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Response of black rice (*Oryza sativa* L.) varieties to organic amendments under SRI method of cultivation

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Abstract
A field investigation was carried out during *kharif* 2019 at Agricultural Research station, Binjhagiri, Chatabar, Faculty of Agricultural Sciences, IAS, SOADU, Bhubaneswar to study growth and yield of black rice (*Oryza sativa* L.) varieties as influenced by different organic amendments under "SRI" (System of Rice Intensification) method of cultivation. The experiment was laid out in factorial randomized block design with three replications. Treatments consisted of two varieties (V_1- Chaka Hao Amubi and V_2- Kala Malli) in main plot and six practices of organic amendments (T_1 - Jeevamrutha, T_2 – Jeevamurtha + Vermicompost, T_3- EM-1, T_4 - EM-1 + Vermicompost, T_5- Jeevamurtha + EM-1 and T_6- Vermicompost) in subplot. Study revealed that among the varieties, Kala Malli performed well and produced significantly the highest yield of grain and straw. The increase in grain yield was associated with significantly higher Number of filled grains panicle^{-1}, Ear bearing tillers m^{-2}, and test weight. Among the organic amendments, T_4 - EM-1 + Vermicompost recorded highest yield of grain & straw over others treatments.

Keywords: Jeevamrutha, vermicompost, organic amendments, Rice varieties, Grain yield

Introduction
Rice (*Oryza sativa* L.) is one of the most important food crop in the world and is a staple food over 2.7 billion people. It is grown almost all countries except the USA. The food quality and safety are two important factors that have gained ever increasing attention of the health and environment conscious people. That's why to solve the above problem and to bring the sustainability in crop production, organic farming is gaining popularity day by day for the nutritional and health benefits. It also protects the environment, save fossil fuel for future generation, brings sustainability in safe food production and has greater socio-economic impact on nation. Organic agriculture is a production system that sustains the health of the soil, ecosystem and people. It relies on ecological process, biodiversity and cycle adapted to the use of input without adverse effect (IFOAM). Organic farming is environmentally supportive, socially and economically sustainable, believe to play a patient role in safeguarding the soil health inclusive of sustainable development of farming community. Generally acceptance of organic farming is not only due to greater demand for casino genic free food but also because of its natural advantages in supporting the sustainability of agriculture. The natural input used in organic farming are easily available at the farm site with low or no cost which releases all essential nutrient required by the crop and provide favorable soil environment for growth of beneficial micro-organism which are capable for meeting the nutritional requirement of the crop (Shashi Dhar 2010, Dev kumar *et al*. 2011). The organic liquid formulation like Jeevamruta and Effective Micro-organism solution (E.M. Solution) are the best source of organic nutrient which can be prepared within seven days, which quickly buildup the soil health through enhanced act of soil micro- flora and fauna (Dev kumar 2008). Organic farming in initial years we have adopted SRI method for conducting our experiment which can increase the yield by 52% to compensate the lower yield 20% under organic farming in initial years. It also increase net return by 128% with reduced cost of cultivation 24% and tolerant to abiotic stress like drought, cyclone damage and extreme temperature due to high root/shoot variation (Uphoof 2007, Zhao *et al*., 2009). Historically black rice was considered to be a royal delicacy and forbidden for common people in Asian countries such as China and Indonesia. Few varieties of Black Rice are available in Odisha namely Kalabati (Tall plant up to 5-6 feet), Kajal, Kalamalli etc.

Materials and methods

A field investigation was carried out during *kharif* 2019 at Agricultural Research station, Binjhagiri, Chatabar, Faculty of Agricultural Sciences, IAS, SOADU, Bhubaneswar to study growth and yield of black rice (*Oryza sativa* L.) varieties as influenced by different organic amendments under "SRI" (System of Rice Intensification) method of cultivation. The soil of the experimental plot was sandy loam in texture with acidic in reaction (pH 5.80), and low in organic carbon (0.49%) and available nitrogen (215.24 kg ha^{-1}), high in phosphorous (28.15 kg ha^{-1}) and medium in potassium (152 kg ha^{-1}) content. The experiment was laid out in factorial randomized block design with three replications. Treatments consisted of two varieties (V_I- Chaka Hao Amubi and V_2- Kala Malli) in main plot and six practices of organic amendments (T_I - Jeevamrutha, T_2 – Jeevamurtha + Vermicompost, T_3- EM-1, T_4 - EM-1 + Vermicompost, T_5- Jeevamurtha + EM-1 and T_6- Vermicompost) in subplot. The recommended agronomic practices and plant protection measures were adopted to raise the crop. Grain and straw yield along with higher associated characters such as ear bearing tillers, dry matter accumulation, leaf area index, panicle length, panicle weight and fertile grains per panicle were recorded and statistically analyzed at a 5% level of significance.

