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Sanjeev Singh
Ph.D., Scholar, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Adesh Singh
Assistant Professor, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

RB Yadav
Professor, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Mukesh Kumar
Professor, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

BP Dhyani
Professor, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

LK Gangwar
Professor, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Corresponding Author:
Sanjeev Singh
Ph.D., Scholar, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Crop growth rate, yield attributes, yield, profitability and quality of basmati rice varieties as influenced by efficient zinc management practices

Sanjeev Singh, Adesh Singh, RB Yadav, Mukesh Kumar, BP Dhyani and LK Gangwar

Abstract
Field experiment conducted during rainy (*kharif*) seasons of 2018 and 2019 at Crop Research Centre (Campus), Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, to evaluate the crop growth rate, yield attributes, yield, profitability and quality of basmati rice varieties as influenced by zinc management practices. In general, among the varieties Pusa Basmati-1121 had the highest CGR, yield attributes and yield, quality and economics which were statistically superior over rest of the varieties during both the years. As compared to Pusa-1401 and Pusa Basmati-1121 about 7.6, 8.7% and 2.6%, 2.1% yield increase was observed in Pusa Basmati-1509 during both the years. On the other hand, the rice grain yield was increased by 9.9% and 10.9% in Pusa Basmati-1121 as compared to Pusa-1401 during 2018 and 2019. The highest test weight (27.4 and 27.3g), biological yield (140.0 and 138.2q/ha), amylose content (24.7 and 24.4%), and grain breadth (279 and 2.79mm) was recorded with Pusa Basmati-1121, while highest panicle length (101.1 and 100.6cm), fertility ratio (4.84 and 4.79) and rough grain length (0.356 and 0.350mm) was noted in Pusa Basmati-1509 during both the years. Pusa-1401 showed the lowest values of growth parameters, yield attributing characters and yield during both the years. Among the zinc management practices, seedling dipping in 2% $ZnSO_4$ + foliar spray @ 0.5% at T and PI stage was found to be the best for the growth parameters, yield attributes, yield and quality. However, soil applied zinc @ 15kg/ha also proved to be second best in this regard, besides the maximum net return/rupee investment.

Keywords: Foliar spray, seedling dipping, varieties and zinc management practices

Introduction
Rice (*Oryza sativa* L.), a vivacious food crop in South and Southeast Asia, is grown under various agro ecological conditions on an area of 44.5 mha in India and makes large energy and protein contribution to human diet (Prasad *et al*., 2014) [11]. Rice is one of the most important staple crops for more than half of the world population and, thus, are important source energy, vitamins, mineral elements, and rare amino acids for people feeding on the rice as staple. It also contains gamma-oryzanol, a compound having cholesterol lowering effect (Bhattacharjee *et. al*., 2002) [4]. Basmati, derived from two Hindi words ‘Bas’ meaning ‘Fragrant or Scented’ and ‘Mati’ meaning ‘Queen’ is regarded as ‘Queen of Fragrance’. The first recorded use of the word ‘basmati’ for the fragnant long grain rice is in a poem, Heer-Ranjha, written by Waris Shah in Punjab in 1766 (Shobha Rani and Krishnaiah, 2001) [16]. It is the world’s most aromatic and fragrant rice having no parallel in terms of its characteristic fragrance attribute by a chemical compound named 2-acetyl-1-pyrroline. This compound is more concentrated in basmati than any other variety approximately 90 parts per billion. Basmati is known for its desirable cooking quality and for its fragrance and is grown in the Indo-Gangetic plains of South Asia and produced only in India and Pakistan.
Globally, about 50% of cultivated soils under cereal–cereal rotations have low Zn content (Prasad *et al*., 2014) [11]. Plant response to Zn deficiency involves decreased membrane integrity, susceptibility to heat stress, and decreased synthesis of carbohydrates, cytochromes, nucleotides, auxin, and chlorophyll. Further, Zn-containing enzymes are inhibited, including alcohol dehydrogenase, carbonic anhydrase, Cu–Zn-superoxide dismutase, alkaline phosphatase, phospholipase, carboxypeptidase, and RNA polymerase (Marschner, 1995) [7]. Zn binds with more than 500 different proteins. Foliar fertilization contributes more than soil application to increasing Zn concentration in rice, due to its immediate crop response to applied nutrients.

