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Effect of organic sources of nutrients on growth physiology and yield components of scented rice (*Oryza sativa* L.)

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ABSTRACT

A field experiment was conducted to evaluate the effect of different organic sources of nutrientson growth physiology and yield components of scented rice, variety KetekiJoha at Regional Agricultural Research Station, AAU, Titabor during 2017 and 2018. Eight treatments were evaluated in randomized block design with three replications. The results revealed that the application of different proportion of organic sources of nutrients significantly improved the growth physiology and yield parameters of scented rice over the control. Among the treatments,the application of green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) recorded the highest grain yield (38.05 qha^{-1}) with significant increase in yield components of the crop.Application of green manure + Vermicompost + Azolla + biofertilizer consortium as root dip + rock phosphate significantly produced higher plant height (78.5cm), leaf area index (4.3), flag leaf area (35.3cm^{-2}), total Chlorophyll content (3.5mgg-1fwt), panicles m^{-2} (304.3), panicle length (28.2 cm), grains panicle^{-1}(108.4),panicle weight (2.7 g), harvest index (35.2 %) and 1000 grain weight(23.6 g). The organic treatments also significantly enhanced the growth physiology viz., crop growth rate, specific leaf weight and net assimilation rate of the plant.

Key words: Scented rice, growth parameters, organics, yield component, yield

INTRODUCTION

Rice (*Oryza sativa* L.) is the principal food grain crop of the North Eastern region occupying more than 80% of the total cultivated area of the region. Among all the cultivars, aromatic rice more particularly the Joha group of this region enjoys the top position due to its unique aroma, superfine kernel, good cooking qualities and excellent palatability. Assam Joha is also known all over the India because of its aroma.Organic farming can improve the quality of scented rice along with price and it has huge export potential (Nayak *et al.*, 2017).In Assam, recent addition of enriched compost, vermicompost, Azolla, vesicular arbuscular mycorrhiza (VAM), phosphate solubilizing bacteria (PSB), Azotobacter, Azospirillium and other bio fertilizers are getting importance for their biological efficiencies under organic cultivation. They are cost effective, ecofriendly and renewable sources of plant nutrients to supplement fertilizers for sustainable agriculture. Phosphate solubilizing bacteria alone or in combination with Azospirillium were able to establish in the rice rhizosphere and increase the grain yield of rice. The specialty agriculture under organic mode where quality and value addition are encouraged, use of bio inputs alone or in combination must be standardized to evaluate agronomic, physiological, chemical, biological properties of soil and cropalong with quality of food.

Moreover, the organic farming system is in concordance with soil health, clean environment, promotion and enrichment of agro-ecosystem services, biodiversity, biological cycles and soil biological properties.Organic residues including green manure, FYM and vermicompost are traditionally applied to rice soils in order to maintain the soil organic matter and plant nutrients status and improve the physical, chemical and biological soil properties that directly or indirectly affect soil fertility and productivity. The use of organic manures in augmenting soil fertilityand cropproductivity is well known (Singh *et al.,*2011). However, efforts need to be made for suitable combination of organic sources of nutrient management for maintaining productivity and profitability of high valued Joha rice. Therefore, present investigation was undertaken to evaluate the effect of combination of organic sources of plant nutrient on growth and yield related parameters of Joharice, var. *KetekiJoha*.

