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Productivity and Quality of Aromatic Rice (*Oryza sativa* L.) Varieties under Varying Level of Vermicompost

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ABSTRACT

The present investigation was conducted during *kharif* seasons of 2018–19 and 2019–20 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India to evaluate the performance of aromatic rice varieties under varying level of vermicompost. The experiment was arranged out in split plot design where three aromatic rice varieties Kataribhog, Geetanjali and CR S. Dhan-910 were allocated in main plots and five level of nutrient management fitted in sub plots namely NM_1: 100% RDF (60:30:30 kg NPK ha^{-1}), NM_2: Vermicompost @ 2 t ha^{-1}, NM_3: Vermicompost @ 3 t ha^{-1}, NM_4: Vermicompost @ 4 t ha^{-1} and NM_5: Vermicompost @ 5 t ha^{-1} and replicated thrice. Results revealed that among the variety Geetanjali was found superior in terms of yield attributes and gave 5.32 and 15.73% yield advantage respectively over CR Dhan-910 and Kataribhog. Pooled data over the years revealed that variety Geetanjali recorded highest amount of carbohydrate (79.61%), starch (73.82%), amylose (24.19%) and lipid (2.63%) while highest protein (9.92%) was found in Kataribhog. Among the level of nutrient management 5 t ha^{-1} of vermicompost (NM_5) ominously enhanced yield attributes, grain yield, grain quality as well as soil quality irrespective of variety and year of experimentation. Highest net return to the tune of ₹ 99212.80 and ₹ 82441.75 ha^{-1} and B:C ratio of 2.20 and 1.79 was realized with variety Geetanjali through 100% recommended dose of fertilizer.

KEYWORDS: Aromatic rice, carbohydrate, vermicompost, yield amylose

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

One of the greatest challenges face with global agriculture is to fulfill the requirement of ever-increasing human populations, which is estimated to exceed 9 billion peoples by 2050 (Godfray et al., 2010; Tilman et al., 2011). Rice (*Oryza sativa* L.) is the most dynamic staple food for more than half of the world's population and it plays a key role in maintaining food security (Zhao et al., 2009; Ariyaratna et al., 2011). Global human population derives their 21% of energy and 15% of protein from rice populations (Depar et al. 2011). In terms of production and consumption of rice China ranked first followed by India in the world. Aromatic rice varieties constitute an insignificant but distinct group of rice. Many varieties of rice are aromatic, extending from the well-known Basmati to the less important Randhunipagal (Singh et al., 2000). Aroma in cultivated rice is being cherished more and more by many people and they are ready to pay at a best price for aromatic or fragrant rice (Sarhadi et al., 2008; Myint et al., 2009; Sakthivel et al., 2009).

Aromatic rice comprises a premier status in India since of its aroma, grain dimension, cooking qualities and is preferred for consumption globally and fetches premium price in domestic and international markets (Khan et al., 2003; Singh et al., 2012). The plea for aromatic rice has passionately amplified over the past two decades due to transformation in the consumer's fondness for superior quality rice.Productivity of scented rice is decreasing fast even in the native areas of adaptation due to low yield and poor quality characters including aroma. The outdated varieties of scented rice grown in West Bengal are tall and susceptible to lodging when a higher dose of nitrogen was applied. Therefore, growing suitable dwarf varieties of scented rice with higher yield and acceptable quality is important to increase the production of aromatic rice. At present, organic agriculture has come out to be the feasible substitute for quality food production, eco sustainability, soil and human health concerns along with other social and cultural issues. Application of organic sources of nutrients likes FYM, poultry manure, vermicompost, green manure and bio-fertilizer not only amended biological properties of soil (Rahman et al., 2018., Siddharam et al., 2017, Ojobor, 2017, Nayak, 2020 and Bagchi et al., 2016) but also played crucial role in quality enhancement of aromatic rice (Davari and Sharma, 2010., Saha et al., 2007 and Jha et al., 2006).