Different varieties of rice showed wide variation in grain and straw yield both with and without Zn application. On average, grain yields of different rice varieties increased by 29% and 22% with soil plus foliar and only soil application of Zn, respectively (Saha *et al*., 2014) [1]. Ferti-fortification is an economically viable approach that may result in higher Zn concentration as well as higher productivity. The tested basmati rice varieties are in a very high demand for their good cooking quality characteristics and aroma.

Materials and Methods

Field experiment were conducted at fixed site during rainy (*kharif*) seasons of 2018 and 2019 at Crop Research Centre (Campus) Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, on sandy-loam soil having pH 8.6, situated at latitude of 29˚04′ North and longitude of 77˚42′ East and at an altitude of 227 metre above mean sea level. It lies in the heart of Western Uttar Pradesh and has sub-tropical climate. The mean annual rainfall of Meerut is 732 mm. The experimental field had an even topography with good drainage system. Soil of the experiment field was low in available N (180 kg/ha), medium in available P (10.6 kg/ha), K (126.7 kg/ha) and organic carbon (0.30%). The available DTPA extractable Zn in soil was 0.70 (mg/kg) of the soil. Three basmati rice varieties *viz.*V_1-Pusa Basmati-1121, V_2-Pusa-1401 and V_3-Pusa Basmati-1509 were taken in the main plot. Five treatments of zinc management *viz.*Z_1-Control-water spray, Z_2- Soil application of $ZnSO_4$ @ 15 kg/ha, Z_3- Foliar spray of $ZnSO_4$ @ 0.5% at tillering and panicle initiation stage, Z_4- Seedling dipping in 2% $ZnSO_4$ + Foliar spray @ 0.5% at tillering and panicle initiation stage and Z_5- Seedling dipping in 2% $ZnSO_4$ + Foliar spray @ 0.5% at panicle initiation stage, respectively were applied in sub plots and replicated thrice in split plot design. Twenty five days old seedlings were transplanted at the spacing of 20 × 15 cm spacing with two seedlings/hill. Soil was sampled before transplanting and after harvest of the crop to know the fertility status of the experiment field.

The experimental field was ploughed twice with disk plough and then after puddled twice with a heavy puddler in standing water and maintained a level of 5 cm of standing water for transplanting of the seedlings. At final puddling 60 kg phosphorus and 40 kg potash through SSP and MOP, respectively were applied uniformly in all the plots. Nitrogen was applied @ 120kg/ha as urea into three splits; half at the time of transplanting and remaining half at the time of maximum tillering and at panicle initiation stage equally in all the treatments. Among zinc management, $ZnSO_4$ was applied as soil application @ 15 kg/ha, seedlings were dipped in 2% $ZnSO_4$ solution for 15 minutes and for foliar spray 0.5% $ZnSO_4$, neutralized with lime was used as per the treatments. Seedlings of basmati rice were transplanted in the field on 18-07-2018 and 21-07-2019. The gross plot size was 4.5m × 3.6m for each treatment. Rice crop grown as per standard recommended package of practices as was harvested in month of October-November during both the years of experimentation.

Mean crop growth rate of plants/hill for a time "t" is defined as the increase in dry weight of plants/hill from a unit area per unit of time. It was calculated with the following formula (Radford, 1967) [12] from periodic dry matter recorded at different stages:

$$\text{CGR (g/m}^2\text{/day)} = 1/A \times \frac{W2 - W1}{t2 - t1}$$

Ten panicles were selected randomly and their length was measured. Figures of all the ten panicles were added and sum was divided by ten to get average panicle length. It was recorded in cm.