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MATERIALS AND METHODS

The field experiment was conducted in organic block on experimental farm of Regional Agricultural Research Station, Assam Agricultural University, Titabar during *kharif* seasons of 2017 and 2018. The site is situated at 26°35′N latitude, 28°10′E longitude having an elevation of 99.4metre above mean sea level. The climatic condition of Titabar is subtropical humid with a hot summer and cold winter. Summer is experienced during May to November, whereas a mild winter is experienced from September to November and February to April. The experimental soilwas clay loam in texture, slightly acidic in reaction (P^H5.5), organic carbon (9.8g ha^{-1}), available nitrogen (332kgha^{-1}), available phosphorus (28kgha^{-1}) and potassium (148kgha^{-1}).The experiment was laid out in randomized block design with 3 replications and consisted of seven treatment combinations and one control. Treatments were,**T_1**Enrich compost (5t ha^{-1}) + biofertilizer consortium as root dip (4 kg ha^{-1} seedling); **T_2**- Green manure (2.5 t ha^{-1}) +Azolla (20 kg ha^{-1}) + biofertilizer consortium(4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}); **T_3-** Green manure (5 t ha^{-1})+ Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} ha seedling) as root dip + rock phosphate (17 kg ha^{-1}) ;**T_4-** Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) +biofertilizer consortium as root dip (4 kg ha^{-1} seedling) + rock phosphate (17 kg ha^{-1}).; **T_5-** Vermicompost (5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium(4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1});**T_6-** Green manure (2.5 t ha^{-1}) +Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium(4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}); **T_7-**Vermicompost (2.5 t ha^{-1}) + Neem cake (300 kg ha^{-1},half basal and half top dressed + Biofertilizer consortium (4 kg ha^{-1} seedling) as root dip and **T_8-**Control**.** The plant protection measures were also carried outorganically. In the control plot, no external organic inputs were added, and treated as organic with native fertility and biological make up.Seed treatment was carried out by soaking the seeds 12 hours in a solution of *Pseudomonas fluoroscense*@ 10 g litre^{-1} of water kg^{-1} of seed. For both the years, green manure was weighed, chopped and incorporated as per treatments one week before transplanting of rice. Enriched compost and vermicompost were applied one week before transplanting of rice on dry weight basis. Root dip treatment with consortium was given one day prior to transplanting as per the treatment.Root dip treatment was carried out with Biofertilizer Consortium @4 kgha^{-1} of seedling before transplanting. Consortium is a specific formulation of Azospirillum, Azotobacter, PSB and Rhizobium. Crop was transplanted on 13th of July for both the years. Azolla was applied 7 days after transplanting (DAT) of rice as per treatment. After formation of a thick mat, the azolla was incorporated into the soil.Plant height, leaf area index, leaf chlorophyll and flag leaf area were measured at 90 days. Observations on growth and development were recorded at subsequent growth stages of the crop. Leaf area index (LAI), net assimilation rate (NAR) and specific leaf weight (SLW) were estimated following formula used by Yoshida *et al.*, (1976), Watson(1952) and Pearce *et al.*, (1969), respectively. The yield and yield attributing characters were recorded. The data collected were subjected to statistical analysis by standard analysis of variance techniques (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant characters and leaf chlorophyll

Among the organic sources of nutrients supplement, green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium(4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) recorded maximum (78.5 cm) plant height (Table 1). The increase in plant height might be due to enhanced availability of nutrients. Organic manure increases the soil organic carbon which holds more moisture in soil and creates suitable condition for better root growth and proliferation which enables extraction and availability of nutrients from larger profile area (Mohana Rao *et al.*, 2014). Flag leaf area was found highest (35.3cm^2) in plants grown with green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) followed by green manure + Azolla + biofertilizer consortium as root dip + rock phosphate treated plots (34.3cm^2). The lowest flag leaf area (20.7 cm^2) was obtained in control plot. The increase in leaf area due to increase in nutrient absorption capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points(Faisal and Al-Tahir, 2014).

Table 1: Effect of organic nutrients on plant characters and leaf chlorophyll content in scented rice

Treatment	Plant height (cm)	Tiller number ($hill^{-1}$)	Leaf area index (LAI)	Flag leaf area (cm^{-2})	Total Chlorophyll content (mgg^{-1}fwt)
T_1	75.7	10.0	3.9	25.8	2.2
T_2	77.2	9.6	4.1	32.4	3.1
T_3	77.2	9.9	4.3	34.4	3.1
T_4	75.6	12.0	3.6	21.4	2.6
T_5	76.5	10.4	3.9	27.3	2.9
T_6	78.5	10.5	4.3	35.3	3.5
T_7	74.6	10.1	3.1	23.4	2.4
T_8	66.5	8.4	3.0	20.7	1.7
SEd (±)	0.40	0.46	0.01	0.20	0.012
C.D (0.05)	0.87	0.98	0.02	0.43	0.026

The highest leaf chlorophyll (3.54 mgg^{-1}fwt) at panicle ignition stage recorded with green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) followed by green manure (5 t ha^{-1})+ Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} ha seedling) as root dip + rock phosphate (3.12 mgg^{-1}fwt).While, the highest tiller number was recorded in the plots treated with Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) +biofertilizer consortium as root dip (4 kg ha^{-1} seedling) + rock phosphate (12 numbers $hill^{-1}$) though green manure in combination with Vermicompost, Azolla, biofertilizer and rock phosphatewas found to be the best for the other parameters. It might be due to application of green manure which reduced the rapid proliferation of tillers in green manure treated plots.