Vermicompost (VC) prepared from animal manure, principally cow-dung, has been recognized to be an outstanding organic fertilizer (Edwards et al., 2011; Hussain and Abbasi, 2018). Presence of microbiota particularly fungi, bacteria and actinomycetes makes it suitable for plant growth (Tomati et al., 1987). Nutrients such as nitrates, phosphates, and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost (Orozco et al., 1996, Fernandez et al., 2010., Adhikary, 2012). Plant growth regulators and other plant growth influencing materials produced by microorganisms are also present in vermicompost (Tomati et al., 1988; Grappelli et al., 1987).

Thus the experiment was conducted to study the effect of varying level of vermicompost on the performance of aromatic rice varieties to optimize dose of vermicompost.

2. MATERIALS AND METHODS

The experiment was conducted during *kharif* season (July to November) of 2018–19 and 2019–20 at the research farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The location is situated in the terai agro climatic zone at 26019'86" N latitude and 89023'53" E longitude and at an elevation of 43 meters above mean sea level. The soil of the experimental site was sandy loam having pH 5.74, organic carbon 0.81%, available nitrogen 133.19 kg ha^{-1}, phosphorus 32.24 kg ha^{-1} and potassium 97.51 kg ha^{-1}. The experiment was laid out in split plot design with three replications and individual plot size was 5×4 m^2. The experiment comprised of three main plot treatments as variety V_1 (Kataribhog); V_2 (Geetanjali) and V_3 (CR S Dhan-910) and five level of management fitted in sub plots namely NM_1: 100% RDF (60:30:30 kg NPK ha^{-1}), NM_2: Vermicompost @ 2 t ha^{-1}, NM_3: Vermicompost @ 3 t ha^{-1}, NM_4: Vermicompost @ 4 t ha^{-1} and NM_5: Vermicompost @ 5 t ha^{-1}.

All the varieties were transplanted on 28th July, 2019 and 23rd July, 2020 in line with a spacing of 20×10 cm^2. All other agronomic practices such as weeding, hoeing, plant protection measures etc. were kept normal and uniform for all the plots. Vermicompost were applied 15 days before transplanting and 50% recommended dose of nitrogen, full dose of phosphorus and 75% potassium was applied at the time of final land preparation. Remaining 50% nitrogen was applied in two equal split at 30 and 60 days after transplanting and 25% potassium at 60 days after transplanting.

Dehulled grain samples and milled rice samples were subjected to grinding in a mixer grinder. The powderified samples, thus formed, were stored in air-tight bottles at normal laboratory temperature (~25°C) till analysis. All chemicals used were of analytical grade and were purchased from Sigma-Aldrich, India and Merck, India. Different aromatic rice grain samples were estimated using a standardized protocol given by The American Association of Cereal Chemists (Anonymous, 2000) for parameters of total carbohydrate, protein and lipid. For moisture content determination, all the samples were oven dried at 105°C until constant weight achieved (Anonymous, 2005). The starch content was assessed using an approach as described by the International Association for Cereal Science and Technology (Anonymous, 2017). The amylose content of the rice flour was determined by using the iodine colorimetric method (Mohana et al., 2007). Chemical properties of soil after harvesting were analyzed using standard protocols. The data on agronomic parameters were recorded during the course of investigation using standard procedures and statistical analysis was done by using SPSS software version 20.

3. RESULTS AND DISCUSSION

3.1. *Plant growth and yield*

Among the variety Kataribhog recorded significantly tallest plant (137.10 cm) at harvest followed by Getanjali though it was statistically at par. Shortest plant height (99.94 cm) was recorded in CR-S-Dhan-910. Geetanjali produced highest number of panicle hill^{-1} (14.10), longest panicle (27.98 cm), more number of grain panicles^{-1} (153.55) and higher test weight (24.67 g) which ultimately helped in producing maximum grain yield of 3.56 t ha^{-1} followed by CR Dhan-910 and Kataribhog. This is mainly due to genetic yield potentiality of the variety. Uppu and Shiv (2019) studied on two basmati genotype HUBR 10-9 and HUBR 2-1and reported differential response with mixed combinations of fertility and the bio-inoculants (Table 1).

