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To optimize doses of Zn, Fe and Mn in different combinations and its effect on yield contributing characters, seed recovery and quality in rice (*Oryza sativa* L.) varieties

Jai Prakash Gupta, SC Vimal, Ajay Kumar, GD Kushwaha and JP Srivastava

Abstract
The present investigation were conducted during *Kharif* 2015 and 2016 at Student Instructional Farm and lab experiments were carried out in Seed Testing Laboratory of Seed Technology Section, N. D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) India with objective of the study was to optimize doses of Zn, Fe and Mn in different combinations and its effect on yield contributing characters, seed recovery and quality in rice (*Oryza sativa* L.) varieties for yield contributing traits and seed quality parameters *i.e.* days to 50% flowering, no of tillers per plant, productive tillers per hill, Plant height (cm), panicle length, Days to maturity, spikelet fertility, harvest index, seed recovery, seed yield (q/ha), 1000 seed weight (g), germination (%), seedling vigour index and electrical conductivity. The experiment was laid out in the three foliar spray of micronutrient doses *viz*. M_1 (Zn, Fe and Mn @0.25%, 0.50% & 0.25%), M_2 (Zn, Fe and Mn @ 0.50%, 1.00% & 0.50%) and M_3 (Zn, Fe and Mn @0.75%, 1.50% & 0.75%) with three varieties *viz.* NDR 97, NDR359 and BPT 5204. The result revealed that inoculation of foliar spray of micronutrients doses significantly improved days to 50% flowering, no. of tillers per plant, productive tillers per hill, Plant height (cm), panicle length, Days to maturity, spikelet fertility, harvest index, seed recovery, seed yield (q/ha), 1000 seed weight (g), germination (%), vigour index and reduce electrical conductivity. Overall the treatment of findings revealed that among doses of foliar spray of micronutrient, Zn, Fe and Mn @ 0.75%, 1.50% & 0.75% may be utilized in rice for seed production as it produced higher seed yield, maintained the seed recovery and other yield contributing quality of seeds.

Keywords: Micronutrients supplementation, foliar spray, seed recovery, Rice seed

Introduction
Rice (*Oryza sativa* L.) is a semi-aquatic annual grass plant belongs to the genus *Oryza*, tribe Oryzeae and family Poaceae. It is the second largest principal food crop in the world after wheat and is one of the main staple food crop in India. Besides being the staple food crop, it has been the cornerstone of food and culture for our people. Among seven billion people on the earth, more than half of them depend on this crop for principal source of energy in their daily diet. Rice is distributed over a wider range of latitude from 50 ^{0} N to 40 ^{0} S and is being grown up to an altitude of 2500 meters. It evolved in humid tropics as a semi aquatic plant and it has got unique adaptive nature to hot humid environment, which is not seen in any other major cereal crop.

Rice yield in India fluctuate greatly in time and space on account of its cultivation under diverse weather, ecological and socio-economic conditions. Out of the total 43.86 million ha. under rice, 20 million ha. area is irrigated and the remaining 23.86 million ha. area is cultivated in rainfed conditions. Rice can be grown under different agro-ecological environments.

Seed quality plays a crucial role in realizing the full genetic potential of varieties as well as benefits of other agricultural inputs (Seshu and Dadlani, 1993) [11]. The use of quality seeds alone increases the productivity to the extent of 15-20 percent (Dahiya *et al.*, 1993) [15]. Only seeds with assured genetic and physical purity can be expected to response to the other inputs in agriculture. Among the inputs used by the farmers for agriculture production seed is the cheapest one and it forms only part of the cultivation expenses. All the efforts and investment would be unremunerative if farmer does not get good quality seeds.

Only seed with good germination and vigour can give a good stand of the crop, otherwise there will be inadequate plant population and low yields. A mere increase in the seed rate may compensate for poor germination, but it cannot ensure vigorous and uniform growth of the crop. Thus, quality seed is a crucial factor to enhance grain production in rice.

