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Evaluation of Rice Varieties for Yield under Organic Farming in Tarai Region of Uttarakhand, India

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A B S T R A C T

Performance of modern cultivars in terms of yield under organic farming differs from that of conventional system. As the demand for organic rice is increasing, so to maintain high productivity, there is a need to evaluate modern high yielding rice varieties under organic farming systems. Field experiments were carried out using randomized complete block design involving fourteen rice (*Oryza sativa* L.) varieties including seven coarse and seven fine grain types with three replications under organic farming systems for three years (2013-2015). Results of the study revealed that higher yield attributes *viz.* grain weight panicle^{-1}, 1000-grain weight, grain and straw yield as well as N, P and K uptake were recorded with coarse grain rice variety NDR-359. Among the fine grain rice varieties, Pant basmati-1 recorded higher grain yield as well as N, P, K and S uptake. So, coarse grain rice variety NDR-359 and fine grain rice variety Pant basmati-1 can be recommended under organic rice production in *Tarai* region of Uttarakhand (India).

Introduction

Organic farming is gaining momentum during recent times due to awareness of people towards environment and food safety. Organic agriculture comes across as a promising opportunity for farmers of Uttarakhand, especially the tribals, small and marginal farmers in the rainfed region or regions where traditional low input farming is practiced (Singh *et al*., 2017b). Rice is the staple food crop of world after wheat and the demand of organic rice is increasing due to its export potential. Basmati rice is regarded as the king of rice and is cultivated for its subtle aroma, long grain and delicious taste. It is priced high owing to better organoleptic quality characteristics but its demand is very high in other countries (Singh *et al.*, 2017a).

There is always a continuous search for agronomic improvement to optimize farming system under organic farming and needs suitable varieties to realise its potential (Kokare *et al.*, 2014). Despite the potential benefits of organic farming in terms of better soil health and quality of produce, maintenance of high yields is one of major challenge under organic farming systems (Tilman *et al.*, 2002). Modern cultivars have been selected by plant breeders under conventional systems and they may not

perform well under organic farming systems where they are grown in stressed environment without addition of external inputs that is entirely different to those in which they were selected (Ceccarelli, 1996; Murphy *et al.*, 2007). So, there is a need to select varieties for organic farming which is believed as a stressed environment as crops are not supplied with chemicals for either supplying nutrients or to protect the crop from pests and diseases. During recent time coarse grain varieties *viz.* PD-4, IR-64, Pusa-44, PD-18, PD-19, NDR-359 and UPR-3425-11-1-1 and fine grain rice varieties *viz.* Taraori, Type-3, Pusa Basmati-1, Pusa-1121, Pant Basmati-1, UPR-3488621 and UPR-3506-7-1-1 are grown widely under different ecosystems due to their high yields under intensive cultivation practices. Therefore, these varieties were chosen to evaluate their performance under organic farming in this study. Our results will make farmers informed about the choices of high yielding varieties (both coarse and fine grain) for organic rice production in *Tarai* region of Uttarakhand.

Materials and Methods

Field experiments were carried out at Seed Production Centre of G.B. Pant University of Agriculture and Technology, Uttarakhand during wet seasons of 2013 to 2015 in the mollisols of *Tarai* region of Uttarakhand. The soil of the experimental site was silty- loam with pH: 7.2; electrical conductivity: 0.38 dS/m; high in organic carbon (1.01 %), high in available N (340 kg/ha) and available P (31.7 kg/ha), medium in available K (210 kg/ha) and high in available S (30.8 kg/ha). The experiment was set up in randomized block design with seven coarse grains rice varieties *viz.* PD-4, IR-64, Pusa-44, PD-18, PD-19, NDR-359, UPR-3425-11-1-1 and seven fine grain rice varieties *viz.* Taraori, Type-3, Pusa Basmati-1, Pusa-1121, Pant Basmati-1, UPR-3488621, UPR-3506-7-1-1 which were replicated thrice. Green manuring with Pant Sesbania-1 was done prior to basmati rice cultivation usually in first fortnight of May in all the three years and incorporated in soil at 50-55 days after sowing. Twenty to twenty-five days old seedlings were transplanted in a puddled field at 20 x 10 cm spacing with one seedling per hill in the experimental plot of 7 m x 3 m in size usually in second fortnight of June in all the three years. All necessary precautions were taken to maintain uniform plant population in each treatment per replication. Observations were recorded and the data was subjected to statistical analysis. The level of significance was tested at 5 per cent using F table value given by Cochran and Cox (1966). Recommended dose of nutrients for different rice varieties were met by green manuring and vermicompost @ 12t/ha. To control weeds, two hand weedings were done at 20 days after transplanting (DAT) and 40 DAT. To control the insects mainly stem borer, trichocards (1 card per acre area; 5 releases), pheromone traps (20 traps/ ha at 20 x 25 m distance) and cow urine (10 %) mixed with neem oil @ 125 mL/L were used after 15 days of transplanting and 4-5 sprays were done at 15 days interval. To control the diseases, seed treatment, soil and foliar application of *Trichoderma spp.* and *Pseudomonas spp.* were done. Observations were recorded on yield attributes of ten randomly selected plants in each replication. Grain and straw yield were recorded at harvesting. Nutrient content in both grain and straw were worked out following standard procedures and respective uptakes were calculated using grain and straw yield of each variety as follows:

Nutrient uptake (N, P, K and S) = Nutrient uptake by grain + Nutrient uptake by straw

Nutrient uptake by grain/straw (kg ha^{-1}) = Grain yield/ straw yield (kg ha^{-1}) × grain/straw nutrient content (%)

