



Effect of varieties and nutrient management on quality and zinc biofortification of wheat (*Triticum aestivum*)

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ABSTRACT

Field experiments were conducted during winter (*rabi*) season of 2016–17 and 2017–18 at Udaipur (Rajasthan) to study the effect of wheat varieties and nutrient management on zinc biofortification. The treatments consist 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 yield viz. grain (5707 kg/ha) and straw (8869 kg/ha) yield; quality parameters viz. protein content (12.96%), hectoliter weight (80.48 kg/hl) and sedimentation volume (45.20 CC); and nutrient content and uptakes of nitrogen, phosphorus, potassium and zinc in both grain and straw was recorded with variety Raj 4037 (on pooled basis). Further, application of treatment 125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray recorded significantly higher grain (5681 kg/ha) and straw (8265 kg/ha) yield; protein content (13.77%), grain appearance score (7.87), hectoliter weight (80.98 kg/hl), sedimentation volume (46.97 CC) and beta carotene content (3.64 ppm); and nutrient content and uptakes of nitrogen, potassium and zinc in both grain and straw (on pooled basis).

Key words: Beta carotene, Grain protein, Hectoliter weight, Sedimentation volume, Zinc concentration

A number of wheat (*Triticum aestivum* L.) varieties have been developed in recent past, which has helped in enhancing food grain production substantially, thereby reducing starvation and malnutrition. However, wheat varieties are inherently very low in bioavailability of micronutrients particularly of Zn, Fe, Cu, etc. Zinc deficiency affects, on average, one third of world's population, ranging from 4 to 73% in different countries (Hotz and Brown 2004). Deficiency of Zn in major wheat growing areas leads to low Zn concentration in grain and is considered as a major factor in low human Zn intake (Aref 2011). The provision of wheat grains with higher micronutrient level is a challenging task for wheat breeders because breeding approach is a long term process and may be affected by very low chemical solubility of Zn and Fe in soil due to high pH and low organic matter (Cakmak 2008) but one that would complement the use of supplemental fertilizers (Agronomic manipulation) particularly on soils inherently

low in these nutrients.

Biofortification is the process of increasing the natural content of nutrients in edible part of crop plants (Welch 2005). Zn mediated agronomic biofortification of cereals proved useful for enriching the micronutrient content in the edible parts (Kumar *et al.* 2016, 2017) and thus, helped overcome hidden hunger caused due to Zn micronutrient deficiency to some extent besides rectifying the deficiency in dietary intake. Latest reports indicate that improved nitrogen status as biofortification strategy may increase the Zn and Fe concentration in the whole grain and endosperm of wheat. Nitrogen nutrition of plant appears to be a critical component for an effective biofortification of food crops with Zn and Fe due to their role in physiological and molecular mechanisms which are under the influence of nutritional status of nitrogen (Kutman *et al.* 2010). Therefore, nitrogen management represents an effective agronomic tool to contribute to grain Zn concentration. Keeping in view the above facts, the present investigation was carried out to know the effect of nitrogen and zinc on grain quality 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, MPUAT,

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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* season 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, 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. 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 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 split twice (in two equal parts) at the time of second and third irrigation. Soil application of zinc was applied at 25 kg/ha through ZnSO₄.7H₂O. In foliar application treatment, two foliar sprays of ZnSO₄.7H₂O @ 0.5% (with 500 water/ha) was applied at milking and dough stages. Grain protein content was calculated by multiplying the nitrogen content (%) in the grain by the factor 6.25. Grain appearance score measures the glossiness, color, size and shape of wheat grain and it was given on a scale of 0 to 10. The weight expressed as kg/hectolitre is known as per hectolitre weight. For sedimentation value 5 g flour was added to 50 ml water and shaken rapidly for 15 sec, then 50 ml sodium dodecyl sulphate was added. Sediment volume was measured to the nearest ml. Beta carotene was estimated using 10 g wheat flour sample from each experimental unit and dispersed in 50 ml water saturated n-butanol to get homogeneous suspension. It was shaken gently and allowed to stand overnight under dark. The optical density of the clear filtrate was measured at 440 nm as absorbance, using the spectrophotometer. Evaluation of the contents was based on a beta carotene calibration curve. N, P, K and Zn content was determined by using the following methods, Nessler's reagent colorimetric method (Lindner 1994), Vanadomolybdophosphoric yellow colour method (Richards 1968), Flame photometric method (Richards 1968) and Atomic absorption spectrophotometer method (Lindsay and Norvell 1978), respectively.

