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Evaluation of Organically Grown Rice Varieties for Their Seed Yield and Quality in the Lower Indo-Gangetic Plains

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Abstract A field experiment was conducted during *kharif* season of 2013 to study the crop performances and the seed quality of leading eight rice varieties viz. IET 4786, MTU 7029, Gitanjali, Lalat, Sabita, Pratiksha, Gobindabhog and Swarna Sub-1 under organic nutrition in the lower Indo-Gangetic Plains. The substitution of recommended dose of N, P_2O_5 and K_2O @ 60 : 30 : 30 kg ha^{-1} was made through organic sources like FYM, Vermicompost and Mustard cake. The application of recommended doses of nutrients by using organics had significant effect on the growth, yield component, grain yield and seed quality of rice varieties in *kharif* season. The variety Sabita performed well in relation to growth parameters followed by Pratiksha and MTU 7029. However, the rice variety Pratiksha recorded the highest grain yield of 6154 kg ha^{-1} followed by MTU 7029 and the lowest grain yield was recorded in Gitanjali by 2148 kg ha^{-1}. In respect of seed quality parameter, Lalat was significantly different from all the varieties tested in terms of seed viability, germination percentage, vigor index, root length, shoot length and seed dry weight. Hence, it is concluded that variety Pratiksha may be recommended for organic rice seed production in West Bengal.

Keywords Organic seed, Rice variety, Seed viability, Germination percentage, Vigor index.

Introduction

Rice (*Oryza sativa*) is one of the most important staple food crops of India, ranking second next to wheat. It occupies 42.96 m ha area with production of 158.76 m t and productivity of 3695 kg ha^{-1}. The productivity level of rice in India is lower as compare to world average of 4636.6 kg ha^{-1} (FAOSTAT 2016). Several factors are responsible for low productivity of rice. However, varieties are one of the most important factors in different ecosystems for low production. On the other hand, many ill effects of high inputs (chemical fertilizers, pesticides), intensive agriculture started to appear in many parts of the country. These included declining factor productivity, large scale degradation of soil and water resources, adverse effects on beneficial soil micro-flora and native biodiversity and wide spread problems associated with the toxic residuals of agro-chemicals entering into the human and animal food-chains (Kamta and Gill 2009). Organic cultivation is responsible for enhanced crop production by minimizing environmental load and by increasing agricultural biodiversity. It keeps ecological balance such a manner that influences the health of agricultural ecosystem. Soil structure was improved due to the application of organic matter and crop residues which ultimately improved aeration and water holding capacity of soil (Reza

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2016). It affects nutrient availability to crops either directly by contributing to nutrient pools, or indirectly by influencing the physical, chemical and biological environment of the soil. The concept of quality varies according to the preparations for which grains are to be used (Bajpai et al. 2012). Although some of the quality characteristics desired by growers, millers and consumers may be the same, each may place different emphasis on various quality characteristics (Catudan et al. 2013). The quality characteristics in rice such as total recovery (%), the proportions of head rice and broken on milling, grain appearance, grain size and shape, taste, flavor, cooking behavior and tenderness of cooked rice are highly influenced by the nutrient management practices. In storage, viability and vigor of the seeds is regulated by many physico-chemical factors like moisture content of the seed, atmospheric humidity, temperature (Meena et al. 2017) and initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure and packaging materials. Indiscriminate use of chemical and their residual toxicity adversely affect the seed quality. Hence, the feasible approach is the treatment of seeds with botanicals which are safe, economical, eco-friendly, cheap, locally available and non-harmful to seeds, animals and human beings. It will be of immense use to the farming community. The higher seed yield and better-quality seed can be produced by using organics and bio-fertilizers and how best rice seed can be stored by treating them with chemicals (halogens) or botanicals under ambient conditions with minimum qualitative and quantitative changes (Raikar et al. 2011). The present experiment was carried out to study the yield performances and quality of seed of locally dominant rice varieties under organic nutrition in Lower Gangetic Plains of West Bengal.

Materials and Methods

The field experiment was conducted at Balindi Research Complex, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during *kharif* season in 2013 to study the effect of variety on organic rice seed production system. The experimental site falls under sub-tropical sub-humid climate. The average rainfall is 1450 mm, 75% of which is received during June to September. The temperature begins to rise from end of February reaching towards April-May. The relative humidity remains high during June to October. The crop growing season of this region could broadly be classified as dry and warm or *pre-kharif* (March–May), wet and warm or *kharif* (June–October) and dry and cool or *rabi* (November–February). During the crop growth period maximum temperature ranged between 27.6°C to 35.8°C and minimum temperature varied between 11.2°C–27.1°C. The maximum relative humidity varied from 80% to 98.0% and minimum relative humidity varied from 50.0% to 92.0%. The total rainfall during the crop growing period was recorded 1040 mm. The details of the climatological parameters pertaining to the period of experimentation are presented in Table 1. The texture of the experimental soil was sandy clay loam and belongs to the order

Table 1. Effect of growth and yield of different rice varieties grown with organics during *kharif* season.