Growth parameters

Application of green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) recorded the highest crop growth rate (CGR) of 16.9$gm^{-2}d^{-1}$at 75-90 DAT followed by green manure (5 t ha^{-1})+ Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} ha seedling) as root dip + rock phosphate (17 kg ha^{-1}) (15.9$gm^{-2}d^{-1}$). The control plant maintained minimum growth rate (9.6 $gm^{-2}d^{-1}$) throughout the growth period compared to other treatments. It might be due to lack of nutrients for its growth. The variations exhibited by the treatments were due to variation in availability of nutrients and their release pattern. The high growth parameters might be due to higher and direct availability of nutrients during development phase of crop growth, which accelerated the metabolic and physiological activity of the plant and put up more growth by assimilating more amounts of nutrients and facilitating more photosynthesis process and ultimately increased the growth parameters. Higher radiation use efficiency in the leaf photosynthesis might have led to higher photo assimilate production and thus increased the crop growth rate. Further availability of ample supply of nutrients especially nitrogen due to decomposition of green manure may be the reason for the better performance with regard to crop growth rate. Crop growth rate during early growth period was slow, then sharply increased, reached its peak during 75-90 DAT, thereafter it declined slowly during 90-105 DAT and then sharply decreased as crop proceeded towards maturity. Such findings were in accordance with those of Kumari *et al.*(2014).Perusal of the data (table 2) revealed thatthe highest (38.70 $mgg^{-1}d^{-1}$) relative growth rate (RGR) was recorded with green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium(4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) at 45-60 DAT followed by green manure (5 t ha^{-1})+ Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} ha seedling) as root dip + rock phosphate (32.58$mgg^{-1}d^{-1}$). The RGR was higher at early stages in all the

Table 2: Effect of organic nutrients on growth physiology at different stages of growth in scented rice

Treatment	Growth parameters											
	Crop growth rate ($g^{-2}d^{-1}$)			Relative growth rate ($mgg^{-1}d^{-1}$)			Specific leaf weight ($mgcm^{-2}$)			Net assimilation rate ($g^{-2}d^{-1}$)		
	45-60	75-90	105-120	45-60	75-90	105-120	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1	4.1	12.7	12.0	28.0	22.3	11.2	2.2	4.3	6.3	25.4	41.9	43.4
T_2	5.6	15.7	13.2	31.2	25.2	14.5	2.3	5.4	7.1	28.3	43.1	45.4
T_3	5.7	15.9	13.8	32.6	28.4	14.5	2.4	5.9	7.2	29.5	44.1	46.6
T_4	5.1	12.5	11.4	27.8	20.3	7.7	2.0	4.2	5.3	27.6	44.2	44.3
T_5	5.3	14.2	12.6	28.8	24.5	13.5	2.2	4.7	6.5	25.9	41.0	44.7
T_6	7.2	16.9	17.3	38.7	34.6	15.3	3.0	6.2	8.6	31.2	45.2	48.4
T_7	4.3	9.6	9.1	27.3	19.7	6.9	1.9	4.1	5.1	25.5	40.9	45.3
T_8	3.1	8.0	8.2	25.2	16.3	6.1	1.8	3.5	4.9	22.7	38.2	41.5
SEd (±)	0.37	0.22	0.32	0.55	0.65	0.38	0.01	0.12	0.03	0.50	0.36	0.23
C.D (0.05)	0.80	0.46	0.67	1.18	1.39	0.82	0.23	0.25	0.06	1.07	0.76	0.49

treatments and gradually declined towards maturity. It may be due to limiting or sub-optimal levels of resources such as water and minerals.

Among all the treatments, application of green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium(4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1})recorded the highest SLW (8.56 95 $mgcm^{-2}$), followed by application of green manure (5 t ha^{-1})+ Azolla + biofertilizer consortium as root dip + rock phosphate (7.17 95 $mgcm^{-2}$); whereas control plants showed the minimum (4.95$mgcm^{-2}$). Specific leaf weight increased considerably up to 90 days after planting. These results are in accordance with Rao *et al.*, (2013) who reported that the variation in plant growth due to different organic manures was due to variation in availability and their release pattern of the nutrients.The highest (48.4$gm^{-2}d^{-1}$) net assimilation rate (NAR) was recorded withgreen manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) followed by green manure (5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} ha seedling) as root dip + rock phosphate (17 kg ha^{-1}). There was accelerated NAR at 90 days after planting which was ascribed due to the enhancement of specific leaf weight at booting stage. These results were in close conformity with the findings of Kumari *et al.*, (2014).

