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Effect of nitrogen and zinc levels on growth and yield of Basmati rice

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ABSTRACT

An experiment was conducted to study the effect of nitrogen levels [Control, 100% recommended dose of nitrogen (RDN) through inorganic source (IS), 25% RDN (IS) + 25% RDN through organic source (OS), 50% RDN (IS) + 25% RDN (OS) and 75% RDN (IS) + 25% RDN (OS)] and zinc levels (2.5, 5.0 and 7.5 kg ha^{-1}) on growth and yield of basmati rice. Growth, yield attributes and yield were highest with nitrogen level of 75% RDN (IS) + 25% RDN (OS) followed by 100% RDN (IS). Zinc level 5.0 kg ha^{-1} has produced maximum growth, yield attributes and yield. Grain yield obtained by combination of 75% RDN (IS) + 25% RDN (OS) along with 5.0 kg ha^{-1} Zn registered 2109.64 kg more yield than combination of control and 2.5 kg ha^{-1} Zn. 75% RDN (IS) + 25% RDN (OS) along with 5.0 kg ha^{-1} Zn has enhanced the growth and productivity of basmati rice.

Keywords : *Basmati rice, Zinc fertilization, Organic sources, Chemical fertilizers, Oryza sativa L.*

Introduction

Rice (*Oryza sativa* L.) is the second most substantial crop globally, cultivated in an area of 161.1 million ha and production of about 751.9 million tonnes (OECD-FAO, 2018). India ranks next to china in rice occupying an area of 43.4 million ha with production of about 112.9 million tonnes in 2017-18 (Anonymous, 2017). Basmati is a type of aromatic rice which originally evolved in north and north-western part of India, Pakistan and Afghanistan (Bligh, 2000). Basmati rice has a pivotal position in international market; its demand is increasing day by day at international level because of its superfine quality, long grain, pleasant aroma and soft texture (Singh *et al.*, 2008). Globally, India is the largest producer as well as exporter of basmati rice and accounts 70% of global production. The aromatic rice including basmati contributes around 15% of global trade of rice. The yield potential of different basmati varieties ranges between 4.5 to 6.0 t ha^{-1}, but the average productivity in fields is still low due to imbalanced nitrogen application and zinc deficiency (Wang *et al.*, 2008 and Shivay *et al.*, 2010).

Nitrogen and zinc are two important fertilizers which are needed to be applied in optimum doses for sustained yields, good quality and better soil health. Nitrogen has direct role and is important yield determinant in rice; however its economic use is important as the inorganic fertilizers prices are continuously escalating (Ali *et al.*, 2014). Zinc is the second most limiting nutrient in rice crop after nitrogen, is essential for many physiological processes in growth and development of plants and is important for kernel protein content (Mirza, 2007). Hence, its optimum rate is important as the zinc fertilizers are costly. The response of nitrogen on growth and yield of rice is well documented, but the interaction effect of nitrogen along with zinc on basmati rice under eastern Uttar Pradesh condition is very meager. Keeping these aspects in view, present study was performed to identify the optimum nitrogen and zinc level for higher growth and yield of basmati rice (*Oryza sativa* L.).

Materials and Methods

Experimental site and treatment details

Field experiment was conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25°15′ N, 82°59′ E) at an altitude of 85.71 m above mean sea level during wet season, 2018 from June to November. The experimental site received a total rainfall of 950.1 mm with mean air temperature of 27.5°C during experimentation. The type of soil was sandy clay loam with pH 7.7, EC (0.2 dS m^{-1}), organic carbon (0.48%), available nitrogen (227.5 kg ha^{-1}), available phosphorus (23.3 kg ha^{-1}), available potassium (222.3 kg ha^{-1}) and available zinc (0.52 mg kg^{-1}). The experiment was conducted in factorial randomized complete block design consisting of 5 nitrogen levels [Control, 120 kg ha^{-1} from inorganic source (IS), 30 kg ha^{-1} from inorganic + 30 kg ha^{-1} from organic source (OS), 60 kg ha^{-1} from IS + 30 kg ha^{-1} from OS and 90 kg ha^{-1} from IS + 30 kg ha^{-1} from OS] and 3 zinc levels (2.5, 5.0 and 7.5 kg ha^{-1}) with three replications. The inorganic source of nitrogen was urea and organic source was farmyard manure. 50% of nitrogen (as per respective treatment), 100% of phosphorus, potash and zinc were applied as basal dose. The remaining nitrogen was applied in two equal splits at active tillering and panicle initiation. Phosphorus and potassium were applied at the rate of 60 kg each. Pusa sugandha-5 basmati rice variety was used at the rate of 40 kg ha^{-1}. Rice seeds were sown in wet bed method on 19th June, 2018 and four week old seedlings were transplanted in plots of 6.0 m × 2.6 m with 2 seedlings per hill at a distance of 20 × 10 cm. Other agronomic management was in accordance with recommended practices.