Micronutrient deficiency is considered as one of the major causes of the declining productivity trends observed in rice growing countries. Zinc plays an important role in different metabolic processes in plant. Iron deficiency chlorosis is caused by imbalance of metallic ions as Cu^{+2} and Mn^{+2}. The levels of micronutrients in soil is depleted due to continuous rowing of high yielding crop varieties and non-addition of organic manures having these elements which are essential for normal growth and development of plants for profitable crop yield.

Foliar sprays are widely used to apply micronutrients, especially iron and manganese, for many crops. Soluble inorganic salts are generally as effective as synthetic chelates in foliar sprays, so the inorganic salts are usually chosen because of lower costs. Correction of deficiency symptoms usually occurs within the first several days and then the entire field could be sprayed with the appropriate micronutrient source. It was found that micronutrients showed towards to increasing the yield of different crops.

Material and methods

The field experiments was conducted on three varieties of rice (*Oryza sativa*) *viz*. NDR-97, NDR-359 and BPT-5204 to study the to optimize doses of Zn, Fe and Mn in different combinations and its effect on yield contributing characters, seed recovery and quality in rice (*Oryza sativa* L.) varieties during *kharif* season 2015 and 2016 at Narendra Deva University of Agriculture & Technology Kumarganj Faizabad. It is situated at 26.47^0 N latitude and 82.12^0 E longitude and at an altitude of 113 m above mean sea level. The soil is silty loam in texture with moderate salinity. It has a semi-arid and sub-tropical climate characterized by extreme hot and cool winters.

The nursery beds of 8 m (length) X 1.5 m. (width) and 4 inches height were prepared and seeds of all the varieties were line sown in month of June. The seeds were then covered with soil and sprinkled with water. Fertilizer application, plant protection measures and regular watering were done as per recommendations.

Twenty one day old seedlings of all the varieties were transplanted at single seedling per hill with the spacing of 20 cm × 15 cm.

Before transplanting, 50 percent of the recommended nitrogen as ammonium sulphate entire dose of phosphorus as single super phosphate and potassium as Muriate of potash were applied to the experimental plot as basal dose. Nitrogen was applied in 2 equal splits, 10 and 50 days after transplanting.

After transplanting the seedling applied micronutrient treatment combination wise Zn, Fe and Mn @ 0.25%, 0.50% & 0.25%, Zn, Fe and Mn @ 0.50%, 1.00% & 0.50% and Zn, Fe and Mn @ 0.75%, 1.50% & 0.75% in the form of Foliar spry at vegetative stage (30 day after transplanting) and reproductive stage (at flowering) respectively. The observations were recorded at days to 50% flowering, no. of tillers per plant, productive tillers per hill, Plant height (cm), panicle length, Days to maturity, spikelet fertility, harvest index, seed recovery, seed yield (q/ha), 1000 seed weight (g), germination (%), vigour index and electrical conductivity.

In each plot, number of plants at flowering was recorded on alternate days. The date on which about 50% of plants attained flowering was taken as the date of 50% flowering and days taken for the same was computed.

Total number of tillers were observed and recorded manually on ten randomly selected plants in the field from each plot of different rice varieties. Among the total number of tillers recorded on ten randomly selected plants in each plot, the tillers which were bearing panicles were counted and recorded as productive tillers.

Plant height was recorded on ten randomly selected plants in each plot at the time of maturity from the base of the stem at ground level to the base of main panicle.

The mean length of panicle was obtained by measuring from the base to the tip of panicle on ten randomly selected panicles in each plot.

In each plot, the number of plants at maturity was recorded on alternate days. The data on which about more than 50% of plants attained maturity was taken as the date of maturity and days taken for the same was computed.

Numbers of fertile spikelet ware recorded from ten selected plants from each plot and the data obtained was computed in to percentage.

$$\text{Spikelet fertility (\%)} = \frac{\text{Filled grains per panicle}}{\text{Total grains per panicle}} \times 100$$

Harvest index was calculated by using following formula,

$$\text{Harvest index (\%)} = \frac{\text{Economical yield (kg)}}{\text{Biological yield (kg)}} \times 100$$

Total amount of pure seed was obtained by separating under sized and light seeds after processing of raw seed. The amount was recorded in the kilogram and it was recorded in percentage by computing with suitable conversion factor. The seeds obtained from the corresponding plots were sun dried, weighed and recorded. The seed yield per hectare was computed with appropriate conversion factor.

