



Effect of nitrogen and zinc management on growth, yield and economics of bread wheat (*Triticum aestivum*) varieties

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ABSTRACT

Field experiments were conducted during *rabi* season of 2016–17 and 2017–18 at Udaipur (Rajasthan) to study the effect of nitrogen and zinc management on growth, yield and economics of different wheat (*Triticum aestivum* L.) varieties. The treatments consisted of four wheat varieties, viz. Raj 4120, Raj 4037, Raj 4079 and Raj 4238 in main plots and seven nutrient management treatments, viz. 100% RDN, 100% RDN + ZnSO₄ 25 kg/ha soil application, 100% RDN + ZnSO₄ 0.5% foliar spray, 100% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray, 125% RDN + ZnSO₄ 25 kg/ha soil application, 125% RDN + ZnSO₄ 0.5% foliar spray and 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray in sub plots. The study of different wheat varieties indicated that highest values of growth parameters, yield attributes, grain yield (5707 kg/ha), straw yield (8869 kg/ha) and biological yield (14576 kg/ha), and net returns (₹ 86255/ha) and B:C ratio (2.36) were recorded with wheat variety Raj 4037. Further, application of treatment 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray recorded significantly higher values of growth parameters, yield attributes, grain yield (5681 kg/ha), straw yield (8265 kg/ha) and biological yield (13946 kg/ha), and net returns (₹ 83230/ha).

Key words: Grain yield, LAI, Net return, Nitrogen and zinc management, Wheat varieties

Wheat (*Triticum aestivum* L.) is the second most important staple food crop of developing world after rice. It had significantly contributed towards success of the green revolution and greatly helped to transform our country from a situation of “ship to mouth” to self sufficiency. However, wheat varieties are inherently very low in bio-availability of micronutrients (Zn, Cu, Mn, Fe etc.). The availability range of Zn in wheat varieties in India varies from 20–30 mg/kg (PAU 2011). Deficiency of Zn in major wheat growing areas leads to poor growth and yield attributes of wheat as well as low Zn concentration in grain and is considered to be a major factor in low human Zn intake (Aref 2011).

Apart from the selection of good variety, wheat productivity and quality also depend upon proper nutrient supply (Behera and Rautary 2010). Among the essential nutrients, nitrogen plays important role in augmenting the agricultural production and its deficiency limits crop production (Aulakh and Malhi 2005, Kumar *et al.* 2017). The most important role of N in the plant is its presence in the structure of protein, the most important building substances

from which the living material or protoplasm of every cell is made (Blumenthal *et al.* 2008). Further, zinc is also an important micronutrient. It needs in small quantity, but play indispensable role in various plant physiological processes such as photosynthesis, protein and sugar synthesis, fertility and production of seeds etc (Kumar *et al.* 2016, Mohan *et al.* 2015). Reports also indicate that improved nitrogen and zinc status may enhance the growth and yield of wheat crop. Therefore, nitrogen and zinc management represents an effective agronomic tool to contribute to higher growth and yield of wheat crop. The present study was thus carried out to study the effect of nitrogen and zinc management on growth, yield and economics of different wheat varieties.

MATERIALS AND METHODS

Field experiments were conducted on wheat during *rabi* 2016–17 and 2017–18 at Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The soil of experimental field was clay loam in texture and slightly alkaline in reaction (pH 8.1 and 8.0). The soil was medium in available nitrogen (285.0 and 279.61 kg/ha) and phosphorus (20.42 and 19.27 kg/ha), high in available potassium (324.16 and 318.15 kg/ha) and low in DTPA extractable Zn (0.54 and 0.51 mg/kg) during the *rabi* seasons of 2016–17 and 2017–18, respectively. The experiment was laid out in split plot design with three replications. The treatments consisted of four wheat varieties, viz. Raj 4120

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(V₁), Raj 4037 (V₂), Raj 4079 (V₃) and Raj 4238 (V₄) in main plots and seven nutrient management treatments, viz. 100% RDN as control (N₁), 100% RDN + ZnSO₄ 25 kg/ha soil application (N₂), 100% RDN + ZnSO₄ 0.5% foliar spray (N₃), 100% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray (N₄), 125% RDN + ZnSO₄ 25 kg/ha soil application (N₅), 125% RDN + ZnSO₄ 0.5% foliar spray (N₆) and 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray (N₇) in sub plots. Wheat varieties were sown on 14th and 12th November during first and second year, respectively, by using 100 kg/ha seed rate with row to row spacing of 22.5 cm. Recommended dose of N, P₂O₅ and K₂O for wheat in Udaipur region is 120, 80 and 60 kg/ha, respectively. Full dose of P and K was applied at the time of sowing and, N and Zn applied as per treatments. One third dose of nitrogen was drilled in furrow while sowing and remaining dose of nitrogen was split twice (in two equal parts) at the time of second and third irrigation. Soil application of zinc was applied @ 25 kg/ha through ZnSO₄.7H₂O. In foliar application treatment two foliar spray of ZnSO₄.7H₂O @ 0.5% (with 500 L water/ha) was applied at milking and dough stages. All observations were recorded by the standard procedures.

