	79.85 bcd
		Triple superphosphate	7405 gh	20.23 p	74.65cdef

Means with similar letters in each column, show non- significant difference according to Duncan multiple range tests at 5% level

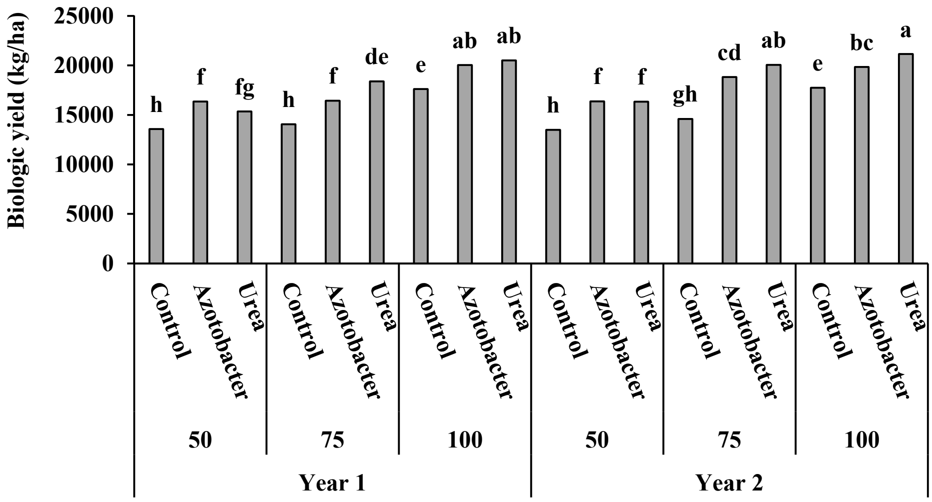

Fig. 2. Mean comparison of interaction effect of year, nitrogen fertilizer and irrigation levels on biological yield of maize

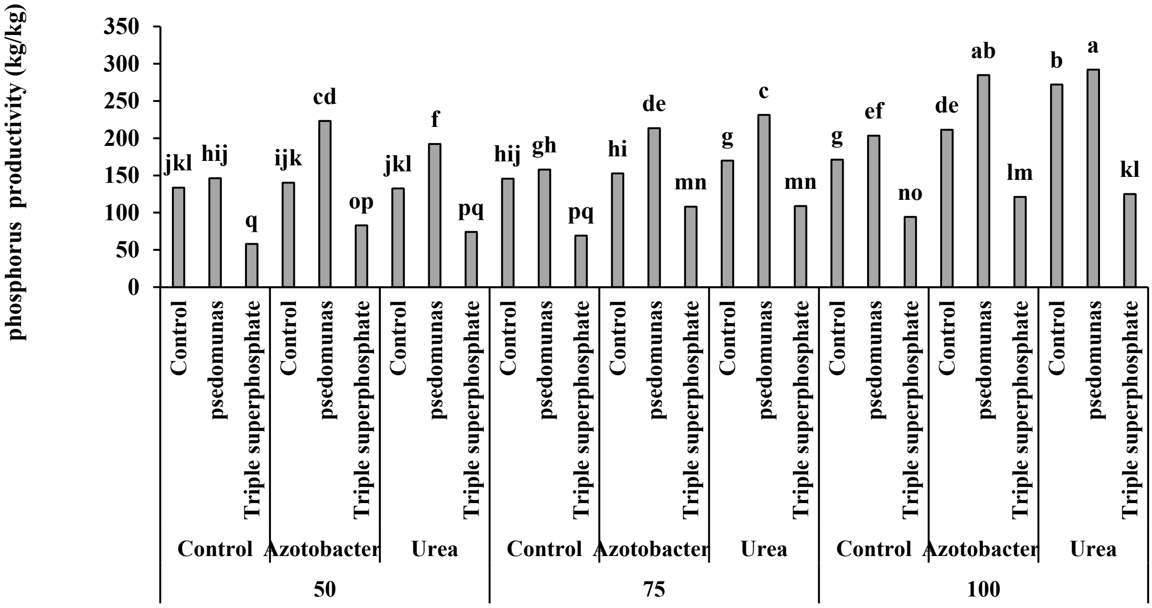

Fig. 3. Mean comparison of interaction effect of Stress, nitrogen fertilizer and phosphorus fertilizer on phosphorus productivity