After threshing a random sample of grains were drawn from grain yield of each plot. From this, 1000-grainswere counted and their weight was recorded as test weight (g).

The produce excluding root, of each net plot was allowed to sundry after harvest and weighed to record the biological yield (grains + straw) per plot and then converted into q/ha.

After harvesting, threshing, cleaning and drying, the grain yield of rice was estimated at 14% moisture content. The fertility ratio was calculated as follows:

$$\text{Fertility ratio} = \frac{\text{number of filled/panicle}}{\text{Total grains/panicle}}$$

Net return/Rupee invested were calculated as follows:

$$= \frac{\text{number of filled/panicle}}{\text{Total grains/panicle}}$$

Ten grains with husks were randomly selected and used for measuring their length and breadth on a graph paper using a 'Photo Enlarger' with a magnification of 3X. The actual mean of grain length and breadth were expressed in mm. A sample of 1 g milled rice grains were gently crushed and made into fine powder in a vitreous pestle and mortar. The flour samples were stored to uniform moisture of 12%. One hundred mg sample was weighed carefully on an electronic meter balance and transferred to a 100 ml volumetric flask. Ten ml of freshly prepared 1 N NaOH solution was pipetted out into the conical flask to soak the flour, allowing it to form a clump and then 1 ml of distilled ethanol was added and mixed well. After an hour of gelatinization, the sample suspension was heated for 10 minutes in a boiling water bath. The volume was made up to 100 ml with distilled water. After thoroughly shaking the content, an aliquot of 2.5 ml was pipetted out into a 50 ml volumetric flask and added about 20 ml of water; three drops of phenolphthalein indicator were added and mixed well. The content was acidified by adding 0.1 N HCl drop by drop until the pink colour just disappears. Then 1 ml of iodine reagent was added to develop blue colour and volume was made up the volume to 50 ml. The absorbance at 590 nm was recorded with the help of a Spectrophotometer. A standard curve was prepared on the basis of the absorbance values of known quantities of pure amylose. The amount of amylose in the sample using the standard curve was prepared from pure amylose (range 0.2-1 mg) against a blank which dilute 1 ml of iodine reagent to 50 ml with distilled water (Thimmiah, 1999) [18].

Calculation

Absorbance corresponds to 2.5 ml of test solution = 'x' mg amylose in test solution.

$$\text{100 ml contains} = \frac{x}{2.5} \times 100\% \text{ amylose}$$

For determining the volume expansion ratio, the standard method of Vergheese (1950) [19], modified by Murthy (1965) was followed. Five grams of milled whole grain rice was soaked in 15 ml of water for 5 minutes in a centrifuge tube after taking the initial volume of rice before cooking by volume displacement method. The tubes were placed in a pressure cooker for cooking, and then the cooked rice was decanted on to a filter paper to remove the excess water if any. Later, the volume of cooked rice kernels was measured by water displacement method. The volume expansion ratio was estimated using the following formula.

$$\text{Volume expansion ratio} = \frac{\text{Volume of cooked rice (ml)}}{\text{Volume of uncooked rice (ml)}} \times 100$$

The uptake of zinc in grains and straw of rice were calculated separately and thus the total uptake were worked out by adding them using the following expression:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content in grains or straw (\%)}}{100} \text{x grain or straw yield (kg/ha)}$$

Total nutrient uptake = nutrient uptake by grains + nutrient uptake by straw

The data obtained from this study for 2 years were analyzed statistically using F-test, as per the procedure given by Panse and Sukhatme (1967) [10]. CD values at p=0.05 were used to determine the significance of different between treatments means.

Results and Discussions

Crop growth rate (g/m^2/day) in rice increased with advancement of the crop growth and reached to maximum between 90 DAT-Harvest stage, irrespective of the treatments, except at Pusa Basmati-1509, which had the highest CGR between 60-90 DAT during both the years (Table 1). Between various stages of crop, CGR of rice differed significantly due to varieties during both the years, except between 30-60 DAT during 2018, while varied significantly due to zinc management practices at various intervals of crop growth during both the years, except between 60-90 DAT during 2018 and at 90-harvest during 2019.