RESULTS AND DISCUSSION

Growth parameters: The maximum plant height (93.72 cm) was recorded in variety Raj 4120 and minimum (86.95 cm) in Raj 4238 (Table 1). This is might be due to

the difference in genetic constitution of different wheat varieties. El Habbasha *et al.* (2015) also reported that plant height significantly influenced by different wheat varieties. Total dry matter production of wheat varieties increased with the advancement in growth stage. Highest dry matter accumulation was recorded in wheat variety Raj 4037 as compared to other varieties. Maximum CGR and LAI were also obtained with wheat variety Raj 4037. Zaman *et al.* (2016) also reported that dry matter accumulation, crop growth rate and leaf area index were significantly influenced by different wheat varieties. Highest chlorophyll content in leaves was obtained in variety Raj 4037. These results are in confirmation with El-Habbasha *et al.* (2015). All the four wheat varieties showed significant difference in total number of tillers per 0.5 m row length. The maximum number of tillers was produced by variety Raj 4037. The similar finding had also been reported by Dhaka *et al.* (2006).

Nutrient management had a remarkable influence on the growth attributes of wheat crop (Table 2). The maximum value of plant height, dry matter accumulation from 0.5 m row length at 60 and 90 DAS and at harvest; CGR between 30-60 DAS and 60-90 DAS; RGR between 60-90 DAS; LAI at 60 and 90 DAS; total chlorophyll content at 60 DAS; and total tiller from 0.5 m row length were obtained with treatment N₇ (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray). Further, there was no significant variations obtained in dry matter accumulation from 0.5 m row length at 30 DAS, crop growth rate (CGR) between

Table 1 Effect of wheat varieties and nutrient management on plant height, dry matter accumulation and leaf area index (Pooled data of 2016–17 and 2017–18)

Treatment	Plant height (cm)	Dry matter accumulation (g) from 0.5 m row length				Leaf area index	
	At harvest	30 DAS	60 DAS	90 DAS	At harvest	60 DAS	90 DAS
<i>Varieties</i>							
V1	93.72	5.61	38.64	122.43	160.28	2.69	4.55
V2	93.23	5.67	40.32	126.12	171.29	3.01	4.74
V3	91.91	5.46	36.83	113.99	144.36	2.50	4.15
V4	86.95	5.40	35.57	104.55	139.77	2.40	3.91
SEm±	0.86	0.16	0.51	1.60	1.91	0.15	0.11
CD (P= 0.05)	2.66	NS	1.58	4.92	5.88	NS	0.34
<i>Nutrient management</i>							
N1	86.28	5.19	33.66	98.37	133.83	2.16	3.64
N2	90.16	5.46	36.72	110.72	149.13	2.46	4.40
N3	89.24	5.20	33.70	98.60	143.83	2.18	3.66
N4	91.28	5.49	36.76	112.18	156.06	2.49	4.42
N5	94.37	5.86	42.35	135.70	165.95	3.16	4.86
N6	93.61	5.66	39.28	124.33	159.29	2.92	4.50
N7	95.21	5.89	42.41	137.52	169.38	3.17	4.88
SEm±	1.05	0.20	0.58	2.04	2.42	0.15	0.13
CD (P= 0.05)	2.95	NS	1.62	5.73	6.78	0.42	0.38

V1 : Raj 4120; V2 : Raj 4037; V3 : Raj 4079; V4 : Raj 4238; N1 : 100% RDN; N2 : 100% RDN + ZnSO₄ 25 kg/ha soil application; N3 : 100% RDN + ZnSO₄ 0.5% foliar application; N4 : 100% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application; N5 : 125% RDN + ZnSO₄ 25 kg/ha soil application; N6 : 125% RDN + ZnSO₄ 0.5% foliar application and N7 : 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application.

Table 2 Effect of wheat varieties and nutrient management on crop growth rate, relative growth rate and net assimilation rate (Pooled data of 2016–17 and 2017–18)

