Effect of integrated nutrient management on yield and seed quality in rice

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ABSTRACT

Field experiments were conducted to find out the effect of rice varieties and integrated nutrient management on rice seed production in rice-wheat cropping system at New Delhi during wet seasons of 2006-08. The experimental treatments included three rice varieties viz. Pusa 44, Pusa Basmati 1 and Pusa 1121and six nutrient management practices viz. control-$N_0P_0K_0$; recommended dose of nitrogenous fertilizer (N 120 kg ha^{-1})*; 75% of recommended dose of nitrogen; 75% of recommended dose of nitrogen + Azolla 1 t ha^{-1}; 75% of recommended dose of nitrogen + Blue Green Algae (BGA) 2kg ha^{-1} and 75% of recommended dose of nitrogen + BGA 2kg ha^{-1} + Azolla 1 t ha^{-1}. In addition to these treatments, standard recommended dose of 37.5kg of P_2O_5 ha^{-1} and 47kg of K_2O ha^{-1} were applied to all the plots except absolute control. The results indicated that integrated application of 75% of recommended dose of chemical nitrogen along with Azolla or BGA significantly influenced plant growth, yield attributes and seed quality of rice as compared to control. Beside seed quality, iron and zinc content in rice grain was enhanced due to integrated nutrient management. Organic content of soil increased due to integrated nutrient management.*

Key words: *rice, seed, quality, biofertilizer, integrated nutrient management*

Use of high energy agricultural inputs like chemical fertilizers and pesticides cause soil and environmental hazards, so it is desirable to develop a sustainable production system that give optimum productivity with minimum environmental pollution. The world's most productive 'rice - wheat production system' occupying 10 million ha area in India has also showing signs of fatigue during the last decade. The evidences suggest that natural resources may be reducing productivity in this production system (Prasad, 2005) In India, zinc deficiency is widespread in the rice-wheat cropping system belt of north India which has high pH and calcareous soils (Prasad 2005). Evidences also indicate increased environmental pollution by nutrient leaching or runoff from farms mainly because of increased fertilizer application with low fertilizer use efficiency of crops (FAO 1994, Singh and Singh, 2003). Judicious management of organic and inorganic sources of nutrients is extremely important to reverse this trend. The integrated use of chemical fertilizers, biofertilizers, green manuring and recycling of crop residues thus assumes greater significance (Meelu, 1996). There are many effective practices like green manuring, use of biofertilizers like blue green algae (BGA), *Azolla etc* (Singh and Bisoyi, 1989; Singh and Mandal, 1997) which can be used as a component of integrated nutrient management in rice. The green manuring and biofertilizers not only add nutrients such as nitrogen to the soil, but also help prevent weeds and increase organic matter to feed soil microorganisms (Singh and Bisoyi, 1989).

Seeds of appropriate characteristics are required to meet the demand of diverse agro-climatic conditions and intensive cropping systems. Effect of integrated nutrient management on crop productivity has been elaborately worked out but information on its effect on the quality of rice seed is scanty. With this background, an experiment was conducted to find out the effect of integrated nutrient management on yield and quality of rice seed.

MATERIALS AND METHODS

A field experiment was conducted on rice seed production at the research farm of Indian Agricultural Research Institute, New Delhi, India during wet seasons of 2006-07 and 2007-08 in rice-wheat cropping system. The soil of the experimental plot was sandy clay loam having 52% sand, 22.5% silt and 22.5% clay. The initial soil test values were: pH 8.4, organic carbon 4.9 g kg^{-1}, available nitrogen 340.5 mg kg^{-1}, available P 23 mg kg^{-1} and available potassium 276.4 mg kg^{-1}. The experiment was started with rice crop and it was fallowed by wheat crop. In the same field rice- wheat system was followed for more than 10 years.