Test weight (g) was determined by counting manually one hundred seeds of eight replicates from each genotype and weighed up to four significant figures on top pan precision balance. Coefficient of variation was calculated, replication showing C.V. less than 6.0 were selected and mean was calculated. The mean was multiplied by 10 to get the final 1000 seed weight. The weight was expressed in grams.

Germination test was conducted by using 'between paper' method as per (ISTA, 2008) [3]. Four replicates of one hundred seeds from each treatment were placed equidistantly on moist germination paper. The rolled towels were incubated at 25±1 ^{0}C for fourteen days. The first and final counts were recorded on fifth and fourteenth day, respectively. The germination percentage was recorded on the basis of normal seedling only at the final count and expressed in percentage.

Ten seedlings from each replication were taken at random after fourteenth day of incubation to determine the seedling length. The seedling length was measured from the tip of the primary root to the tip of the primary leaf and mean of ten seedlings was calculated and expressed in centimetres. The seedlings used to measure seedling length were dried in a hot air oven maintained at 80 ±2 ^{0}C for 24 hours. Later they were cooled over silica gel and weighed. The mean dry weight of seedlings was computed and expressed in milligram. Seedling vigour index was calculated by using seedling growth parameters and expressed as a whole number as suggested by Abdul-Baki and Anderson (1973) and it is given below.

Vigour index I = Germination (%) x Mean seedling length (cm)
Vigour index II = Germination (%) x Mean seedling dry weight (mg)

Four replicates of fifty seeds each for each treatment were soaked in 50 ml distilled water for 24h at 20 ± 1 ^{0}C. At the end of soaking, the steeped water (seed leachate) was decanted and electrical conductivity of the seed leachate was measured with the help of Conductivity Bridge and expressed in dS/m/gm (ISTA, 2008) [3].

Results and Discussion

The data recorded on various characters were analyzed statistically to authenticate the effects of different variety, transplanting spacing, transplanting methods, varied doses of foliar spray micronutrients (Zn, Fe and Mn) on rice seed production and its quality. The conspicuous findings of the present investigation entitled "To optimize doses of Zn, Fe and Mn in different combinations on yield contributing characters, seed recovery and quality in rice (*Oryza sativa* L.)" have been elaborated under following heads and presented in corresponding tables.

Days to 50% flowering

Early flowering results the early maturity of crop but seed crop may require more number of days for complete desiccation of seed than the crop grown for production point of view. The results over two years revealed that days to 50% flowering significantly responded to varied fertilizer doses. A significant decrease in days to 50% flowering was noticed under each increment of foliar spray of micronutrient doses in the year 2015 and 2016. The minimum days to 50% flowering (95.53 days and 97.86 days respectively) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively (Table 1). And also significant decrease in days to 50% flowering was noticed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties. The present findings are in accordance with the results obtained by Rao and Shrivatava (1999) [9].

No. of tillers per plant and Productive tillers per hill

Number of tillers per plant and number of productive tillers per hill was significantly influenced. The maximum number of tillers per plant (20.06 and 22.06 respectively) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found significantly superior to other levels of micronutrients supplementations, whereas maximum number of productive tillers per hill (18.06 and 18.81 respectively) was observed under foliar spray Zn, Fe and Mn @0.75%, 1.50% & 0.75%, which was found significantly superior to other levels of micronutrients supplementations in 2015 and 2016, respectively,(Table 1). And also Number of tillers per plant and number of productive tillers per hill was significantly influenced under foliar spray Zn, Fe and Mn @0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties. The present findings are in accordance with the results obtained by Sarkar *et al*. (2002) and Zayed *et al*. (2011) [10, 15] .