Results and discussion

The plant height of Black Rice was progressively increased with advancement in age of the crop. Results reveled significant variation in plant height at all the crop growth stages. Maximum plant height was observed with the variety kalamalli (121.34) and followed by Chaka Hao Amubi (121.05) at harvest. Among the organic nutrient management practices maximum plant height was recorded with the application of treatment EM+ Vermicompost. Among other treatments maximum plant height was recorded with the application of EM-1 followed by Jeevamrutha + EM. Lowest plant height was recorded under the treatment of T_1 (Jeevamurtha) at harvest. Vermicompost is rich organic manure consisting of macro and micronutrients, plant growth promoting substances, beneficial microorganisms necessary for plant growth (Muthuselvam, 2010; Rajasekar *et al*., 2012). Similar trend followed in number of tillers in hill. Variety Kala Malli produced highest number of tillers per hill than variety Chaka Hao Amubi at harvest. Among the nutrient management practices treatment EM-1 + Vermicopost recorded highest number of tillers per hill over other treatments at harvest and it was closely followed by treatment Jeevamrutha + EM-1 at harvest (Table 1). Among other organic nutrient management practices T_3 (EM-1) registered highest number of tillers per hill at harvest followed by T_6 (Vermicopmpost) and T_2 (Jeevamrutha + Vermicompost). Least number of tillers per hill was recorded with the treatment of Jeevamrutha (T_1) at harvest. Similar result was reported by uploff, 2002. He reported that in SRI planting strategy, there was less trauma to the root system and the plants recover from the shock of transplanting more quickly which preserve the potential of the plant for much greater tillering, faster root growth and grain filling.

The dry matter production of rice plant increased progressively as the growth advances. Kala Malli recorded maximum dry matter production of 26.62 g $hill^{-1}$ at harvest followed by variety Chaka Hao Amubi 25.32 g $hill^{-1}$. Application of organic nutrient management practices also significantly influenced the dry matter production in all the growth stages. At harvest maximum dry matter production of 31.04 g $hill^{-1}$ was recorded with the application of. EM + Vermicompost (T_4) at harvest followed by that of Jeevamrutha + EM (T_5) 29.00 g $hill^{-1}$. The treatment Jeevamrutha (T_1) had the minimum value of dry matter production of 20.54 g $hill^{-1}$ at harvest.

Yield Attributing Characters and grain yield

The variety and nutrients significantly influenced the number of panicles $hill^{-1}$ and grains $panicle^{-1}$ during the crop season. Kala Malli recorded the maximum panicle $hill^{-1}$ and grains $panicle^{-1}$ which was significantly superior than Chaka Hao Amubi. Panicle $hill^{-1}$ and grains $hill^{-1}$ differed significantly with regard to organic nutrient management practices (Table 2). Application of EM + Vermicompost showed highest No. of Panicles $hill^{-1}$ and grains $panicle^{-1}$. Lowest no. of panicles $hill^{-1}$ and grains $panicles^{-1}$ was observes in Jeevamrutha (Table 2).

Varieties and nutrient management practices influenced the grain yield significantly. The data regarding seed yield at harvest in Black Rice was significantly influenced due to different treatments are presented in (Table 2).

Highest grain yield was also recorded in V_2 (Kala Malli) which was significantly superior to T_1 (Chaka Hao Amubi). Different Amendment has been taken in the experiment which has given very good result in two varieties. Among the amendment T_4 (EM-1 + Vermicompost) recorded the highest grin yield among rest of the amendment tried in the experiment followed by T_5 (Jeevamrutha+ EM-1) and T_2 (Jeevamrutha + Vermicompost). However the lowest value of grain yield recorded in treatment T_1 (Jeevamrutha) which was statistically inferior then other treatment. Test weight not varied significantly due to both variety and organic nutrient management practices.

Table 1: Growth attributes of black Rice varieties as influenced by Organic amendments.

Treatments	Plant height(cm)	No. tillers $hill^{-1}$	Dry matter production $hill^{-1}$
Variety			
V_1	121.05	15.05	25.32
V_2	121.34	15.66	26.62
Sem±	0.015	0.047	0.021
CD	0.044	0.138	0.062
Nutrient management practices			
T_1	112.55	14.50	20.54
T_2	118.02	14.57	25.40
T_3	122.88	15.66	25.41
T_4	127.48	16.14	31.03
T_5	122.63	15.59	29.00
T_6	118.61	14.61	24.40

Sem±	0.026	0.081	0.037
CD	0.076	0.239	0.107
VXN			
Sem±	0.037	0.115	0.052
CD	0.108	0.338	0.152

Table 2: Yield attributes and grain yield of Black Rice varieties as influenced by Organic amendments

Treatments	No. of panicle Hill^{-1}	No. grains Panicle^{-1}	Test weight(g)	Grain yield (q ha^{-1})
Variety				
V_1	15.05	138.78	20.771	24.457
V_2	15.66	141.43	20.434	25.775
Sem±	0.047	0.252	0.88	0.058
CD	0.138	0.740	NS	0.171
Nutrient management practices				
T_1	14.50	172.82	21.505	19.848
T_2	14.57	171.10	20.610	24.569
T_3	15.66	185.97	17.268	24.564
T_4	16.14	1212.87	22.507	30.019
T_5	15.59	183.12	20.230	28.069
T_6	14.61	160.73	21.495	23.626
Sem±	0.081	0.437	1.52	0.101
CD	0.239	1.282	NS	0.296
VXN				
Sem±	0.115	0.618	2.15	0.143
CD	0.338	1.813	NS	0.419

Conclusion

So from this experiment we can conclude that variety Kala Malli performed well and produced significantly the highest yield of grain. Among the nutrient management practices application of EM+ Vermicompost was found to be superior in respect to growth, yield attributes character and yield of rice under SRI system.

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