Table 1: Effect of different basmati rice varieties and zinc management practices on crop growth rate (g/m^2/day)

Treatment	Crop growth rate (g/m^2/day)					
	30-60 DAT		60-90 DAT		90 DAT-Harvest	
	2018	2019	2018	2019	2018	2019
Varieties						
V_1	5.73	5.56	17.0	16.9	28.7	28.6
V_2	5.42	4.85	17.1	17.0	34.9	33.8
V_3	7.03	7.01	41.6	41.2	0.0	0.0
S.Em±	0.36	0.19	0.3	0.4	0.5	0.5
C.D. (P=0.05)	NS	0.77	1.3	1.7	2.0	2.2
Zinc management practices						
Z_1	4.74	4.79	24.0	23.9	19.3	18.4
Z_2	6.53	6.26	25.7	25.1	22.1	21.5
Z_3	5.45	5.33	24.9	25.0	21.0	20.8
Z_4	7.96	7.23	26.6	26.0	22.4	22.1
Z_5	5.63	5.43	25.1	25.1	21.3	21.2
S.Em±	0.27	0.21	0.5	0.6	0.8	0.7
C.D. (P=0.05)	0.79	0.61	1.3	NS	NS	2.2

The maximum crop growth rate (7.03 and 7.01, 41.6 and 41.2g/m^2/day) was recorded in Pusa Basmati-1509 between 30-60 DAT and 60-90 DAT, however it differed significantly with Pusa-1401 and Pusa Basmati-1509 during 2018 and 2019, respectively. Although, during 90 DAT-harvest stage Pusa-1401 had significantly higher crop growth rate (34.9 and 33.8g/m^2/day) than Pusa Basmati-1121 during both the years. This might be due to the differential behaviour and genetic makeup of the varieties which leads to attain the higher plant height, more number of tillers and dry matter accumulation earlier in the Pusa Basmati-1509 than others. Harish *et al.*, (2017) reported the similar results.

Harish, M.N., Choudhary, A.K., Singh, Y.V., Pooniya, V., Das, A., Varatharajan, T. and Babu, S. (2017). Effect of promising rice (*Oryza sativa* L.) varietiesand nutrient management practices on growth, development and cropproductivity in eastern Himalaya. Annals of Agricultural Research 38(4):375-384.

Among the different zinc management practices, maximum crop growth rate of 7.96 and 7.23, 26.6 and 26.0 and 22.4 and 22.1g/m^2/day was noted between 30-60 DAT, 60-90 DAT and 90-Harvest stage with seedling dipping in 2% $ZnSO_4$+foliar spray @ 0.5% at T and PI stage, which was superior over rest of the treatments during 2018 and 2019, respectively. However, Z_4 remained *on par* with all the zinc applied treatments during 2019 at 90 DAT-Harvest stage during 2019 and in 2018 with Z_2 only during 60-90 DAT. Although, the minimum crop growth rate was observed among all the intervals under control during both the years. It might be due to the fact that zinc plays a vital role in the synthesis of auxins which promotes the cell division and elongation and thus inturn the growth parameters. Similar findings were also made by Alam and Kumar (2015).

Alam, M.A. and Kumar, M. (2015). Effect of zinc on growth and yield of rice var. Pusa Basmati-1 in Saran district of Bihar. Asian Journal of Plant Science and Research 5(2):82-85.