Plant height (cm)

Increased foliar spray of micronutrients doses had shown significant increase in plant height during both the years. The maximum plant height of 91.23 cm and 92.60 cm was registered under the treatment of foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which showed significant superiority over other doses of foliar spray of micronutrients doses in 2015 and 2016, respectively, (Table 1). And also plant height was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

Panicle length (cm)

Increased foliar spray of micronutrients doses had shown significant increase in panicle length during both the years. The maximum panicle length of 23.79 cm and 24.83 cm was registered under the treatment of foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which showed significant superiority over other doses of foliar spray of micronutrients doses in 2015 and 2016, respectively,(Table 1). The shortest panicle length (22.50 cm and 23.54 cm) was recorded with foliar spray Zn, Fe and Mn @ 0.25%, 0.50% & 0.25% during first and second year, respectively, (Table 1). And also panicle length was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

Days to maturity

A significant decrease in days to maturity was noticed under each increment of foliar spray of micronutrient doses in the year 2015 and 2016. The minimum days to maturity (124.47 days and 127.14 days respectively) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively (Table 2). And also significant decrease in days to maturity was noticed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

Spikelet fertility (%)

A significant increase in spikelet fertility was noticed under each increment of foliar spray micronutrients doses in both the years. The maximum spikelet fertility (88.46% and 89.62%) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found significantly superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively, (Table 3). And also spikelet fertility was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

Harvest Index (%)

A significant increase in harvest index was noticed under each increment of foliar spray micronutrients doses in both the years. The maximum harvest index (32.24% and 33.24%) was observed under foliar spray Zn, Fe and Mn @0.75%, 1.50% & 0.75%, which was found significantly superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively, (Table 2). And also harvest index was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties. The present findings are in accordance with the results obtained by Yassen *et al.* (2010) and Zayed *et al.* (2011) [14, 15].

Seed recovery (%)

A significant increase in seed recovery was noticed under each increment of foliar spray micronutrients doses in both the years. The maximum seed recovery (86.70% and 89.11%) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found significantly superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively, (Table 2). And also seed recovery was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

Seed Yield

A significant increase in seed yield was noticed under each increment of foliar spray micronutrients doses in both the years. The maximum seed yield (42.40q/ha and 43.22q/ha) was observed under foliar spray Zn, Fe and Mn @0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively,(Table 2). And also seed yield was significantly influenced under foliar spray Zn, Fe and Mn @0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

1000 seed weight (gm)

1000 seed weight was noticed under each increment of foliar spray micronutrients doses in both the years. The maximum 1000 seed weight (23.29g and 23.40g) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively, (Table 3). And also 1000 seed weight was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties. The present findings are in accordance with the results obtained by Yassen *et al.* (2010) and Zeidan *et al.* (2010) [14, 16] .

Germination test (%)

A significant increase in seed germination was noticed under each increment of foliar spray micronutrients doses in both the years. The maximum germination (90.23% and 91.56%) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found significantly superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively, (Table 3). And also seed germination was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

Seedling vigour index

A significant increase in seedling vigour index was noticed under each increment of foliar spray micronutrients doses in both the years. The maximum seedling vigour index I and II (2188.20 and 2254.17) and (1383.89 and 1371.32) was observed under foliar spray Zn, Fe and Mn @0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively, (Table 3). And also seedling vigour index was significantly influenced under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

Table 1: Effect of foliar spray of micronutrients does on days to 50% flowering, tillers per plant, productive tillers per hill, plant height and panicle length in rice varieties during 2015 and 2016