The experimental treatments included three rice varieties viz. Pusa 44, Pusa Basmati 1 and Pusa 1121 in main plot and six nutrient management practices viz. control without any application of nutrients recommended dose of nitrogenous fertilizer (120kg ha^{-1} fertilizer); 75% of recommended dose of nitrogen; 75% of recommended dose of nitrogen + *Azolla* 1 t ha^{-1} ; 75% of recommended dose of nitrogen + BGA 2.0 kg ha^{-1} and 75% of recommended dose of nitrogen + Blue Green Algae 2kg ha^{-1} + *Azolla* 1 t ha^{-1} in sub-plot. The treatments were laid out in split plot design and replicated thrice. *Azolla microphylla* was applied in this experiment as it multiplied better in the agro-climatic conditions of Delhi. Chemical analysis of *Azolla* inoculums before application indicated that it contained 3.2 to 3.4% nitrogen on dry weight basis. Inoculums of *Azolla* and BGA were broadcasted as per treatment on the standing water 3 to 4 days after transplantation of rice. After the application, the field was kept water logged for 20 days. During field preparations, the standard recommended dose of P and K were applied 37.5 kg P_2O_5 and 47 kg K_2O ha^{-1} to all plots except control plot. Nitrogen was applied as per treatments in three equal splits at transplanting, active tillering and booting stage. Twenty one days old seedlings were transplanted with 2 seedlings $hill^{-1}$. The gross and net plot sizes were 24 and 16 m^2, respectively.

Observations on plant height, yield attributes and grain yield were taken. Soil samples taken at crop harvest stage from 0-15 cm depth were analyzed for its organic carbon content (Walkley and Black, 1934 and Prasad *et al.,* 2006) and micronutrients (iron and zinc) content in rice grains (Prasad *et al.,* 2006; Lindsay and Norvell, 1978). Seed quality attributes like 1000-seed weight, initial germination, shoot length, root length, total seedling length, seedling dry weight, vigor index-I and vigor index-II were recorded in randomly selected seeds in each replication following the ISTA rules (Anonymous, 1999). Seed germination test was conducted between the paper (BP) in four replicates of 50 seeds each, following ISTA method at 25 ^{0}C (Anonymous 1999). The germinated seeds were evaluated on the seventh day as normal seedlings, abnormal seedlings, hard seeds and dead seeds. Germination percentage was recorded on the basis of normal seedlings only were subjected to statistical analysis (Fisher and Frank 1963). Seedling vigor was measured as the dry weight of 10 normal seedlings taken randomly from each replication after the final count of germination. Seedlings were dried at $80^{0}C$ for 24 hours and then weight was taken. Seedling vigor index–I was calculated by multiplying germination percent with total seedling length and vigor index–II was calculated by multiplying germination percent with seedling dry weight (Abdulbaki and Anderson 1973).

RESULTS AND DISCUSSION

Plant growth characteristics viz. plant height and tillers $hill^{-1}$ was significantly influenced by the different nutritional treatments over control during both the years of experimentation (Table 1). Plants of Pusa 1121 were the tallest but Pusa 44 produced maximum tillers. The maximum plant height and tillers $hill^{-1}$ were recorded when 75% recommended dose of nitrogen was added with BGA and *Azolla.* Application of adequate nutrients promoted the supply of assimilates from the sources to sink would have resulted in increased plant height and production of more tillers $hill^{-1}$ at higher NPK level applied as integrated or fertilizer. (Singh and Mandal,1997).

Yield attributes like productive tillers $hill^{-1}$, panicle length, filled grain $panicle^{-1}$, spike fertility and spike sterility were significantly influenced by different inorganic as well as integrated nutrient management practices over control in both the years (Table 1). However, test weight of grain and panicle exertion did not increase significantly. Among the three rice varieties, Pusa 44 showed maximum filled grains $panicle^{-1}$ and spikelet fertility while Pusa Basmati 1 had maximum panicle length and panicle exertion. The maximum enhancement in yield attributes were recorded when 75% recommended dose of nitrogen was added with BGA and *Azolla.* Thus, application of adequate nutrients at higher NPK level or applied through integrated nutrient management promoted the supply of assimilates from the sources to sink would

Table 1. Effect of different treatments on plant height and yield attributes in rice