RESULTS AND DISCUSSION

Quality parameters: Wheat varieties had significant effect on different quality parameters, viz. protein content, grain appearance score, hectolitre weight, sedimentation

volume and beta carotene content (Table 1). The maximum grain protein content was recorded in V2 wheat variety i.e. Raj 4037 (12.96 %) and minimum in variety Raj 4120 (12.06 %). The high protein content in Raj 4037 might be due to its high nitrogen content and equally higher nitrogen accumulation or uptake in grains. Alam (2012) also reported that protein content in wheat grain significantly influenced in different varieties. The higher grain appearance score was obtained with wheat variety Raj 4079. This might be due to lustrous grains and attractive color of variety Raj 4079. Significantly higher value of hectolitre weight was recorded by variety Raj 4037 as compared to other varieties. This might be due to the bold and attractive grains of variety Raj 4037. Maximum sedimentation volume was recorded in wheat variety Raj 4037 whereas minimum in variety Raj 4079. It might be due to the fact that different genotypes had different diastatic power which is an indicator of enzymatic activity in the wheat flour. Further, wheat variety Raj 4238 recorded significantly higher beta carotene content as compared to other varieties. Results of the present investigation are in close agreement with Kumar *et al.* (2018).

Table 1 Effect of varieties and nutrient management on quality of wheat grain (Pooled data of 2016–17 and 2017–18)

Treatments	Protein content (%)	Grain appearance score	Hectolitre weight (kg/hl)	Sedimentation volume (CC)	Beta carotene (ppm)
<i>Varities</i>					
V1	12.06	6.58	79.72	44.59	2.95
V2	12.96	6.22	80.48	45.20	2.84
V3	12.32	7.72	79.17	39.25	3.05
V4	12.60	6.72	79.51	42.29	3.42
SEm±	0.10	0.20	0.17	0.27	0.06
CD (P= 0.05)	0.30	0.61	0.51	0.84	0.20
<i>Nutrient management</i>					
N1	11.37	5.75	77.78	39.10	2.25
N2	11.82	5.95	78.88	40.53	2.66
N3	11.99	6.35	79.29	41.41	2.92
N4	12.44	6.70	79.84	42.69	3.07
N5	12.73	7.34	80.54	43.79	3.40
N6	13.27	7.72	80.72	45.34	3.52
N7	13.77	7.87	80.98	46.97	3.64
SEm±	0.07	0.23	0.19	0.31	0.08
CD (P= 0.05)	0.20	0.66	0.55	0.87	0.22

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 quality parameters were also influenced by different nutrient management treatments (Table 1). Application of treatment N7 (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray) recorded highest grain protein content. This might be due to the fact that soil and foliar application of zinc enhanced the nitrogen use efficiency in wheat grain and as the nitrogen is the major component of amino acids, it leads to protein synthesis. Akram *et al.* (2017) also reported that interaction effect of nitrogen and zinc increased the grain protein content in wheat. The higher grain appearance score and hectoliter weight was obtained with treatment N7 (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray). The hectolitre weight and grain appearance score reflect the conditions during the grain filling period of the crop and as the foliar application of zinc at milking and dough stage leads to bold, lustrous and attractive grain of wheat grain which ultimately enhanced the value of hectolitre weight and grain appearance score. Sardana *et al.* (2005) reported that increased grain appearance score and hectoliter weight was obtained with increasing nitrogen levels. Further, maximum value of sedimentation volume and beta carotene was also obtained with treatment N7 (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray). This might be attributed to the fact that foliar application of zinc in association with higher nitrogen dose leads to increased amino acid synthesis which enhanced protein content and grain hardness, which further contributed to increase in

sedimentation value. Further, foliar application of zinc with higher value of nitrogen enhanced the absorption of zinc by wheat grain which improved the value of beta carotene in wheat grain. Mattas *et al.* (2011) reported that betacarotene in durum wheat increased significantly with raising levels of nitrogen.

Nutrient content and uptake: Study indicated that significantly higher content and uptake of nitrogen, phosphorus, potassium and zinc was recorded by wheat variety Raj 4037 (Table 2 and 3). This might be attributed due to the genetic potential of nutrient content and uptake. The uptake of nutrients by the crop depends upon the dry matter production and nutrient content in plant parts. Thus, improvement in both of these ultimately led to higher uptake of nitrogen, phosphorus, potassium and zinc. Chattha *et al.* (2017) reported that zinc application via different methods markedly influenced grain zinc concentrations in wheat. The maximum increase in grain zinc concentrations was observed in soil + foliar application of ZnSO₄.7H₂O at two growth stages (booting and milking). Haque *et al.* (2017) reported that N uptake increased with progressive rates of N application.

Further, treatment N7 (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray) recorded significantly higher nitrogen, potassium and zinc content as well as uptake of these nutrients in the grain and straw as compared to other nutrient management options.