	Crop growth and yield							
Rice variety	Plant height (cm)	Effective tillers m^{-2}	Filled grains panicle^{-1}	Chaff (%)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
Gitanjali	108.4	358	106	20.22	24.5	2148	3838	0.34
Lalat	95.0	325	153	19.27	25.6	2466	4724	0.42
Sabita	138.7	396	155	15.93	32.5	2879	6822	0.29
IET-4786	94.7	316	165	11.46	21.2	2710	3243	0.46
Pratiksha	92.3	448	208	5.82	23.5	6154	6415	0.48
MTU-7029	94.4	442	189	8.21	21.2	5216	5670	0.44
Gobindabhog	117.3	401	197	4.71	10.9	2895	5154	0.35
Swarna Sub–1	89.6	413	191	6.82	20.2	4044	4407	0.46
SEm (±)	1.62	6.27	4.460	0.455	0.074	6.00	16.89	0.01
CD (p=0.05)	4.92	19.01	13.529	1.382	0.226	18.21	51.24	0.03

inceptisol with medium fertility and almost neutral in soil reaction. The experiment was conducted on a medium land, well-drained Gangetic alluvial soil. The experiment was laid down in randomized block design with three replications comprising of eight rice varieties viz. IET 4786, MTU 7029, Gitanjali, Lalat, Sabita, Pratiksha, Gobindabhog and Swarna Sub-1. The size of individual plot was 5.5 m × 4.5 m with 1.0 and 0.75 m spacing between replications and plots respectively. The total number of experimental plots was 24. The rice seedlings were uprooted from the nursery bed and transplanted (31st July, 2013) in main field with a row spacing of 20 cm × 20 cm at 3 seedlings per hill without damaging the seedlings. Depth of transplanting was 2-3 cm. The recommended dose of N, P_2O_5 and K_2O was 60 : 30 : 30 kg ha^{-1}. It was applied in three splits application. At the time of land preparation FYM @ 7 t ha^{-1} was applied on the entire plot. Twenty days after transplanting (DAT) 1st top dressing was done by using mustard cake @ 0.45 t ha^{-1} and 2nd top dressing was done by using vermicompost @ 0.7 t ha^{-1}. The crop was harvested on different dates according to their maturity. Harvesting was done (19th October to 3rd December, 2013) with the help of sickle, when the grains became yellowish in color before dead ripe stage and tied in bundles separately and taken to the threshing floor after logging the bundles. After sun drying, threshing was done by paddy thresher and thereafter, straw and grains were again dries separately under the sun after proper cleaning. Then weight of dried grains and straw of each plot were recorded and converted into kg ha^{-1}. Seed quality parameters were assessed in the seed science laboratory following standard methods.

Results and Discussion

Crop growth and yield

The crop growth in terms of plant height of rice varieties grown with organic sources of nutrients was found significant and the variation in plant height among cultivars ranged from 39.05 to 89.68% at different growth stages. Among the eight varieties, the highest plant height of 138.7 cm was observed in the variety Sabita at harvest and the lowest plant height of 89.6 cm was recorded in the variety Swarna Sub-1. The differences in plant height among the varieties might be due to the influence of organic nutrition and genetic variations. The ear bearing tillers of rice varieties grown organically showed significant differences among themselves (Table 1). It has been observed that effective tillers m^{-2} was to the tune of 448 to 316 with a variation of 41.77%. The highest number of effective tillers of 448 per m^{-2} was recorded in the variety Pratiksha followed by MTU 7029 and the lowest number of 316 effective tillers m^{-2} was recorded in the variety IET 4786. Pratiksha recorded the highest effective tillers m^{-2} among all the varieties as it showed satisfactory tillers $hill^{-1}$ at all the crop growth stages and it might be due to the effects of organic nutrition to the crop or might be due to the genetic makeup of the variety. Rakshit et al. 2008 reported that the influence of nutrient sources in the order of extent of tillering was Vermicompost > Farm yard manure > Chemical fertilizer > Water hyacinth compost > untreated control.