Yield attributes

Pusa Basmati-1509, being *on par* with Pusa Basmati-1121 had the longest panicle (27.2 and 27.1cm) which was significantly superior over Pusa-1401 during 2018 and 2019, respectively (Table 2). Being significantly superior over rest of the varieties during 2018, the highest fertility ratio (0.76 and 0.77) was noted in Pusa Basmati-1509 during both the years. However, the highest test weight (27.4 and 27.3g) was noted with Pusa Basmati-1121, being significantly higher than Pusa-1401 (21.4 and 21.3) and remained *at par* with Pusa Basmati-1509 during both the years. This might be due to congenial weather conditions which favour the development of higher growth attributes and better translocation of photosynthates resulted in production of higher values of yield attributes (Kaushal) Kumar, K. (2014). Effect of zinc management and varieties on yield and zinc biofortification in rice (*Oryza sativa* L.). Thesis, BHU, Varanasi.

Table 2: Effect of different basmati rice varieties and zinc management practices on panicle length, fertility ratio and test weight

Treatments	Panicle length (cm)		Fertility ratio		Test weight (g)	
	2018	2019	2018	2019	2018	2019
Varieties						
V_1	26.8	26.6	0.72	0.76	27.4	27.3
V_2	25.8	25.5	0.67	0.73	21.4	21.3
V_3	27.2	27.1	0.76	0.77	27.2	27.1
S.Em±	0.27	0.30	0.01	0.02	0.28	0.28
C.D. (P=0.05)	1.09	1.23	0.02	NS	1.12	1.14
Zinc management						
Z_1	25.9	25.8	0.66	0.68	24.9	24.8
Z_2	26.9	26.7	0.73	0.78	25.5	25.3
Z_3	26.5	26.4	0.69	0.73	25.3	25.3
Z_4	27.2	26.9	0.78	0.82	25.6	25.4
Z_5	26.6	26.3	0.71	0.75	24.4	25.3
S.Em±	0.26	0.20	0.02	0.02	0.47	0.28
C.D. (P=0.05)	0.75	0.50	0.04	0.06	NS	NS

The application of zinc significantly increased the yield attributes, *viz*., panicle length (cm), and fertility ratio over control, while the test weight (g) remained unaffected during both the years. However, the highest values were recorded with seedling dipping in 2% $ZnSO_4$ + foliar spray @ 0.5% at T and PI stage, which was very close to soil applied $ZnSO_4$ @ 15 kg/ha during both the years. This was probably due to the proper zinc supply through root dipping and foliar mean of Zn at tillering and panicle initiation stage which in turn improved the translocation of photosynthates towards sink. These results are in conformity with Shivay *et al.*, (2015) [6].

In case of test weight the improvement due to zinc application during both the years was non-significant, being the highest in Z_4. The lowest fertility ratio in control compared with the zinc applied plots was mainly due to the more number of chaffy grains/panicle and/or the lowest filled grains/panicle. Significantly longest panicles and highest fertility ratio was recorded In Z_4. Though, the shortest panicle length, minimum fertility ratio and test weight was recorded under control during both the years. This might be due to increased synthesis of carbohydrates and their transport to the site of grain formation. Shivay *et al.*, (2015) [6] reported the similar results

Yield

Basmati rice varieties and zinc management practices had a significant effect on biological and grain yield (q/ha). Pusa Basmati-1121 gave the maximum biological yield (140.0 and 138.2q/ha) and grain yield (54.6 and 53.8q/ha) and differed significantly with rest of the varieties, except in grain yield which was *on par* to Pusa Basmati-1509 during both the years (Table 3). The lowest biological and grain yield was noted in Pusa-1401 during both the years. As compared to Pusa-1401, about 7.0% and 8.7% yield increase was observed in Pusa Basmati-1509 under same sets of environment during 2018 and 2019, respectively. Moreover, Pusa Basmati-1121 produces 11.3 and 11.4q/ha more biological yield than Pusa-1401 during first and second year, respectively. On the other hand, the rice grain yield was increased by 9.9% and 10.9% in Pusa Basmati-1121 as compared to Pusa-1401. However, Pusa Basmati-1509 and Pusa Basmati-1121 were statistically alike in terms of grain yield during both the years. It might be due to the improvement in the growth parameters and yield attributing parameters which finally makeup the yield. Similar findings were also reported by Rehman *et al.*, (2011) [13] and and Sarwar, (2011) [14].