Table 2 Effect of varieties and nutrient management on nutrient content in wheat grain and straw (Pooled data of 2016–17 and 2017–18)

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Zinc content (ppm)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
<i>Varieties</i>								
V1	1.929	0.458	0.4542	0.1643	0.315	1.583	33.45	29.49
V2	2.074	0.549	0.4618	0.1711	0.402	1.686	34.34	30.40
V3	1.971	0.490	0.4475	0.1672	0.365	1.631	32.70	28.85
V4	2.016	0.519	0.4577	0.1690	0.386	1.662	29.72	27.20
SEm±	0.016	0.012	0.0018	0.0007	0.011	0.014	0.19	0.21
CD (P= 0.05)	0.048	0.036	0.0055	0.0021	0.033	0.042	0.59	0.65
<i>Nutrient management</i>								
N1	1.819	0.388	0.4517	0.1672	0.282	1.540	25.72	22.26
N2	1.891	0.423	0.4475	0.1631	0.295	1.587	27.56	25.69
N3	1.919	0.415	0.4406	0.1661	0.334	1.571	29.77	24.33
N4	1.991	0.486	0.4352	0.1586	0.387	1.640	36.87	30.07
N5	2.037	0.606	0.4759	0.1732	0.405	1.702	33.44	33.49
N6	2.124	0.546	0.4721	0.1754	0.414	1.677	35.39	31.03
N7	2.203	0.668	0.4642	0.1718	0.454	1.764	39.13	36.01
SEm±	0.012	0.014	0.0019	0.0005	0.013	0.014	0.17	0.21
CD (P= 0.05)	0.033	0.040	0.0053	0.0015	0.038	0.040	0.48	0.59

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 3 Effect of varieties and nutrient management on nutrient uptake in wheat grain and straw (Pooled data of 2016–17 and 2017–18)

Treatment	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Zinc uptake (g/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
<i>Varieties</i>								
V1	101.75	38.57	24.09	13.66	16.74	131.84	177.38	247.41
V2	118.97	48.80	26.68	15.19	23.29	149.57	197.96	270.73
V3	101.55	34.56	23.26	11.74	18.91	114.53	169.29	203.59
V4	97.68	36.38	22.39	11.71	18.81	115.16	144.97	190.86
SEm±	1.78	1.06	0.47	0.31	0.69	2.89	3.29	5.67
CD (P= 0.05)	5.48	3.28	1.45	0.94	2.13	8.89	10.13	17.47
<i>Nutrient management</i>								
N1	83.05	26.94	20.84	11.56	12.85	106.53	117.97	154.86
N2	96.49	32.81	23.10	12.55	15.04	122.23	140.88	199.41
N3	92.28	30.96	21.45	12.46	16.04	117.66	143.93	182.82
N4	107.25	37.78	23.71	12.39	20.74	127.81	199.37	235.78
N5	114.46	49.74	27.03	14.23	22.91	139.88	188.16	275.78
N6	116.13	43.43	25.99	14.11	22.69	134.29	193.32	250.63
N7	125.26	55.38	26.60	14.20	25.78	146.00	223.17	297.75
SEm±	2.19	1.25	0.59	0.37	0.86	3.50	4.08	7.11
CD (P= 0.05)	6.15	3.50	1.64	1.03	2.43	9.82	11.44	19.95

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 Interaction effect of varieties and nutrient management on zinc content in wheat grain (Pooled data of 2016–17 and 2017–18)

Nutrient management	Zinc content in grain (ppm)			
	Varieties			
	Raj 4120	Raj 4037	Raj 4079	Raj 4238
N1	25.95	28.15	25.28	23.48
N2	28.54	29.62	27.55	24.52
N3	31.33	31.42	30.47	25.86
N4	37.98	38.83	36.74	33.94
N5	33.69	34.68	34.19	31.20
N6	35.79	36.37	35.86	33.54
N7	40.91	41.33	38.78	35.51
	SEm±		CD (P = 0.05)	
Same varieties for different nutrient management treatments	0.34		0.96	
Same nutrient management treatments for different varieties	0.37		1.07	

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.

However, maximum phosphorus content in grain and straw was obtained with treatment N5 (125% RDN + ZnSO₄ 25 kg/ha soil application) and N6 (125% RDN + ZnSO₄ 0.5% foliar application), respectively, whereas, maximum value of phosphorus uptake in grain and straw recorded with treatment N5 (125% RDN + ZnSO₄ 25 kg/ha soil application). This might be attributed due to positive interaction of nitrogen and zinc, nitrogen and potassium and zinc and potassium and negative interaction of zinc with phosphorus. Prasad *et al.* (2016) reported that zinc interacts positively with nitrogen and potassium and negatively with phosphorus in plants. The uptake of nutrients by the crop depends upon the dry matter production and nutrient content in plant parts. Thus, improvement in both of these ultimately led to higher uptake of nitrogen, phosphorus, potassium and zinc. Cakmak (2010) reported that enrichment of wheat grain with Zn was maximized when plants were supplied sufficiently with nitrogen through soil and or foliar application of nitrogen fertilizers.

Zinc bio-fortification through interaction effect: Interaction effect of variety Raj 4037 along with N7 (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray) recorded highest grain zinc concentration (Table 4) which was significantly higher over rest of the treatment combinations except variety Raj 4120 along with N7 (125% RDN + ZnSO₄ 25 kg/ha soil application + ZnSO₄ 0.5% foliar spray). Coronado *et al.* (2017) reported that soil

application of zinc combined with two foliar sprays could be a good option for biofortifying bread wheat under Zn deficient soils. Haque *et al.* (2017) also reported positive interaction between wheat varieties and nitrogen levels.

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