The number of filled grains $panicle^{-1}$ in eight rice varieties was found significant (Table 1). However, the number of filled grains $panicle^{-1}$ varied from 106 to 208 and the variation was recorded at 96.22%. Filled grain / panicle in variety Pratiksha (208) was significantly superior to all the other varieties of rice followed by Gobindabhog (197) and the lowest number of filled grain/panicle was recorded in the variety Gitanjali (106). The variety Pratiksha produced the highest number of filled grains per panicle, which might be due to the effects of organic nutrition to the cop or might be due to the genetic makeup of this variety. It had been revealed that grain filling in terms of percentage of chaffy grains varied significantly among the varieties of rice grown organically (Table 1). Chaffy percentage of rice varieties varied from 4.71 to 20.22%. Variety Gitanjali showed the highest percentage of chaffiness (20.22%) followed by the variety Lalat. The variety Gobindabhog recorded the lowest percentage of chaffy grains (4.71%) followed by Pratiksha (5.82%). Gitanjali recorded the highest percentage of chaffy grains as it produced the lowest numbers of filled grains/panicle. On the other hand variety Gobindabhog showed the lowest numbers of chaffy grains which might be due to the effects of organic nutrition to the crop or might be due to the genetic variation of the variety. The plumpness of

Table 2. Seed quality parameters of different rice varieties grown with organics during *kharif* season.

Treatment (variety)	Seed quality					
	Seed viability (%)	Germination (%)	Vigor index	Root length (cm)	Shoot length (cm)	Seedlings dry weight (mg)
Gitanjali	84.44	83.33	23.89	18.2	10.5	11.33
Lalat	95.55	93.33	28.48	18.5	12.1	11.00
Sabita	57.77	81.67	21.19	14.3	11.6	9.67
IET-4786	68.88	88.33	19.84	15.4	7.1	9.67
Pratiksha	77.78	86.67	25.31	20.6	8.6	9.33
MTU-7029	75.55	91.67	22.06	17.7	6.4	8.67
Gobindabhog	64.44	88.33	20.36	16.6	6.5	7.67
Swarna Sub–1	66.66	91.67	20.98	16.7	6.2	8.67
SEm (±)	2.924	1.739	1.455	0.11	0.12	0.14
CD (p=0.05)	8.869	5.276	4.415	0.33	0.36	0.23

grain in terms of test weight (1000 grain weight) of eight rice varieties grown organically was found significant. However, the test weight of rice varieties varied from 10.9 to 32.5 g. Among the varieties Sabita showed the highest test weight of 32.5 g followed by Lalat. Variety Gobindabhog recorded the lowest test weight of 10.9 g. The variety MTU 7029 was statistically at par with the variety IET 4786. Test weight was found maximum in variety Sabita as it has the boldest grains among the varieties. In general test weight is a genetical character so it does not differ significantly by the influence of external factors.

The seed production of eight rice varieties grown organically was found significant (Table 2). The seed yield of rice varieties varied from 2148 to 6154 kg ha^{-1} and the variation was recorded by 186.49%. Among the varieties, Pratiksha recorded the highest grain yield of 6154 kg ha^{-1} followed by the variety MTU 7029 (5216 kg ha^{-1}) and the lowest grain yield was recorded in the variety Gitanjali (2148 kg ha^{-1}). With this respect, variety Sabita was statistically at par with Gobindabhog. The seed yield performances of the varieties was very much corresponding to their growth parameters and yield attributes. Pratiksha recorded the highest seed yield as it showed satisfactory growth with regards to number of effective tillers m^{-1}, panicle weight, panicle length, more filled grains $panicle^{-1}$ and test weight. On the other hand, Gitanjali showed less numbers of effective tillers, poor grain filling capacity and less ability to translocate dry matter to sink i.e. poor source to sink ratio. The positive effects can be attributed mainly to the increased soil organic carbon and soil nutrient capacity due to the long-term application of organic amendment (Bi et al. 2009). Similarly, straw yield of rice varieties grown with the application of recommended doses of organic nutrients varied significantly in *kharif* season (Table 2). The straw yield of rice varieties ranged from 3243 to 6822 kg $ha^{-1}$and the variation was recorded at 110.36%. Among the varieties Sabita recorded the highest straw yield (6822 kg ha^{-1}) followed by the variety Pratiksha and the lowest straw yield was recorded in the variety IET 4786 (3243 kg ha^{-1}). The higher straw yield in Sabita was attributed to plant statures i.e. plant height and its foliage. The variety Sabita recorded the highest dry matter throughout the all growth stages and for this reason it showed the highest straw yield. Harvest index of rice varieties grown organically was found significant (Table 2). It ranged from 0.29 to 0.48 with a variation of 65.51%. Among the different varieties of rice Pratiksha recorded the highest harvest index i.e. 0.48 followed by Swarna Sub-1 and IET 4786. The lowest harvest index of 0.29 was observed in the variety Sabita. The higher harvest index in the variety of Pratiksha was attributed to the highest economic yield. On the other hand, Sabita recorded the lowest harvest index owing to the highest biological yield among all the varieties.