Results and Discussion

Yield attributes, yield and harvest index

Effective tillers m^{-2}, grain weight $panicle^{-1}$, 1000 grain weight, grain yield, straw yield and harvest index were significantly influenced by rice varieties. Maximum number of effective tillers m^{-2} was registered with rice variety Pusa-44 which significantly higher than others except variety PD-118, NDR-359, UPR-3425-11-1-1, PD-19 and Pant Basmati-1 which were statistically *at par*. In general coarse varieties have higher grain weight $panicle^{-1}$, 1000 grain weight and produced more grain and straw yield than fine grain varieties. Variety NDR-359 recorded highest grain weight $panicle^{-1}$ which was significantly greater than other varieties tested except variety UPR-3425-11-1-1 which was statistically *at par*. Maximum value of 1000 grain weight was observed with variety NDR-359 which was statistically comparable with varieties UPR-3425-11-1-1 and PD-19. Highest grain yield was recorded with variety NDR-359 (6069 kg ha^{-1}) which was significantly higher than other coarse and fine grain varieties except coarse grain varieties PD-18, PUSA-44 and PD-19 which were statistically *at par*. Among the fine grain varieties, Pant basmati-1 recorded maximum grain yield and was significantly superior over all other fine grain varieties. Highest straw yield (6690 kg ha^{-1}) was observed in variety NDR-359 which was statistically *at par* with variety PD-18, PD-19 and UPR-3425-11-1-1 which were statistically *at par*. Among the fine grain varieties, maximum grain yield was recorded with variety *Taraori* which was significantly superior over all other fine grain varieties except variety Pusa Basmati-1 which were *at par* with each other. Iannucci and Codianni (2016) screened durum wheat varieties for conventional and low input organic conditions based on variability in yield attributes and yield. Layek *et al.*, (2016) screened maize varieties suitable for organic production system. The differences observed in yield attributes and yield of rice varieties attributed to the genetic character as well as their adaptation potential under low input organic conditions. Higher values for yield attributes with variety NDR-359 could be due to better growth and translocation of photosynthates to reproductive parts. Higher grain weight $panicle^{-1}$ and 1000 grain weight might have resulted in higher grain yield of NDR-359.

Nitrogen, phosphorus, potassium and sulphur uptake

Nitrogen, phosphorus, potassium and sulphur uptake by rice varied significantly due to varieties. Nitrogen, phosphorus, potassium and sulphur uptake by fine grain rice varieties were lesser than coarse grain rice varieties. Highest nitrogen uptake by rice was recorded with variety NDR-359 which was statistically comparable with PD-18, PD-19, UPR-3425-11-1-1, Pusa-44 and PD-4. Highest phosphorus uptake by rice was recorded with variety NDR-359 which was statistically comparable with PD-19, PD-18 and UPR-3425-11-1-1. Highest potassium uptake by rice was recorded with variety NDR-359 which was statistically comparable with PD-18, UPR-3425-11-1-1, PD-19, Pusa-44 and IR-64. Highest sulphur uptake by rice was recorded with variety PD-18 which was statistically comparable with PD-19 and NDR-359. The nutrient uptake is a function of nutrient content and yield (grain and straw).

Moreover, nutrient content is dependent upon various factors like nutrient acquisition characteristics of the variety, root characteristics and secretion of root exudates to favour microbial growth for making the nutrient available in the rhizosphere. The variety NDR-359 produced higher grain and straw yield than rest of the varieties tested, so could have led to higher uptake of N, P and K.

Table.1 Yield attributes, yield and N P K and S uptakes of coarse and fine grain rice varieties under organic farming (data pooled over 3 years)

Varieties	Effective tillers m $^{-2}$	Grain wt. Panicle^{-1} (g)	1000 grain wt. (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	S uptake (kg ha^{-1})
Coarse grain										
PD-4	265	2.23	28.70	5256	6047	47.01	97.48	23.88	135.38	18.67
IR-64	273	2.30	27.28	5301	6088	47.11	94.64	22.56	140.11	15.32
Pusa-44	290	2.57	27.99	5708	6281	47.96	98.29	25.59	147.53	19.14
PD-18	285	2.49	28.67	5829	6432	49.75	102.31	26.9	157.48	24.08
PD-19	279	2.51	29.41	5672	6424	46.16	101.93	27.87	150.36	23.36
NDR-359	281	2.97	30.43	6069	6690	47.77	104.80	28.07	160.71	22.73
UPR-3425-11-1-1	279	2.71	29.51	5555	6347	47.24	99.47	26.7	151.53	19.10
Fine grain										
Taraori	237	1.56	22.65	2694	5300	33.65	56.95	16.77	108.77	14.14
Type-3	251	1.65	24.71	3235	4928	39.73	68.05	18.08	108.29	12.66
Pusa Basmati-1	261	1.65	23.79	3482	4799	42.35	68.13	20.48	106.00	12.00
Pusa-1121	265	1.78	24.51	4006	4980	44.74	77.21	21.47	123.92	12.68
Pant Basmati-1	275	1.90	24.96	4444	5299	45.65	87.76	21.75	126.93	15.89
UPR-3488621	269	1.96	25.58	3989	4886	44.63	69.07	17.61	110.54	12.41
UPR-3506-7-1-1	268	1.84	24.95	3891	4892	44.66	66.33	19.5	108.90	11.95
SEm±	5.97	0.1	0.55	146.9	129.2	0.91	3.38	1.2	8.12	1.73
CD (P=0.05)	16.8	0.28	1.54	413.6	363.7	2.57	9.52	3.37	22.86	4.88

Based on three years experiment it can be concluded that coarse grain rice variety NDR-359 and fine grain rice variety Pant Basmati-1 can be recommended for organic rice production to get higher yields under *Tarai* region of Uttarakhand, India.

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