Table 3: Effect of different basmati rice varieties and zinc management practices on biological yield, grain yield and net returns/rupee invested

Treatment	Biological yield (q/ha)		Grain yield (q/ha)		Net returns/rupee invested (□/□)	
	2018	2019	2018	2019	2018	2019
Varieties						
V_1	140.0	138.2	54.6	53.8	1.18	1.14
V_2	128.7	126.8	49.7	48.5	1.01	0.96
V_3	131.3	130.1	53.2	52.7	1.16	1.16
S.Em±	1.0	0.7	1.0	0.5	0.03	0.02
C.D. (P=0.05)	4.2	2.9	3.9	2.0	0.13	0.07
Zinc management practices						
Z_1	124.3	122.2	45.9	44.8	0.90	0.86
Z_2	137.1	135.7	55.0	54.3	1.22	1.19
Z_3	132.1	130.4	51.8	51.0	1.10	1.07
Z_4	138.5	136.7	55.9	55.2	1.21	1.17
Z_5	134.8	133.6	53.6	52.9	1.16	1.14
S.Em±	2.3	2.1	1.0	0.8	0.03	0.03
C.D. (P=0.05)	6.6	6.1	2.8	2.2	0.10	0.08

The time and method of zinc application significantly improved biological and grain yields of rice over control during both the years. Among different zinc management practices seedling dipping in 2% $ZnSO_4$ + foliar spray @ 0.5% at T and PI stage showed highest biological and grain yields, which was significantly superior over control and Z_3, except biological yield during 2018. The higher grain yield was obtained under Z_4; this might be due to the positive combined effect of yield attributing characters, like effective tillers/m^2, filled grains/panicle, panicle length (cm) and higher fertility ratio. Besides, during grains filling stage the process of zinc storage in plant parts and it loading has influence on more dry matter accumulation. The combined application in this treatment might have helped in transport process which ultimately resulted in about 21.8 and 23.2% grain yield increase over control during both the years. Similar results were also reported by Kaushar *et al.*, (2001) and Mehla *et al.*, (2006) [9]. Similarly, the comparable biological yield was observed with Z_2, which might be due to the favourable effect of zinc on the proliferation of roots and thereby increasing the uptake of plant nutrients from the soil supplying it to the aerial parts of the plant and ultimately enhancing the vegetative growth of plants. Our results are in close conformity with those of Beebout *et al.* (2011) [3].

Net return/rupee invested

Economic benefit in terms of net return/rupee invested (₹/₹) differed significantly among the different rice varieties during both the years (Table 3). Pusa Basmati-1121, being *on par* with Pusa Basmati-1509 during both the years had the highest net return/rupee invested (₹1.18) during 2018, but during 2019 it was maximum in Pusa Basmati-1509 (₹1.16). It was mainly due to the lower cost involved and relatively more yield gains/ha in Pusa Basmati-1509, being the shortest among them. These results are in close conformity with findings of Ghasal *et al.*, 2015 [6]. However, the minimum net return/rupee was recorded in Pusa-1401 during both the years. Moreover, Pusa basmati-1121 incurred 16.8 and 18.8% more net return/rupee invested than Pusa-1401 during both the years.

The monitory return was significantly influenced by the different zinc management practices during both the years. The maximum net return/rupee invested of ₹1.22 and 1.19 was recorded with soil applied $ZnSO_4$ @ 15kg/ha, which was *on par* with combined application of $ZnSO_4$ through seedling dipping @ 2% and foliar mean @ 0.5% at PI+T and PI stage and significantly superior over rest of the treatments. However, the lowest net return/rupee invested (₹0.90 and 0.86) was recorded under control followed by Z_3 during both the years. The highest net return/rupee investment under soil applied treatment was mainly due to the comparable yield and relatively lesser cost of cultivation involvement in this treatment. Similar results were also reported by Barua and Saikia, 2018.