Seed quality

Seed quality index in terms of seed viability of rice

grains tested at 6 weeks after harvesting of rice revealed significant variation among themselves (Table 2) ranging from 57.77 to 95.55%. Seed viability in the variety Lalat was recorded the highest (95.55%) followed by variety Gitanjali (84.44%) and the lowest seed viability percentage recorded in variety Sabita (57.77%). Variety Pratiksha was recorded at par with the variety MTU 7029 in this regards. The variation in seed viability might be due to the effects of organic nutrition to the crop or might be for the genetic variation of variety. It has been observed from Table 2 that germination percentage of seed varied significantly among the varieties grown during *kharif* season and it ranged from 81.67 to 93.33% with variation of 14.27%. The germination percentage in the variety Lalat was the highest i.e. 93.33% followed by variety MTU-7029 and Swarna Sub-1. The lowest seed germination percentage showed by the variety Sabita by 81.67%. It has been reported that rice seeds produced through organic management system were of high quality in terms of viability percentage, germination percentage, root length, shoot length and seedling dry weight as compared to the grains produced by using synthetic fertilizers (Nokkoul and Wichitparp 2009). The seed vigor index of eight rice varieties varied significantly with the application of recommended doses of nutrient by using organics (Table 2) and it ranged from 19.84 to 28.48 with 43.54% variation. Vigor index in the variety Lalat was the highest i.e. 28.48 followed by Pratiksha. The lowest seed vigor index recorded in variety IET 4786 i.e. 19.84%. Variety Gobindabhog, Swarna Sub-1 and MTU 7029 were recorded statistically at par with the variety Gitanjali. The variation might be due to the effects of organic nutrition to the crop, storage condition and genetic variation of the variety.

Grow out test of organically grown seeds revealed that root length of seedlings of eight rice varieties grown with organic sources of nutrients varied significantly among themselves and it ranged from 14.3 to 20.6 cm with a variation of 44.05% (Table 2). Root length in the variety Pratiksha was the highest i.e. 20.6 cm followed by variety MTU 7029 and the shortest root length recorded in variety Sabita i.e. 14.3 cm. Variety Gobindabhog was statistically at par with the variety Swarna Sub-1. The shoot length of seedlings of eight rice varieties varied significantly (Table 2). However, shoot length of eight rice varieties varied from 6.2 to 12.1 cm and the variation recorded at 95.16%. Shoot length in the variety Lalat was the highest i.e. 12.1 cm followed by Sabita and shortest shoot length was recorded in Swarna Sub-1 i.e. 6.2 cm. Variety Gobindabhog and MTU 7029 were recorded statistically at par with variety Swarna Sub-1. The highest shoot length reported in variety Lalat due to its satisfactory vigor index and viability percentage. It has been reported that rice seeds produced through organic management system were of high quality in terms of viability percentage, germination percentage, root length, shoot length and seedling dry weight as compared to the grains produced by using synthetic fertilizers (Nokkoul and Wichitparp 2009). It has been revealed that seedling dry weight of eight rice varieties grown with organic sources of nutrients varied significantly among them (Table 2). However, it varied from 7.67 to 11.33 mg and the variation recorded at 47.71%. Seedling dry weight of the variety Gitanjali was the highest i.e. 11.33 mg followed by the variety Lalat. The lowest seedling dry weight was recorded in variety Gobindabhog i.e. 7.67 g. Variety Sabita was statistically at par with IET 4786 and MTU-7029 also recorded statistically at par with variety Swarna Sub-1.

Conclusion

The application of recommended doses of nutrients by using organics had significant effect on the growth, yield component, grain yield and seed quality of rice varieties in *kharif* season. The variety Sabita recorded the best in relation to growth parameters followed by Pratiksha and MTU 7029. However, the rice variety Pratiksha recorded the highest grain yield (6154 kg ha^{-1}) followed by MTU 7029 and the lowest grain yield was recorded in Gitanjali by 2148 kg ha^{-1}. In respect of seed quality parameters, Lalat was significantly different from all the varieties tested in terms of seed viability, germination percentage, vigor index, root length, shoot length and seed dry weight. Hence, it is concluded that variety Pratiksha may be recommended for organic rice seed production in West Bengal.

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