Treatment	Total tillers $hill^{-1}$		Productive tillers $hill^{-1}$		Plant height at harvest(cm)		Panicle length (cm)		Panicle exertion (%)		Filled grain $panicle^{-1}$		Spikelet fertility (%)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Rice varieties														
Pusa 44	21.6	28.0	19.3	25.0	88.6	89.2	33.4	34.1	85.6	80.8	200	191	89.3	87.8
Pusa 1121	19.8	24.2	17.1	21.2	116.3	115.5	34.8	35.2	85.7	80.3	168	165	78.5	74.0
P Basmati1	19.6	25.0	17.3	23.0	110.4	109.8	38.7	38.2	89.7	83.3	157	136	83.8	80.5
C.D (5%)	1.9	2.3	1.4	1.6	4.5	12	2.5	3.2	NS	NS	17.5	22.7	8.5	6.8
Nutrient doses														
T-1	14.8	21.7	13.2	19.0	100.4	101.2	34.8	35.1	88.3	89.7	122	105	82.0	77.2
T-2	20.2	31.3	19.2	28.3	106.5	104.2	36.8	37.2	87.3	91.9	161	122	82.5	80.4
T-3	20.4	29.7	19.1	24.3	104.9	103.4	37.3	36.6	87.5	91.7	145	145	85.6	83.2
T-4	20.5	28.7	19.5	25.7	105.6	105.2	37.0	37.8	88.7	91.4	143	142	84.4	81.6
T-5	22.0	27.3	20.2	24.3	108.4	107.9	36.5	37.3	89.8	92.1	153	149	84.4	81.1
T-6	23.1	25.7	21.0	24.7	108.5	109.9	37.6	37.7	89.3	93.6	165	153	84.2	81.0
C.D (5%)	1.7	6.7	8.7	4.5	3.3	1.8	1.3	1.4	0.5	0.5	8	10	NS	NS

have resulted in production of greater number of filled grains $panicle^{-1}$. (Budhar and Palaniappan, 1996, Singh and Mandal, 1997).

Among the rice varieties, Pusa 44 showed significantly higher number of filled grains $panicle^{-1}$ and spikelet fertility than the other two varieties and this resulted in higher seed yield of this variety (Table2). The higher seed yield of Pusa 44 was mainly attributed to the higher number of productive tillers, greater panicle length, filled grain $panicle^{-1}$ and spikelet fertility. Although Pusa Basmati 1 had maximum panicle length and panicle exertion did not record highest grain yield. The lower seed yield by Pusa Basmati 1 was mainly attributed to the less number of grain $panicle^{-1}$ and lower number of total and productive tillers $hill^{-1}$. The causes of lower seed yield by Pusa 1121 were the same as for Pusa Basmati 1. The difference in seed yield among the rice varieties having scented (Pusa Basmati 1 and Pusa 1121) and non-scented (Pusa 44) characteristics

Table 2. Effect of different treatments on seed quality attributes and yield of rice

Treatment	Seed recovery (%)		Seed length (mm)		Seed width (mm)		1000-Seed wt.(g)		Seed moisture (%)		Seed yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Rice varieties												
Pusa 44	93.3	89.2	9.1	9.6	2.1	2.1	22.4	22.4	16.2	16.4	4.81	5.22
Pusa 1121	89.4	86.2	11.8	13.4	2.2	2.7	29.7	29.6	15.7	17.1	4.45	4.52
P Basmati1	85.6	85.4	10.8	11.9	2.2	2.1	22.6	22.7	14.9	16.1	4.38	4.51
C.D (5%)	6.8	4.5	1.5	2.0	NS	NS	5.6	4.5	1.5	0.5	0.45	0.41
Nutrient doses												
T-1	78.1	78.9	10.5	11.6	2.4	2.3	25.0	24.9	15.6	16.8	3.92	4.07
T-2	80.6	80.5	10.5	11.6	2.3	2.5	24.9	24.8	15.5	16.4	5.38	5.49
T-3	80.0	79.5	10.7	11.8	2.3	2.3	25.0	25.0	15.6	16.5	4.48	4.42
T-4	79.7	79.3	10.3	11.3	2.2	2.1	24.9	24.9	15.8	16.7	4.98	5.15
T-5	79.4	79.4	10.6	11.7	2.2	2.2	24.3	24.5	16.0	16.9	4.86	4.93
T-6	83.2	84.2	10.8	11.8	2.5	2.3	25.3	25.2	15.3	16.3	5.26	5.52
C.D (5%)	0.5	1.7	NS	NS	NS	NS	NS	NS	0.5	0.7	0.46	0.32