Growth, yield attributes and yields

The growth parameters studied were SPAD chlorophyll content at 90 days after transplanting (DAT) and dry matter accumulation at harvest sampled from selected five plants. The selected five plants which used for SPAD chlorophyll content were also used for measuring panicle number, length and weight of panicle and number of filled grains per panicle, were averaged and mean values presented. For 1000 grain weight, 1000 filled grains from selected panicles were counted and their weight was recorded. Grain and straw yield was recorded from an area of 11.6 m^2, harvested material was allowed for sun drying in threshing floor till moisture content reached 14%, threshed manually and grain yield was recorded and expressed in kg ha^{-1}. The straw yield was obtained by deducting grain yield from biological yield.

Statistical analysis

All the data obtained from experiment was statistically analyzed using statistical package SPSS software (version 23.0; IBM Corp.; Armonk, NY, USA). LSD values ($p = 0.05$) were used to compare the significance between treatment means. Graphs were prepared in excel and mean values are reported with standard error of means.

Results and Discussion

Growth parameters

The growth parameters (SPAD chlorophyll content and dry matter accumulation) varied significantly with nitrogen and zinc levels (Table 1). SPAD chlorophyll content was maximum with application of 75% RDN (IS) + 25% (OS) and produced 20.4% higher chlorophyll than control. The drymatter accumulation obtained with 75% RDN (IS) + 25% (OS) showed significantly greater than rest of the nitrogen levels. This might be due to the increased metabolic activities of plant because consistent supply of nitrogen for longer period (Sravan and Singh, 2019). With decreased levels of nitrogen there is poor and ineffective shoot and root growth which resulted in reduced drymatter. Lowest values for both SPAD chlorophyll and drymatter were obtained with control. Higher dry matter accumulation might be due to increased number of tillers, number of green leaves, leaf area index leading to increased photosynthetic efficiency of the crop plants (Yadav *et al.*, 2009 and Nanda *et al.*, 2016). Among the Zn levels maximum SPAD chlorophyll and drymatter accumulation was obtained with 5 kg ha^{-1} and it was significantly greater than rest of Zn levels. Lowest zinc level (2.5 kg) registered significantly lowest growth parameters. The findings are in line with that of Kumar and Singh (2006) and Arif *et al*. (2016). Along with nitrogen if zinc is present in meristemetic regions of the plant it facilitate rapid cell division and cell elongation which result in good growth and development of the crop (Rehman *et al*., 2012). The interaction effect of N × Zn could not produce significant change in growth parameters.

Yield attributes

Yield attributes i.e. panicles hill^{-1}, panicle length, panicle weight, number of filled grains panicle^{-1} and 1000 grain weight significantly altered with both nitrogen levels and zinc levels (Table 1 and 2). Among all nitrogen treatments, 75% RDN (IS) +

Table 1. Effects of nitrogen and zinc levels on growth and yield parameters of basmati rice

Treatment	SPAD chlorophyll content at 90 DAT	Dry matter accumulation hill^{-1} (g) at harvest	Panicles hill^{-1}	Panicle length (cm)	Panicle weight (g)
Nitrogen level					
Control	27.48	17.98	5.52	24.47	1.82
100% RDN (IS)	32.27	23.31	6.85	26.28	2.85
25% RDN (IS) + 25% RDN (OS)	30.02	20.06	5.84	24.97	2.16
50% RDN (IS) + 25% RDN (OS)	31.13	22.11	6.06	25.57	2.58
75% RDN (IS) + 25% RDN (OS)	33.08	24.61	7.15	27.07	3.02
SEm±	0.55	0.43	0.13	0.50	0.07
LSD (p=0.05)	1.58	1.25	0.38	1.46	0.21
Zinc level (kg ha^{-1})					
2.5	29.37	20.70	5.99	25.09	2.22
5.0	32.70	22.58	6.67	26.29	2.69
7.5	30.31	21.57	6.20	25.62	2.55
SEm±	0.42	0.34	0.10	0.39	0.06
LSD (p=0.05)	1.22	0.97	0.29	1.13	0.16
N × Zn	NS	NS	NS	NS	*

RDN – Recommended dose of nitrogen; IS – Inorganic source; OS – Organic source; NS – Non-significant; * - Significant.