Treatment	50% Flowering		Tillers/Plant (No.)		Pro. Tillers/hill (No.)		Plant Height (cm)		Panicle length (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
NDR 97 (V_1)	69.85	71.85	15.48	17.48	13.48	13.38	80.37	81.38	20.72	21.98
NDR 359 (V_2)	102.08	105.08	19.54	21.54	17.54	17.54	94.93	97.14	24.27	25.37
BPT 5204 (V_3)	119.38	121.38	16.98	18.98	14.98	15.29	93.46	94.35	23.52	24.27
SEm ±	0.77	0.94	0.16	0.16	0.16	0.21	1.02	0.97	0.24	0.29
CD 5%	2.27	2.76	0.47	0.47	0.47	0.63	3.00	2.84	0.70	0.86
Control (M_0)	98.83	101.17	14.47	16.47	12.47	12.11	88.01	89.38	21.97	23.01
Zn, Fe and Mn @0.25%, 0.50% & 0.25% (M_1)	97.50	99.83	16.69	18.69	14.69	14.31	89.04	90.41	22.50	23.54
Zn, Fe and Mn @0.50%, 1.00% & 0.50% (M_2)	96.56	98.89	18.11	20.11	16.11	16.39	90.06	91.43	23.09	24.12
Zn, Fe and Mn @0.75%, 1.50% & 0.75% (M_3)	95.53	97.86	20.06	22.06	18.06	18.81	91.23	92.60	23.79	24.83
SEm ±	0.67	1.07	0.16	0.16	0.16	0.24	0.88	0.79	0.25	0.34
CD 5%	1.90	3.02	0.46	0.46	0.46	0.68	2.49	2.32	0.71	0.95
$V_1 \times M_0$	71.50	73.50	13.42	15.42	11.42	11.50	78.66	79.67	19.83	21.09
$V_1 \times M_1$	70.17	72.17	14.83	16.83	12.83	12.17	79.66	80.67	20.42	21.68
$V_1 \times M_2$	69.50	71.50	16.17	18.17	14.17	13.83	80.87	81.88	20.93	22.19
$V_1 \times M_3$	68.25	70.25	17.50	19.50	15.50	16.00	82.30	83.31	21.70	22.96
$V_2 \times M_0$	103.42	106.42	16.00	18.00	14.00	13.17	93.37	95.58	23.38	24.48
$V_2 \times M_1$	102.25	105.25	18.83	20.83	16.83	16.58	94.42	96.63	23.93	25.03
$V_2 \times M_2$	101.67	104.67	20.50	22.50	18.50	18.83	95.39	97.60	24.53	25.63
$V_2 \times M_3$	101.00	104.00	22.83	24.83	20.83	21.58	96.56	98.77	25.24	26.34
$V_3 \times M_0$	121.58	123.58	14.00	16.00	12.00	11.67	92.01	92.90	22.71	23.46
$V_3 \times M_1$	120.08	122.08	16.42	18.42	14.42	14.17	93.04	93.93	23.16	23.91
$V_3 \times M_2$	118.50	120.50	17.67	19.67	15.67	16.50	93.94	94.83	23.80	24.55
$V_3 \times M_3$	117.33	119.33	19.83	21.83	17.83	18.83	94.84	95.73	24.43	25.18
SEm ±	1.17	1.86	0.282	0.282	0.282	0.417	1.530	1.526	0.434	0.582
CD 5%	3.29	5.23	0.795	0.795	0.795	1.175	4.313	4.302	1.224	1.641

Table 2: Effect of foliar spray of micronutrients on days to maturity, spikelet fertility, harvest Index, Seed recovery and Seed yield in rice