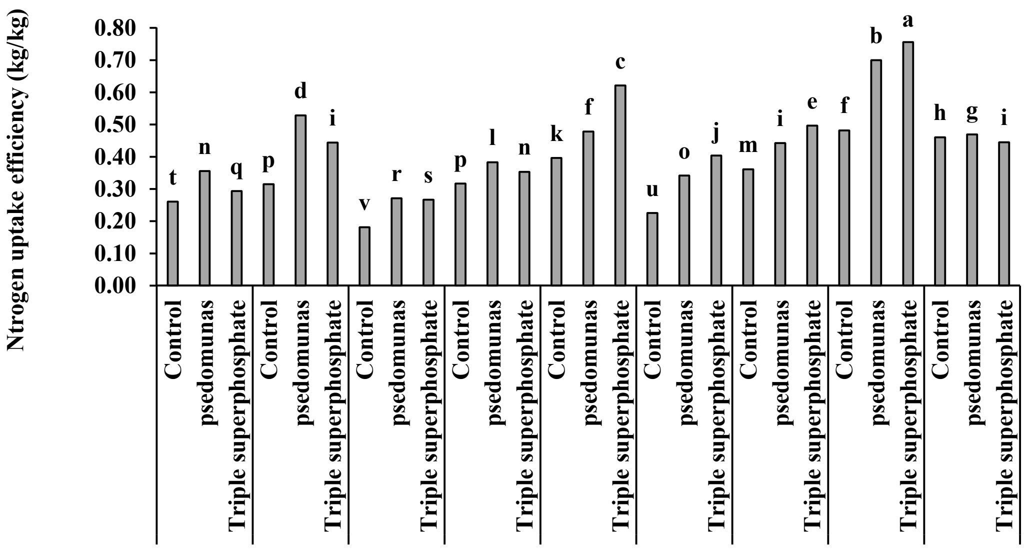

Fig. 4. Mean comparison of interaction effect of Stress, nitrogen fertilizer and phosphorus fertilizer on nitrogen uptake efficiency

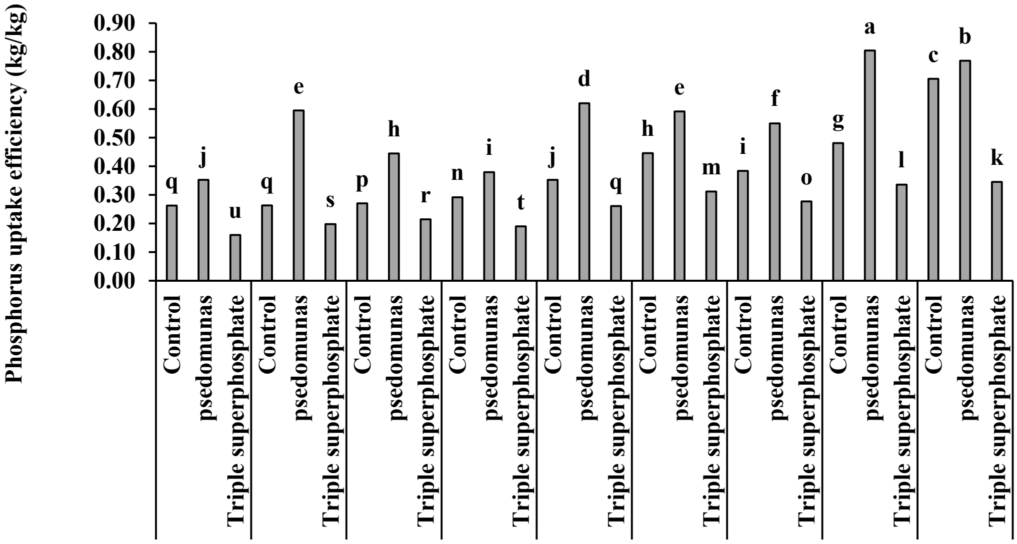

Fig. 5. Mean comparison of interaction effect of Stress, nitrogen fertilizer and phosphorus fertilizer on phosphorus uptake efficiency

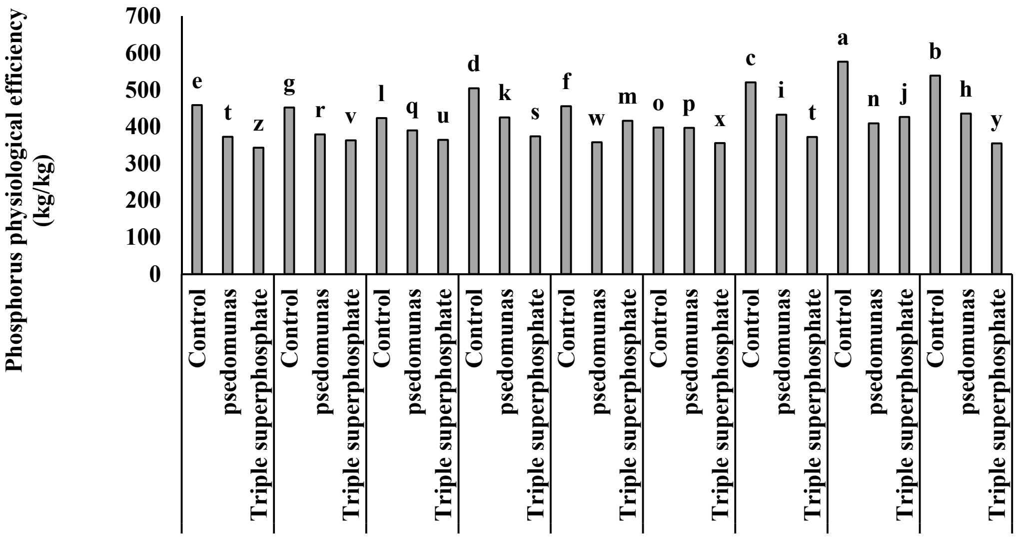

Fig. 6. Mean comparison of interaction effect of Stress, nitrogen fertilizer and phosphorus fertilizer on phosphorus physiological efficiency