Table 2. Effects of nitrogen and zinc levels on yield attributes and yields of basmati rice

Treatment	No. of filled grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Nitrogen level					
Control	93.79	18.67	3178.06	4853.84	8031.90
100% RDN (IS)	112.66	21.82	4333.00	5910.33	10243.33
25% RDN (IS) + 25% RDN (OS)	100.87	19.35	3708.90	5367.25	9076.15
50% RDN (IS) + 25% RDN (OS)	106.05	20.20	3991.13	5725.11	9716.24
75% RDN (IS) + 25% RDN (OS)	119.38	22.85	4453.38	5909.38	10362.76
SEm±	1.89	0.50	70.73	90.73	84.06
LSD (p=0.05)	5.48	1.46	204.88	262.83	243.51
Zinc levels (kg ha^{-1})					
2.5	101.41	20.00	3718.03	5437.14	9155.17
5.0	111.04	21.14	4108.65	5565.24	9673.88
7.5	107.20	20.60	3972.00	5657.18	9629.18
SEm±	1.47	0.39	54.78	70.28	65.11
LSD (p=0.05)	4.25	1.13	158.70	203.59	188.62
N × Zn	NS	NS	*	NS	*

RDN – Recommended dose of nitrogen; IS – Inorganic source; OS – Organic source; NS – Non-significant; * - Significant.

25% (OS) registered greater panicles, lengthy and heavier panicles, and 1000 grain weight closely followed by 100% RDN (IS), and did not exhibited any significant change under both treatments. Similar results were reported by Jisan *et al.* (2016). Number of filled grains/panicle was found significantly superior with 75% RDN (IS) + 25% (OS) over all other nitrogen levels. Minimum values of these yield attributes were achieved under control. The better yield parameters with integrated nutrient management were probably due to efficient translocation of photosynthates from source to sink due to constant supply of nitrogen and other nutrients for longer period. In contrast, inorganics supply the nutrients at early growth stages and their availability might decrease at later stages (Alim, 2012 and Sravan and Singh, 2019). Zn also has a marked effect over panicle number, panicle length, panicle weight, number of filled grains panicle^{-1} and 1000 grain weight. Maximum value of yield attributes were found with 5 kg ha^{-1} Zn, however it was similar with highest zinc level (7.5 kg ha^{-1}). Similar type of results for yield attributes was reported by Jana *et al.* (2009). However, interaction of N × Zn was significant for panicle weight (Fig. 1). The combination of 75% RDN (IS) + 25% (OS) + 5.0 kg ha^{-1} Zn has produced heavier panicles. The gradual and continuous supply of nutrients through inorganics and organics has resulted in heavier panicles (Ali *et al.,* 2014).

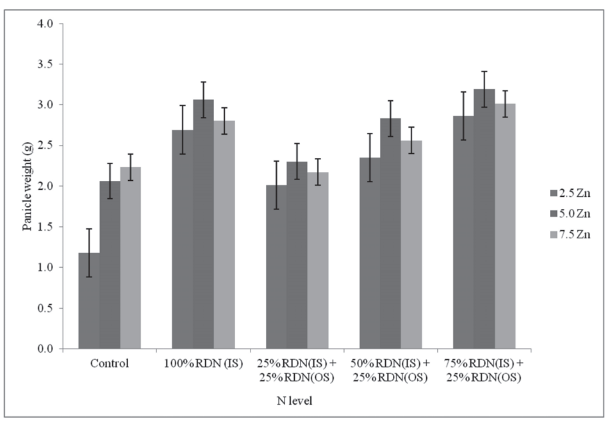

Fig. 1. Interaction effect of nitrogen and zinc levels on panicle weight of basmati rice. Vertical bars represent ± standard error of the mean