Among the levels of nutrient management NM_5 i.e. 5 t ha^{-1} of vermicompost recorded significantly tallest plant (128.21 cm) as compared with NM_2 and rest of the treatments were statistically at par. Treatments receiving 5 t ha^{-1} of vermicompost (NM_5) recorded longest panicle (25.11 cm), higher grains panicle^{-1} (129.37) and test weight (19.39 g) that ultimately helped in producing highest grain yield of 3.56 t ha^{-1} which was followed by NM_4, NM_1, NM_3 and NM_2. Higher yield attributes and yield of rice might be due to the encouraging impression of vermicompost at higher doses (4 and 5 t ha^{-1}) which offers a balanced nutrient release compared to lower doses of vermicompost and 100% RDF. This phenomenon allows plants to improved nutrient uptake which resulted in the better source accumulation and effectual translocation of photosynthates into the sink. Moe et al., 2019 experienced improved yield of Indica rice with organic fertilizer from the second year onwards. Significant improvement of grain yield of rice with FYM 10 t ha^{-1} was also noticed by Sudhankar et al., 2018. Interaction effect of nutrient management and variety also achieved level of significance in terms of plant height at harvest, yield attributes and grain yield.

3.2. *Quality of aromatic rice*

Variety, Getanjali contained significantly highest amount of total carbohydrate (79.61%), starch (73.82%),

Table 1: Growth and yield attributes of aromatic rice varieties under varying level of vermicompost (pooled data over year)

Treatments		Plant height at harvest (cm)	Panicles hill^{-1}	Panicle length (cm)	Grain panicle^{-1}	Test weight (g)	Yield (t ha^{-1})
Variety	Kataribhog	137.10	12.87	22.55	103.11	13.87	3.00
	Getanjali	131.29	14.10	27.98	153.55	24.67	3.56
	CR S. Dhan-910	99.94	14.03	23.03	119.60	18.70	3.38
	SEm±	3.15	0.52	0.21	2.52	0.31	0.27
	CD (p=0.05)	12.37	NS	0.83	9.83	0.95	NS
Nutrient management	NM_1	122.74	13.31	24.50	125.84	19.11	3.27
	NM_2	123.32	13.18	24.07	121.32	18.72	3.14
	NM_3	121.26	13.25	24.20	123.12	18.94	3.17
	NM_4	118.35	13.39	24.73	127.46	19.23	3.44
	NM_5	128.21	15.20	25.11	129.37	19.39	3.56
	SEm±	3.39	0.39	0.31	3.29	0.28	0.26
	CD (p=0.05)	9.88	NS	NS	NS	NS	NS
Interaction (NM×variety)							
	SEm±	5.87	0.68	0.55	5.64	0.44	0.43
	CD (p=0.05)	17.63	2.05	1.66	16.48	1.31	1.30

NM_1: 100% RDF (60:30:30 kg NPK ha^{-1}); NM_2: Vermicompost @ 2 t ha^{-1}; NM_3: Vermicompost @ 3 t ha^{-1}; NM_4: Vermicompost @ 4 t ha^{-1}; NM_5: Vermicompost @ 5 t ha^{-1}