T1: Control-$N_0P_0K_0$
T 2 : Recommended dose of nitrogenous fertilizer (N_{120})
T3: 75% of recommended dose of nitrogen
T 4 : 75% of recommended dose of nitrogen+ *Azolla* 1.0t ha^{-1}
T5: 75% of recommended dose of nitrogen + BGA 2kg ha^{-1})
T6 : 75% of rec. dose of nitrogen+ BGA 2kg ha^{-1}+ *Azolla* 1.0t ha^{-1}

was mainly due to their genetic potentials which were reflected by better yield attributes (higher productive tillers, panicle length, filled grain panicle^{-1} and spike fertility) of Pusa 44.

Seed yield of rice was significantly influenced by integrated nutrient management as well as application of inorganic fertilizer over control (Table 2). The maximum seed yield (5.26 and 5.52 t ha^{-1}) was recorded when 75% recommended dose of nitrogen was added with BGA and *Azolla* and this yield was at par with inorganic fertilizer application yielding 5.38 and 5.49 t ha^{-1} during 2005 and 2006, respectively. The sustainable yield advantages by integrated nutrient management have been emphasized by many workers (Gunri et al.2004; Singh and Mandal, 1997; Dixit and Gupta, 2000; Singh *et al*.2006, Sahrawat, 2009). The seed yield increase due to *Azolla* alone and BGA alone applied with 75% recommended dose of nitrogen was found to range between 11 to 16.5% and 8.5 to 11.5%, respectively. However, yield increase was found between 25 to 35% when both *Azolla* and BGA were applied with 75% recommended dose of nitrogen. Comparable increase in grain yield of rice due to BGA and *Azolla* has been reported by Singh and Mandal (1997) and Dixit and Gupta (2000).

All the three rice varieties showed high germination percentages (95.3 to 97.7%) during both the years of experimentation and the difference in germination was statistically non-significant (Table 3). Among the rice varieties Pusa 44 showed the significantly higher vigor index as compared to other two varieties. However, Pusa 1121 showed higher seedling root and shoot length as compared to other two varieties. Different seed quality parameters like seed recovery, seedling dry weight, Vigor Index–I, Vigor Index–II and germination % were positively and significantly influenced by integrated nutrient management but seed length, seed width, seedling root length and seedling root length were not significantly influenced by nutritional treatments (Table 2 and 3). The increased supply of nutrients either by increased fertilizer doses, application of organics or integration of both the sources must have improved the nutrient uptake and balanced nutrition to the crop under the influence of improved physico-chemical properties of soil (Bhoite, 2005; Gunri *et al*. 2004; Singh and Mandal, 1997; Maiti *et al*. 2006) and this might have influenced the seed quality positively.

Iron and Zinc content in seed of rice varieties varied significantly among scented and non scented varieties during both the years and higher iron and zinc content were recorded in scented varieties as compared to non scented variety (Table 4). The difference in iron and zinc content in both the scented varieties was not significant. Integrated nutrient management as well as inorganic fertilizer application significantly influenced

Table 3. Effect of different treatments on seed quality parameters in rice.

Treatment	Germination (%)		Seedling root length (cm)		Seedling shoot length (cm)		Seedling dry wt. (mg)		Vigour Index -I		Vigour Index-II	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Rice varieties												
Pusa 44	96.7	94.3	8.9	10.6	4.7	6.5	55.8	51.6	1162	1161	4702	4341
Pusa 1121	97.7	95.3	9.2	10.9	5.7	7.4	53.0	52.5	940	1151	3365	3323
P Basmati1	97.4	96.6	6.3	7.3	3.8	5.5	42.8	40.9	881	592	2024	1889
C.D (5%)	NS	NS	1.5	1.7	0.5	0.7	7.8	8.1	75	95	117	235
Nutrient doses												
T-1	91.5	92.5	7.0	8.3	4.9	6.6	45.9	40.9	861	1011	3078	3340
T-2	92.3	93.7	7.8	9.0	4.4	6.1	51.8	50.1	919	1059	3922	3778
T-3	93.5	96.8	8.1	9.8	4.5	6.	52.0	50.0	930	1177	3745	3180
T-4	95.0	98.6	8.7	10.4	5.0	6.8	48.7	46.9	992	1221	3494	3341
T-5	96.5	96.8	8.1	9.8	4.7	6.4	53.0	48.6	900	1011	3324	2983
T-6	98.9	98.3	7.9	9.6	4.8	6.6	51.9	44.4	866	1029	3020	3046
C.D (5%)	1.8	3.1	0.5	1.3	NS	NS	4.4	1.6	18	14	150	168