Treatment	Crop growth rate (g/m/day)			Relative growth rate (g/g/day)			NAR (g/m ² day)
	0-30 DAS	30-60 DAS	60-90 DAS	0-30 DAS	30-60 DAS	60-90 DAS	60-90 DAS
<i>Varieties</i>							
V1	1.66	9.78	24.83	0.1302	0.0641	0.0385	6.27
V2	1.68	10.27	25.42	0.1303	0.0656	0.0378	5.98
V3	1.62	9.30	22.86	0.1293	0.0637	0.0375	6.23
V4	1.60	8.94	20.44	0.1288	0.0628	0.0357	6.16
SEm±	0.05	0.16	0.53	0.0013	0.0010	0.0007	0.26
CD (P= 0.05)	NS	0.50	1.65	NS	NS	NS	NS
<i>Nutrient management</i>							
N1	1.54	8.44	19.17	0.1276	0.0623	0.0357	6.28
N2	1.62	9.26	21.92	0.1291	0.0637	0.0368	5.95
N3	1.54	8.44	19.23	0.1276	0.0624	0.0357	6.03
N4	1.63	9.26	22.35	0.1295	0.0633	0.0371	6.00
N5	1.74	10.81	27.66	0.1316	0.0660	0.0387	6.34
N6	1.68	9.96	25.20	0.1304	0.0647	0.0384	6.20
N7	1.74	10.82	28.18	0.1318	0.0658	0.0392	6.31
SEm±	0.06	0.17	0.65	0.0016	0.0012	0.0006	0.33
CD (P= 0.05)	NS	0.49	1.82	NS	NS	0.0016	NS

V1 : Raj 4120; V2 : Raj 4037; V3 : Raj 4079; V4 : Raj 4238; N1 : 100% RDN; N2 : 100% RDN + ZnSO₄ 25 kg/ha soil application; N3 : 100% RDN + ZnSO₄ 0.5% foliar application; N4 : 100% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application; N5 : 125% RDN + ZnSO₄ 25 kg/ha soil application; N6 : 125% RDN + ZnSO₄ 0.5% foliar application and N7 : 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application.

0-30 DAS, relative growth rate (RGR) between 0-30 and 30-60 DAS and net assimilation rate between 60-90 DAS due to different nutrient management treatments. Different researchers reported that increasing levels of nitrogen increases the plant height (Kousar *et al.* 2015), dry matter accumulation (Lifeng *et al.* 2011), LAI and CGR (Warraich *et al.* 2007), leaf chlorophyll content and tiller numbers (Mattas *et al.* 2011) in wheat.

Yield attributes: The highest number of effective tillers per 0.5 m row length, grains/ear and average ear length were recorded with wheat variety Raj 4037 (Table 3). The differences in effective tillers, grains/ear and average ear length in general attributed because of different genetic potential of wheat varieties to produce these yield attributes. Yadav and Raghvanshi (2007) reported that the number of grains/ear and earheads/m² (effective tillers) significantly influenced by different wheat varieties. Further, wheat varieties had no significant effect on test weight. Musaddique *et al.* (2000) also noticed non-significant differences in test weight of different wheat cultivars.

Further, treatment N₇ (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray) recorded highest number of effective tillers per 0.5 m row length, grains/ear, average ear length and test weight (Table 3). The differences in effective tillers, grains/ear, average ear length and test weight in general attributed because with the higher nitrogen and zinc (both soil and foliar) application, tillers produced more productive panicles which led to higher

numbers of effective tillers. Further, better nutrition with higher nitrogen and zinc (both soil and foliar) application increases the length of ear and as the number of grains/ear is associated with ear length, it also increases with increasing ear length. Ahmadi and David (2016) also reported that number of grains/ear and test weight in wheat significantly influenced by nitrogen and zinc management.

Yield: Wheat variety Raj 4037 recorded highest values of grain, straw and biological yields. However, harvest index did not influence significantly with different wheat varieties (Table 4). Grain yield is a manifestation of various yield attributes, viz. numbers of effective tillers, grains/ear, average ear length and test weight. In the present investigation positive correlation of grain yield with numbers of effective tillers ($r = 0.973$), grains/ear ($r = 0.982$), average ear length ($r = 0.994$) and test weight ($r = 0.898$) validate the above statement. Further, straw yield depends upon the dry matter production per unit area, therefore high production of total dry matter is the first prerequisite for higher straw yield which showed the progressive increase in total dry matter accumulation as the crop attained maturity. It is also validated by positive correlation ($r = 0.993$) between straw yield and dry matter accumulation at harvest. These results corroborate the findings of El Habbasha *et al.* (2015) and Chattha *et al.* (2017). Further, treatment N₇ (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray) recorded highest grain, straw and biological yields. However, harvest index was not influenced significantly by different

Table 3 Effect of wheat varieties and nutrient management on total chlorophyll, number of tillers, grains/ear, average ear length and test weight (Pooled data of 2016–17 and 2017–18)