varieties during 2015 and 2016

Treatment	Days to Maturity		Spikelet fertility (%)		Harvest Index (%)		Seed Recovery (%)		Seed Yield(q/ha)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
NDR 97 (V_1)	98.06	100.06	83.42	85.71	27.65	28.78	81.27	84.43	26.67	27.63
NDR 359 (V_2)	129.38	132.38	89.47	90.27	30.16	30.86	80.04	82.12	44.84	45.70
BPT 5204 (V_3)	150.06	153.06	89.22	89.83	27.72	28.57	84.60	86.58	50.14	50.79
SEm ±	0.95	1.04	1.11	1.08	0.31	0.38	0.93	0.96	0.51	0.52
CD 5%	2.78	3.06	3.24	3.17	0.91	1.11	2.74	2.83	1.48	1.51
Control (M_0)	127.14	129.81	86.16	87.47	25.60	26.41	78.59	81.00	38.92	39.74
Zn, Fe and Mn @0.25%, 0.50% & 0.25% (M_1)	126.25	128.92	87.09	88.34	27.27	28.13	80.32	82.73	39.84	40.66
Zn, Fe and Mn @0.50%, 1.00% & 0.50% (M_2)	125.47	128.14	87.77	88.97	28.94	29.84	82.28	84.68	41.04	41.86
Zn, Fe and Mn @0.75%, 1.50% & 0.75% (M_3)	124.47	127.14	88.46	89.62	32.24	33.24	86.70	89.11	42.40	43.22
SEm ±	1.09	1.11	0.89	1.11	0.33	0.41	0.90	1.05	0.51	0.53
CD 5%	3.08	3.13	2.51	3.14	0.93	1.15	2.54	2.96	1.42	1.49
$V_1 \times M_0$	99.17	101.17	81.83	84.27	23.44	24.45	77.89	81.05	25.04	26.00
$V_1 \times M_1$	98.50	100.50	83.06	85.39	26.16	27.26	79.62	82.78	25.96	26.92
$V_1 \times M_2$	97.75	99.75	84.01	86.24	28.61	29.77	81.58	84.74	27.16	28.12
$V_1 \times M_3$	96.83	98.83	84.78	86.93	32.37	33.65	86.00	89.16	28.52	29.48
$V_2 \times M_0$	130.83	133.83	88.44	89.28	28.02	28.69	76.66	78.74	43.21	44.07
$V_2 \times M_1$	129.75	132.75	89.19	90.00	28.67	29.34	78.39	80.47	44.13	44.99
$V_2 \times M_2$	128.83	131.83	89.80	90.59	29.91	30.60	80.35	82.43	45.33	46.19
$V_2 \times M_3$	128.08	131.08	90.46	91.22	34.05	34.83	84.77	86.85	46.69	47.55
$V_3 \times M_0$	151.42	154.42	88.22	88.86	25.33	26.08	81.22	83.20	48.51	49.16
$V_3 \times M_1$	150.50	153.50	89.02	89.63	26.97	27.79	82.95	84.93	49.43	50.08
$V_3 \times M_2$	149.83	152.83	89.49	90.09	28.30	29.16	84.91	86.89	50.63	51.28
$V_3 \times M_3$	148.50	151.50	90.15	90.73	30.30	31.25	89.33	91.31	51.99	52.64
SEm ±	1.89	1.92	1.54	1.93	0.57	0.71	1.56	1.82	0.88	0.91
CD 5%	5.33	5.41	4.35	5.43	1.61	1.99	4.40	5.12	2.47	2.58

Table 3: Effect of foliar spray of micronutrients on 1000 seed weight, germination test, seedling vigour index and electrical conductivity in rice varieties during 2015 and 2016

Interaction	1000 Seed weight (g)		Germination (%)		Seedling vigour index I		Seedling vigour index II		E.C. (dS/m/gm)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
NDR 97 (V_1)	22.29	22.40	85.08	87.08	2176.64	2253.85	1449.10	1497.07	1.36	1.25
NDR 359 (V_2)	26.40	26.52	88.08	89.08	2011.79	2067.56	1771.96	1809.88	1.20	1.09
BPT 5204 (V_3)	19.05	19.16	87.08	88.08	1984.37	2043.25	712.87	741.31	0.98	0.87
SEm ±	0.24	0.28	0.52	0.50	13.12	14.38	13.93	8.75	0.01	0.01
CD 5%	0.68	0.80	1.46	1.41	36.72	40.27	39.00	24.50	0.04	0.03
Control (M_0)	21.89	22.00	82.60	83.94	1915.15	1976.87	1230.43	1267.41	1.31	1.20
Zn, Fe and Mn @0.25%, 0.50% & 0.25% (M_1)	22.35	22.46	86.35	87.69	2030.85	2094.40	1298.02	1335.94	1.23	1.12
Zn, Fe and Mn @0.50%, 1.00% & 0.50% (M_2)	22.79	22.90	87.79	89.13	2096.21	2160.78	1332.91	1371.32	1.14	1.03
Zn, Fe and Mn @0.75%, 1.50% & 0.75% (M_3)	23.29	23.40	90.23	91.56	2188.20	2254.17	1383.89	1423.00	1.05	0.94
SEm ±	0.28	0.33	0.60	0.58	15.14	16.61	16.08	10.10	0.02	0.01
CD 5%	0.78	0.92	1.69	1.63	42.41	46.50	45.03	28.29	0.05	0.03
$V_1 \times M_0$	21.44	21.54	80.94	82.94	2013.50	2088.11	1356.11	1402.88	1.61	1.50
$V_1 \times M_1$	22.02	22.12	84.69	86.69	2142.07	2218.63	1432.82	1480.51	1.45	1.34
$V_1 \times M_2$	22.49	22.60	86.13	88.13	2222.20	2300.19	1473.01	1521.30	1.28	1.17
$V_1 \times M_3$	23.22	23.32	88.56	90.56	2328.79	2408.48	1534.47	1583.59	1.12	1.01
$V_2 \times M_0$	25.59	25.72	83.94	84.94	1874.08	1927.83	1669.63	1706.51	1.27	1.16
$V_2 \times M_1$	26.12	26.25	87.69	88.69	1985.83	2041.28	1755.91	1793.66	1.23	1.12
$V_2 \times M_2$	26.71	26.83	89.13	90.13	2048.19	2104.50	1800.68	1838.90	1.18	1.07
$V_2 \times M_3$	27.16	27.28	91.56	92.56	2139.07	2196.65	1861.63	1900.46	1.11	1.00
$V_3 \times M_0$	18.63	18.74	82.94	83.94	1857.85	1914.66	665.53	692.86	1.05	0.93
$V_3 \times M_1$	18.90	19.00	86.69	87.69	1964.67	2023.28	705.34	733.64	1.01	0.89
$V_3 \times M_2$	19.17	19.28	88.13	89.13	2018.23	2077.65	725.04	753.76	0.96	0.85
$V_3 \times M_3$	19.50	19.60	90.56	91.56	2096.73	2157.40	755.57	784.96	0.91	0.80
SEm ±	0.48	0.57	1.04	1.01	26.23	28.77	27.86	17.50	0.03	0.02
CD 5%	1.35	1.59	2.92	2.82	73.45	80.55	78.00	49.00	0.08	0.05