T1 : Control-$N_0P_0K_0$
T 2 : Recommended dose of nitrogenous fertilizer (N_{120})
T3 : 75% of recommended dose of nitrogen
T 4 : 75% of recommended dose of nitrogen+ Azolla 1 t ha^{-1}
T5 : 75% of recommended dose of nitrogen + BGA 2kg ha^{-1})
T6 : 75% of rec. dose of nitrogen+ BGA 2kg ha^{-1}+ Azolla 1 t ha^{-1}

iron and zinc content in seed over control. The maximum iron and zinc content in seed was recorded when 75% recommended dose of nitrogen was added with BGA and *Azolla* and this yield was statistical at par with inorganic fertilizer application. Several workers in India have reported response of rice-wheat systems to Zn. Without application of $ZnSO_4$ at recommended dose, application of biofertilizers likes BGA and *Azolla* and

Table 4. Effect of different treatments on Iron and Zinc content in rice grain and soil organic carbon content

Treatment	Iron content in rice grain (mg kg^{-1})		Zinc content in rice grain (mg kg^{-1})		Soil organic carbon content (g kg^{-1})	
	2006	2007	2006	2007	2006	2007
Rice varieties						
Pusa 44	33.4	34.1	31.2	32.4	4.8	4.6
Pusa 1121	35.6	34.9	36.3	35.5	5.1	5.0
P Basmati 1	35.0	35.7	36.4	35.8	5.0	4.8
C.D (5%)	1.5	0.8	1.8	1.2	NS	NS
Nutrient doses						
T-1	31.2	30.8	30.6	31.3	4.3	4.2
T-2	33.4	34.0	31.2	32.4	4.5	4.7
T-3	33.0	34.5	31.8	33.2	4.4	4.7
T-4	34.8	35.3	32.4	33.5	4.7	4.9
T-5	35.5	36.0	34.9	34.6	4.6	4.7
T-6	36.6	37.3	34.9	35.8	4.8	5.0
C.D (5%)	1.3	1.4	0.8	1.2	0.3	0.4

T1 : Control-$N_0P_0K_0$
T 2 : Recommended dose of nitrogenous fertilizer (N_{120})
T3 : 75% of recommended dose of nitrogen
T4 : 75% of recommended dose of nitrogen+ Azolla 1 t ha^{-1}
T5 : 75% of recommended dose of nitrogen + BGA 2kg ha^{-1})
T6 : 75% of rec. dose of nitrogen + BGA 2kg ha^{-1} + Azolla 1 t ha^{-1}

organic manures also improve the zinc and iron content in grains as these biofertilizers and organic manures also provide zinc and iron in small quantity which is taken up by the plants. Positive response of biofertilizers and organic manures application on zinc and iron content in rice has been reported by several workers. (Prasad 2005, Singh and Mandal, 1997, Singh *et al.* 2007).

Application of nutrients at different levels had significant impact on soil organic carbon level in both the years (Table 4). Soil organic carbon content ranged between 0.42 and 0.50% with the lowest in control and highest under integrated nutrient management through 75% recommended dose of nitrogen + BGA+ *Azolla.* Dixit and Gupta (2000) and Singh *et al.* (2007) have also reported the increase in soil organic carbon content due to application of *Azolla*, BGA, FYM and integrated nutrient management. Sahrawat (2004) reported the positive influence of balanced fertilization and addition of fresh organic matter on better decomposition of soil organic matter and N mineralization under continuously submerged rice soils, where two or three crops of rice were grown on a long-term basis.

It was concluded that the seed yield and its quality was influenced due to the genetic potentials of rice varieties, however, addition of organic amendments like BGA and *Azolla* in integrated manner with chemical fertilizers produced higher quantity of seed and quality of seed was also better than the seed obtained in sole chemical fertilizer application.

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