Application ofgreen manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium(4 $kgha^{-1}$ seedling) as root dip + rock phosphate (17 kg ha^{-1}) recorded the highest (4.32) leaf area index (LAI)followed bygreen manure (5 t ha^{-1})+ Azolla + biofertilizer consortium as root dip + rock phosphate (4.26). It might be due to better physiological growth of the plants as organic matter ameliorate the micronutrients deficiencies and increases thecationentry and enhance growth. Different nitrogen sources increased the number of leaves per hill leading to higher leaf area index. Sufficient availability of nitrogen helps in vigorous growth of leaves and foliage since a greater number of leaves with expanded leaf blades were produced, hence leaf area index also increased. Application of N through green manures increased the leaf area index and dry matter production.Geetha *et al.*, (2015) also recorded highest LAI in combined application of green manure, FYM, poultry manure and neem cake.

Yield attributing characters and total yield

Perusal of the data (table 3) revealed that there were significant differences among the treatments on yield and yield attributing characters viz., panicle m^{-2}, grains $panicle^{-1}$, 1000 grain weight (g). The green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1} seedling) as root dip + rock phosphate (17 kg ha^{-1}) significantly produced higher panicles m^{-2} (304.3 m2), grains $panicle^{-1}$(108.43), and test weight(23.62 g). The enhanced and continuous supply of nutrients by the organic manure leads to a better tiller production and filled grain of rice. Organic manure can supply the nutrients in soluble form for a quite longer period by not allowing the entire soluble form into solution, to come in contact with soil and other constituents, thereby minimizing fixation and precipitation from organic manures. The highest yield (38.1 qha^{-1}) was recordedwithapplication of green manure (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1}) + Azolla (20 kg ha^{-1}) + biofertilizer consortium (4 kg ha^{-1}

Table 3: Effect of organic nutrients on yield attributing characters and yield of scented rice

Treatment	Panicle m^{-2}	Grain $panicle^{-1}$ (no's)	Panicle length (cm)	Panicle weight (g)	1000 grain weight (g)	Harvest Index (%)	Grain yield (q ha^{-1})	Straw Yield (q ha^{-1})
T_1	275.6	98.4	27.2	2.3	21.5	31.7	33.0	71.1
T_2	287.6	100.0	27.2	2.5	23.3	34.0	35.4	67.8
T_3	289.6	103.0	27.9	2.5	23.4	34.8	36.8	67.5
T_4	274.0	98.0	27.0	2.5	21.3	32.5	32.3	67.1
T_5	281.0	98.8	27.8	2.3	22.0	33.6	34.5	63.3
T_6	304.3	108.4	28.2	2.7	23.6	35.2	38.1	70.3
T_7	253.0	97.7	27.4	2.4	20.8	30.1	31.8	73.9
T_8	219.3	90.5	27.1	2.0	18.3	29.8	31.5	73.9
SEd (±)	8.79	2.17	0.75	0.65	0.78	0.75	1.56	0.76
C.D (0.05)	18.85	4.65	1.24	1.40	1.66	1.58	3.35	1.63

seedling) as root dip + rock phosphate (17 kg ha^{-1}) followed by green manure (5 t ha^{-1}) + Azolla + biofertilizer consortium as root dip + rock phosphate (36.80 qha^{-1}). The lowest yield in control plot might be due to scarcity of nutrients. Organic sources of nutrients enhance nutrient availability which improve nitrogen and other elements absorption, and enhancing the production and translocation of dry matter from source to sink. These results are in close conformity with the findings ofSangeetha *et al.*(2013).

The different combinations of organic input can improve growth physiology and yield in scented rice. However, it can be concluded that the cultivation of scented rice with 2.5 t green manure ha^{-1} + 2.5 t Vermicompost ha^{-1} + 20 kg Azolla ha^{-1} + 4 kg biofertilizer consortium ha^{-1} + 17 kg rock phosphate ha^{-1} was found to be better in improving yield attributing characters and grain yield of the crop.

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