amylose (24.19%) and lipid (2.63) which was followed by CR S. Dhan-910 and kataribhog, while kataribhog contained highest amount of protein (9.92%) and moisture (10.19%) might be due genetic character of the variety. Application of vermicompost more than 2 t ha^{-1} helped in qualitative improvement irrespective of variety and year of experimentation over chemically fertilized plot. Treatment receiving 5 t ha^{-1} (NM_5) of vermicompost recorded higher values of total carbohydrate (79.02%) starch (72.81%) amylose (22.22%), lipid (2.60%) and protein (9.91%) followed by NM_4, NM_3, NM_1 and NM_2. Except 2 t vermicompost ha^{-1} (NM_2), all other vermicompost treated plot showed superiority over chemically treated plot. Qualitative improvement through vermicompost might be due to prolong release and balanced supply of nutrients compared to synthetic nutrition. Biswas et al., 2016 reported higher protein content with combined application of manures (PM 5 t ha^{-1}) over sole application of inorganic fertilizer. Paul et al., 2019 found highest protein content of aromatic boro rice with 2.5 t ha^{-1} of poultry manure along with 75% RDF. Interaction effect of nutrient management and variety also achieved level of significance with regards to proximate parameters namely total carbohydrate, starch, amylose, protein, lipid and moisture (Table 2).

Table 2: Proximate composition of aromatic rice as affected by level of vermicompost and variety (pooled data over years)

Treatments		Total carbohydrate (%)	Total starch (%)	Amylose (%)	Protein (%)	Lipid (%)	Moisture (%)
Variety	Kataribhog	76.29	70.64	19.27	9.92	1.90	10.19
	Getanjali	79.61	73.82	24.19	7.77	2.63	9.60
	CR S. Dhan-910	77.49	71.80	22.13	9.56	2.29	9.95
	SEm±	0.05	0.029	0.029	0.057	0.032	0.043
	CD (p=0.05)	0.197	0.112	0.114	0.224	0.126	0.169
Nutrient management	NM_1	77.23	71.62	21.65	8.61	2.11	9.85
	NM_2	76.83	71.46	21.52	8.18	1.93	9.75
	NM_3	77.66	72.07	21.87	9.14	2.27	9.88
	NM_4	78.24	72.46	22.05	9.59	2.47	9.99
	NM_5	79.02	72.81	22.22	9.91	2.60	10.09
	SEm±	0.082	0.025	0.025	0.045	0.018	0.041
	CD (p=0.05)	0.241	0.074	0.073	0.130	0.054	0.119
Interaction (NM×variety)							
	SEm±	0.143	0.044	0.043	0.077	0.032	0.070
	CD (p=0.05)	0.417	0.128	0.126	0.226	0.093	0.206

3.3. *Quality of soil*

In term of quality of soil, variety does not have any significant influential effect on pH raising, organic carbon built up and availability of nitrogen, phosphorus and potassium; however it is quite obvious that more addition of nutrients and biomass through vermicompost left higher quantity of available nitrogen, phosphorus and potassium and also built up organic carbon. All the chemical parameters analyzed were found non-significant among the varieties. Available nitrogen (136.14 kg ha^{-1}), phosphorus (44.32 kg ha^{-1}) and potassium (98.73 kg ha^{-1}) were found highest under nutrient management treatment NM_5 i.e. 5 t ha^{-1} of vermicompost followed by NM_4, NM_3 and NM_2 might be due to addition of more nutrients and steady release throughout the growing season which improved efficiency and resulted higher residual fertility. Ojobor, 2017 reported enhanced residual soil fertility with the application of rice husk amended poultry manure 1:1 @ 10 t ha^{-1} after harvesting of maize in Nigeria. Rahman et al., 2018 reported positive nutrient balance and organic carbon buildup with the use of poultry manure. 100% nutrients supplied through inorganic sources (NM_1) left lowest residual available nitrogen (117.08 kg ha^{-1}), phosphorus (34.59 kg ha^{-1}) and potassium (77.21 kg ha^{-1}) after harvesting of rice might be due to rapid release and maximum losses of nutrients by different means namely denitrification, volatilization, leaching and fixation. It is quite obvious that 100% chemically fertilized plot recorded lowest values of organic carbon (0.77%) simply due to non-addition of organic matter (Table 3).