Quality parameters

Amylose content (%), rough rice length (mm), rough grain breadth (mm) and volume expansion ratio as influenced by various basmati rice varieties and zinc management practices have been presented in (Table. 4). The maximum amylose content, rough grain breadth (mm) and volume expansion ratio was found in Pusa Basmati-1121, which was superior over rest of the varieties during both the years, except in amylose content where it was *on par* with Pusa-1401 during 2018. While the lowest amylose content, rough grain breadth (mm) was recorded in Pusa Basmati-1509, however the lowest volume expansion ratio was recorded in Pusa-1401 during both the years. Although, being *at par* with Pusa Basmati-1121 the maximum rough grain length was recorded in Pusa Basmati-1509 (12.7 and 12.66mm), which was significantly superior over Pusa-1401 during both the years. The differences in the quality parameters were probably be due to the variation in genetic makeup of the different varieties. The results are in corroboration with the finding of Singh *et al.*, 2012 [17]. However, data collected also revealed that amylose content and rough grain length different significantly among the different zinc management practices, but rough grain breadth and volume expansion ratio showed a non-significant difference during both the years. The maximum amylose content (%), rough rice length (mm) and volume expansion ratio was recorded in seedling dipping in 2% $ZnSO_4$ + foliar spray @ 0.5% at T and PI stage, while maximum rough grain breadth was recorded under control during both the years. Application of zinc fertilizers may improve the quality parameters through higher Zn availability to plants than control. Ghasal *et al.*, 2016 [5] reported the similar findings.

Table 4: Effect of different basmati rice varieties and zinc management practices on amylose content, grain length, grain breadth and water uptake

Treatment	Amylose content (%)		Grain length (mm)		Grain breadth (mm)		Volume expansion ratio	
	2018	2019	2018	2019	2018	2019	2018	2019
Varieties								
V_1	24.7	24.4	12.4	12.4	2.79	2.79	0.368	0.370
V_2	23.8	23.6	11.5	11.5	2.67	2.62	0.301	0.305
V_3	21.8	21.7	12.7	12.6	2.54	2.53	0.352	0.352
S.Em±	0.3	0.3	0.08	0.09	0.04	0.01	0.002	0.001
C.D. (P=0.05)	1.3	1.0	0.34	0.38	0.14	0.03	0.008	0.005
Zinc management practices								
Z_1	22.4	22.1	11.8	11.8	2.69	2.67	0.338	0.339
Z_2	23.9	23.8	12.3	12.2	2.66	2.63	0.341	0.344
Z_3	23.2	23.0	12.1	12.1	2.68	2.66	0.340	0.342
Z_4	24.4	24.0	12.3	12.4	2.63	2.62	0.342	0.349
Z_5	23.4	23.2	12.3	12.3	2.67	2.65	0.341	0.340
S.Em±	0.3	0.4	0.07	0.07	0.03	0.03	0.004	0.003
C.D. (P=0.05)	0.9	1.3	0.21	0.22	NS	NS	NS	NS

From the present study (2 years), it may be concluded that among the varieties Pusa Basmati-1121 followed by Pusa Basmati-1509 were found better for growth parameters, yield attributes and yield and quality parameters. While, Pusa Basmati-1121 and Pusa Basmati-1509 were nearly similar in net returns/rupee invested to each other. Application of seedling dipping in 2% $ZnSO_4$ + foliar spray @ 0.5% at T and PI stage proved superior most in respect of growth parameters, yield attributes, grain yield and quality parameters. But, Highest net return was incurred with soil applied zinc @ 15 kg/ha followed by seedling dipping in 2% $ZnSO_4$ + foliar spray @ 0.5% at T and PI stage and seedling dipping in 2% $ZnSO_4$ + foliar spray @ 0.5% at PI stage.

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