Electrical conductivity (dS/m/gm)

A significant decrease in electrical conductivity was noticed under each increment of foliar spray micronutrients doses in both the years. The minimum electrical conductivity (1.05 dS/m/gm and 0.94 dS/m/gm) was observed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found significantly superior to other levels of foliar spray micronutrients doses in 2015 and 2016, respectively, (Table 3). And also significant decrease in electrical conductivity was noticed under foliar spray Zn, Fe and Mn @ 0.75%, 1.50% & 0.75%, which was found superior to other levels of foliar spray micronutrients doses with all investigated varieties.

The above findings are in accordance with the results obtained by Hammes (1969) [7] found positive relationship between seed quality parameters and size of seeds. There was an increase in shoot length, root length and dry matter with increase in seed weight. According to Cicero and Orsie (1978) [4] vigour was greater in the heavy seeds than in the light seeds. Amral and Dos (1979) [2] observed that rice seeds of higher weight and size had better physiological quality as shown by higher longevity, germination capacity and higher vigour, than lighter seeds. Gasper and Bus (1981) [6] reported that, in seeds of higher 1000 seed weight were superior both in germination capacity and seedling vigour. Mathur *et al.* (1982) [8] observed a significant positive association between 1000 seed weight (g), dry matter (mg/10 seedlings), germination percent, germination index, root length and shoot length. Vannagamudi and Ramaswamy (1984) [13] reported that co-efficient of variation in seed weight and vigour parameters like root, shoot and coleoptiles lengths of the seedlings varied significantly within and between size grades of seed. Tomar and Prasad (1993) [12] reported that germination percentage decreased as specific gravity of seed decreased.

Yassen *et al.* (2010) [14] reported that among the nutrients, Zn, Fe and Mn are prerequisite to crop plants. These can play a vital role enabling the rice crop to achieve their full genetic potential. Generally the seed crop have additional requirement of plant nutrients in place of recommended dose of fertilizer for better growth and development. In addition, increased fertilizer doses helped greater root establishment due to increased meristematic activates which contribute to rapid cell division and cell elongation and thus led to taller plants under the treatments.

Conclusion

In the light of results obtained in above investigation may be safely concluded that among doses of foliar spray of micronutrient, Zn, Fe and Mn @ 0.75%, 1.50% & 0.75% may be utilized in rice for seed production as it produced higher seed yield, maintained the seed recovery and other yield contributing quality of seeds. In future, more increased doses of foliar spray of micronutrient should be tested for optimization of doses up to critical level of hunger in seed crop of rice.

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