3.4. *Economics*

Economics of aromatic rice varieties as influenced by varying level of vermicompost was calculated based on

Table 3: Chemical properties of soil after harvesting of rice

Treatments		pH	Organic carbon (%)	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
Variety	Kataribhog	5.92	0.79	121.89	43.45	77.11
	Getanjali	5.85	0.86	122.30	37.08	89.08
	CR S. Dhan-910	5.84	0.86	120.21	38.34	86.09
	SEm±	0.048	0.044	1.34	4.28	5.07
	CD (*p*: 0.05)	NS	NS	NS	NS	NS
Nutrient management	NM_1	5.95	0.77	117.08	34.59	77.85
	NM_2	5.87	0.80	120.52	36.08	77.21
	NM_3	5.86	0.83	123.61	41.27	82.10
	NM_4	5.93	0.89	128.00	42.86	86.58
	NM_5	5.73	0.90	136.14	44.32	98.73
	SEm±	0.06	0.03	3.61	2.54	4.23
	CD (*p*: 0.05)	0.17	0.09	NS	7.41	12.35
Interaction (NM×variety)						
	SEm±	0.10	0.05	6.26	4.40	7.33
	CD (*p*= 0.05)	0.29	0.16	18.26	12.84	21.39

prevailing market price and presented in table 4. Highest gross return to the tune of ₹ 151400 and ₹ 133000 ha^{-1} was obtained during 2018–19 and 2019–20 respectively, from V_2NM_5 simply due to higher yield followed by V_3NM_5 and V_3NM_5. Highest net return to the tune of ₹ 99212.80 and ₹ 82441.75 ha^{-1} and B: C ratio of 2.20 and 1.79 was realized from treatment V_2NM_1 which was followed by V_3NM_1 might be due to comparatively lower cost of treatments. Irrespective of varieties and year of experimentation lowest gross return and B:C ratio were

Table 4: Economics of aromatic rice varieties as influenced by varying level of vermicompost

Treatments combination	Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})		B:C ratio	
	2018–19	2019–20	2018–19	2019–20	2018–19	2019–20
V_1NM_1	134000	116600	88812.80	70641.75	1.97	1.54
V_1NM_2	132000	113400	81738.50	62582.50	1.63	1.23
V_1NM_3	132800	114000	77538.50	58182.50	1.40	1.04
V_1NM_4	137400	120000	77138.50	59182.50	1.28	0.97
V_1NM_5	141000	121200	75738.50	55382.50	1.16	0.84
V_2NM_1	144400	128400	99212.80	82441.75	2.20	1.79
V_2NM_2	142400	125200	92138.50	74382.50	1.83	1.46
V_2NM_3	143200	125800	87938.50	69982.50	1.59	1.25
V_2NM_4	147800	131800	87538.50	70982.50	1.45	1.17
V_2NM_5	151400	133000	86138.50	67182.50	1.32	1.02
V_3NM_1	143400	122400	98212.80	76441.75	2.17	1.66
V_3NM_2	141400	119200	91138.50	68382.50	1.81	1.35
V_3NM_3	142200	119800	86938.50	63982.50	1.57	1.15
V_3NM_4	146800	125800	86538.50	64982.50	1.44	1.07
V_3NM_5	150400	127000	85138.50	61182.50	1.30	0.93

1US$=INR, 72.15 and 74.26 during November 2019 and 2020 found in treatment NM_5, might be due to higher cost of treatment. In general, gross return, net return and B:C ratio was less during 2019–20 simply due to lower grain yield. These results are in agreement with of Haque et al., 2018; Mohanty et al., 2013; Rahman et al., 2019 and Surekha et al., 2013.

4. CONCLUSION

Application of 50:25:25 kg NPK ha^{-1} through inorganic fertilizer found profitable with the all the rice cultivars viz. Geetanjali or CR S. Dhan-910 or Kataribhog. Among the levels of vermicompost, application of 3 t ha^{-1} was realized higher profit as compared to 4 and 5 t ha^{-1} of vermicompost without affecting soil and grain quality.

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