Yield

Yield is the result of interaction between environment, genetic character of crop species and management factor. Nitrogen and zinc levels significantly altered grain, straw and biological yields of rice (Table 2). The grain yield with the application of treatment 75% RDN (IS) + 25% RDN (OS) was greater over all other levels of nitrogen. The nitrogen level 100% RDN (IS) and integrated nutrient management treatments [25% RDN (IS) + 25% RDN (OS), 50% RDN (IS) + 25% RDN (OS) and 75% RDN (IS) + 25% RDN (OS)] showed a yield increment of 36.34%, 16.70%, 25.58% and 40.12% over control. The greater yield is due to higher panicles, panicle weight, number of filled grains/panicle and 1000 grain weight. The superior yields with integrated nutrient management were because FYM release aromatic and aliphatic hydroxyl acids, humates, lignins etc. which acts as nutrient reservoir and slowly releases nutrient throughout the crop growth period (Sravan and Singh, 2019). Besides these macro nutrients, FYM also provides micronutrients and has ability to maintain soil nutrient balance and favors growth and development of soil micro flora and fauna for better soil and plant health. Highest straw yield was obtained with 100% RDN (IS) whereas maximum biological yield was with 75% RDN (IS) + 25% (OS), however both these treatments were statistically similar. Lowest grain, straw and biological yields were obtained with control. Similar results were observed by Haque *et al.* (2006), Shivay *et al*. (2016) and Kumar *et al*. (2017). Among Zn levels maximum grain and biological yield was obtained with the application of 5 kg ha^{-1}, however highest straw yield was achieved with highest level (7.5 kg ha^{-1}) and both treatments were similar statistically for all yields. Better yield attributes with these Zn levels has resulted in greater yields. Lowest level of Zn (2.5 kg ha^{-1}) produced significantly lowest grain, straw and biological yields. Similar result of zinc is also reported by Jana *et al*. (2009).

Interestingly, significant interaction of N × Zn was observed for grain yield (Fig. 2) and biological yield (Fig. 3). Maximum grain and biological yield was obtained with combination of 75% RDN (IS) + 25% (OS) along with 5 kg ha^{-1} Zn that could not differ statistically from 100% RDN (IS) and 5 kg ha^{-1} Zn. Earlier reports suggest that zinc has synergistic effect with the nitrogen levels, which ultimately enhanced growth and yield. Under flooded condition, urea applied as nitrogen has increased zinc solubility and enhanced Zn contents in rice and increased root efficiency for uptake by plants (Singh and Singh, 1981). Under submerged conditions urea application curtails soil pH and in addition forms

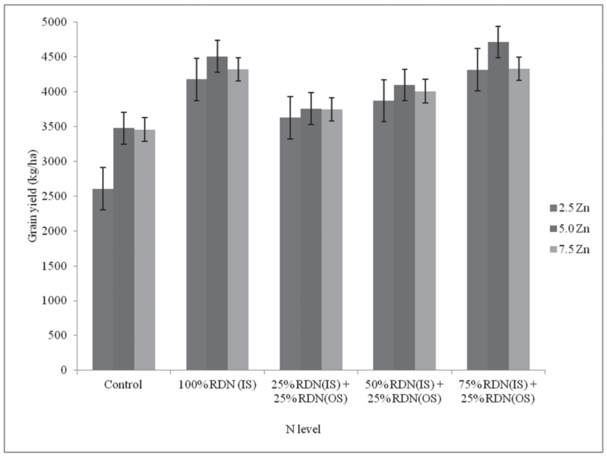

Fig. 2. Interaction effect of nitrogen and zinc levels on grain yield of basmati rice. Vertical bars represent ± standard error of the mean.

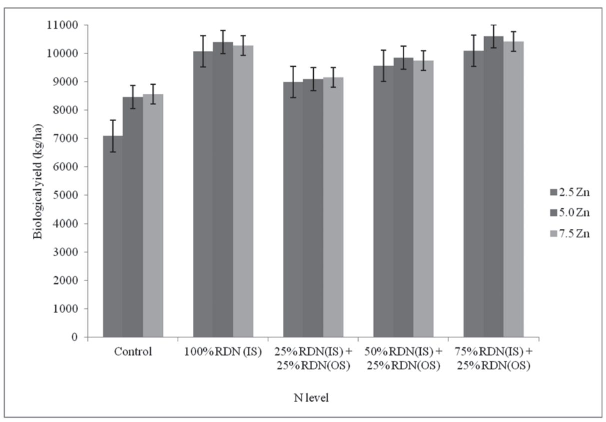

Fig. 3. Interaction effect of nitrogen and zinc levels on biological yield of basmati rice. Vertical bars represent ± standard error of the mean.

NH_3-Zn complex thus improves Zn availability (Gao *et al.,* 2012).

The results of present study reveals that application of 75% RDN (IS) + 25% RDN (OS) along with 5.0 kg ha^{-1} Zn improves growth, yield attributes and yield of rice followed by 100% RDN (IS) and 5 kg ha^{-1} Zn compared to other combinations.

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