Treatments	Total chlorophyll content (mg/g fresh weight)	Number of tillers from 0.5 m row length at harvest		Grains/ ear	Average ear length (cm)	Test weight (g)
	60 DAS	Total tillers	Effective tillers	At harvest	At harvest	At harvest
<i>Varieties</i>						
V1	1.69	46.94	45.62	44.21	10.82	41.64
V2	1.82	49.07	47.13	45.20	11.32	43.05
V3	1.79	45.66	43.83	44.06	10.65	42.08
V4	1.66	43.43	42.46	43.70	10.42	41.44
SEm±	0.02	0.73	0.65	0.18	0.10	0.39
CD (P= 0.05)	0.08	2.25	2.01	0.56	0.31	NS
<i>Nutrient management</i>						
N1	1.53	38.74	37.31	41.64	10.06	40.23
N2	1.68	45.08	43.24	42.75	10.55	41.24
N3	1.52	39.59	37.90	43.22	10.40	41.77
N4	1.69	45.76	44.36	44.70	10.83	43.00
N5	1.95	52.05	50.59	45.34	11.25	42.03
N6	1.81	49.38	48.03	45.69	11.12	42.61
N7	1.97	53.35	51.90	46.71	11.42	43.50
SEm±	0.03	0.92	0.84	0.23	0.11	0.32
CD (P= 0.05)	0.08	2.59	2.36	0.63	0.32	0.90

V1 : Raj 4120; V2 : Raj 4037; V3 : Raj 4079; V4 : Raj 4238; N1 : 100% RDN; N2 : 100% RDN + ZnSO₄ 25 kg/ha soil application; N3 : 100% RDN + ZnSO₄ 0.5% foliar application; N4 : 100% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application; N5 : 125% RDN + ZnSO₄ 25 kg/ha soil application; N6 : 125% RDN + ZnSO₄ 0.5% foliar application and N7 : 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application.

Table 4 Effect of wheat varieties and nutrient management on yield, harvest index and economics (Pooled data of 2016–17 and 2017–18)

Treatment	Yield (kg/ha)			Harvest index	Economics	
	Grain	Straw	Biological	(%)	Net return (₹/ha)	B:C ratio
<i>Varieties</i>						
V1	5264	8306	13571	38.97	77098	2.11
V2	5707	8869	14576	39.30	86255	2.36
V3	5134	7016	12150	42.24	71155	1.95
V4	4820	6915	11735	41.15	65515	1.79
SEm±	84	170	184	0.86	1416	0.04
CD (P= 0.05)	260	523	567	NS	4364	0.13
<i>Nutrient management</i>						
N1	4562	6912	11474	39.91	62109	1.75
N2	5106	7690	12797	40.52	72752	2.00
N3	4809	7504	12312	39.20	67430	1.87
N4	5389	7807	13196	41.11	77319	2.09
N5	5612	8219	13831	40.80	82513	2.24
N6	5460	8040	13499	40.56	79685	2.18
N7	5681	8265	13946	40.82	83230	2.23
SEm±	101	210	216	0.82	1637	0.05
CD (P= 0.05)	283	589	607	NS	4594	0.13

V1 : Raj 4120; V2 : Raj 4037; V3 : Raj 4079; V4 : Raj 4238; N1 : 100% RDN; N2 : 100% RDN + ZnSO₄ 25 kg/ha soil application; N3 : 100% RDN + ZnSO₄ 0.5% foliar application; N4 : 100% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application; N5 : 125% RDN + ZnSO₄ 25 kg/ha soil application; N6 : 125% RDN + ZnSO₄ 0.5% foliar application and N7 : 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar application.

wheat varieties (Table 4). Presence of positive correlation of grain yield with numbers of effective tillers ($r = 0.970$), grains/ear ($r = 0.938$), average ear length ($r = 0.981$) and test weight ($r = 0.842$) validate the above statement. Further, straw yield depends upon the dry matter production per unit area, therefore high production of total dry matter is the first prerequisite for higher straw yield which showed the progressive increase in total dry matter accumulation as the crop attained maturity. It is also validated by positive correlation ($r = 0.982$) between straw yield and dry matter accumulation at harvest. These results corroborate the findings of Ahmadi and David (2016).

Economics: The highest net return and benefit:cost ratio was obtained with wheat variety Raj 4037. It is obvious because of higher grain and straw yield of variety Raj 4037 as compared to other varieties which consequently resulted in higher net return and benefit:cost ratio. Meena *et al.* (2016) reported that wheat variety Raj 4037 recorded maximum net return and B:C ratio. Significantly higher net return was recorded under treatment N_7 (125% RDN + $ZnSO_4$ 25 kg/ha soil application + $ZnSO_4$ 0.5% foliar spray) whereas, maximum value of benefit:cost ratio was found with treatment N_5 (125% RDN + $ZnSO_4$ 25 kg/ha soil application) which was at par with treatment N_7 (125% RDN + $ZnSO_4$ 25 kg/ha soil application + $ZnSO_4$ 0.5% foliar spray) and N_6 (125% RDN + $ZnSO_4$ 0.5% foliar spray). Meena *et al.* (2017) also reported that both soil and foliar application of zinc with higher dose of nitrogen obtained higher net return and benefit:cost ratio in wheat (Table 4).

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