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Impact of Organic and Natural Farming Practices on Growth, Yield Attributes and Yield of *Joha* Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of the experiment was to study the impact of organic and natural farming practices on the growth, yield attributes and yield of *Bokul Joha* variety of rice

Study Design: The experiment was laid in a randomized block design with three replications.

Place and Duration of Study: Assam Agricultural University-Assam Rice Research Institute, Titabar, Assam, India, during the kharif season of 2022-2023

Methodology: The number of treatments used were eight in total including control which were T_1 [Absolute control], T_2 [(Natural farming, Beejamrit as root dip treatment (3%) (100 L ha^{-1}) + Jeevamrit as spray (3%) (100 L ha^{-1}) + Ghanajeevamrit as soil treatment at 100 kg (Jeevamrit and Ghanajeevamrit at 30, 60 and 90 DAT)], T_3 [(Enriched compost (5 tha-1) + Biofertilizer (*Azospirillum*, PSB as seedling root dip) (4 kg ha^{-1})], T_4 [Enriched compost (5 t ha^{-1})], T_5 [Vermicompost (5 t ha^{-1})], T_6 [Enriched compost (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})], T_7 [Fresh azolla as dual crop (400 kg ha^{-1}) + Biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 $kgha^{-1}$)] and T_8 [Vermicompost (1 tha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5 ha^{-1})]. The experiment was laid in a randomized block design with three replications. Where T= Treatment, PSB = Phosphate Solubilizing Bacteria, KSB=Potassium Solubilizing Bacteria, DAT = Days After Transplanting and NF=Natural Farming.

Results: Plants that were noticeably taller were observed with treatment T_8: application of vermicompost (1 tha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5) i.e., at 45 DAT (81.78 cm),90 DAT (128.15 cm) and at harvest (145.71 cm). The same treatment recorded the highest no. of tillers 45 DAT (8.31m^{-2}), at 90 DAT (13.79 m^{-2}) and at harvest (10.40 m^{-2}). Also, dry weight was noted to be highest for the same treatment, at 45 DAT (29.34 g $plant^{-1}$), 90 DAT (79.11 g $plant^{-1}$) and at harvest (92.29 g $plant^{-1}$). Additionally, the same treatment resulted in highest grain (34.62 qha^{-1}) and straw (70.30 q ha^{-1}) yield.

Conclusion: Combined application of vermicompost (1 t/ha) along with inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4kg/ha) and rock phosphate (10 kg P_2O_5) can be used as a suitable treatment for attaining higher growth, yield attributes and yield in *Bokul Joha* variety of rice.

Keywords: Natural farming; organic farming; rice, rock phosphate; vermicompost.

1. INTRODUCTION

Rice being the staple food for a sizeable portion of the world's population has increase in demand for its production as the population is increasing day by day. In fiscal year 2023, India's estimated production volume of rice was over 130 million metric tons. There has been a gradual increase in the production of rice since fiscal year 2017 [1]. Rice is the most common staple crop consumed all over India. Rice is mostly being produced by the application of various inorganic sources of fertilizers which in turn costs for the health of these planets. The cultivation methods of rice have a profound impact on the food security and the environmental sustainability. In recent years, there has been a growing interest in organic farming practices and natural farming practices in the Indian sub-continent as well as in the entire world to these critical concerns.

Natural farming, pioneered by Masanobu Fukuoka (1913–2008), is an ecological approach to agriculture. Known alternatively as "the Fukuoka method," "the natural way of farming," or "do-nothing farming," it represents a chemical-free adaptation of traditional farming techniques. This method is regarded as an agroecology-centered, diverse farming system that harmoniously incorporates crops, trees, and livestock alongside functional biodiversity [2]. Natural Farming, centered on 'Zero-Budget' input costs, originated in the 1980s through the work of Shri Subhash Palekar. Several variations of this system can be found in ancient Indian literature and Vedic agricultural practices [3,4]. Numerous initiatives in India have been launched to encourage natural farming through capacity building, providing input support, and demonstrating technology to farmers and other stakeholders. Additionally, various financial incentives have been implemented to promote environmentally friendly products [3,5]. India has the potential to transition approximately 20% of its conventional farming area to Organic and Natural Farming (ONF) by 2030, while simultaneously ensuring a balance between the increasing demand for agri-food and its supply [6]. Organic cultivation not only emphasizes ecological harmony but also aims to produce healthier and more nutritious crops. Organic manures have the capacity to fulfil nutrient demand of crops adequately and promote the activity of macro and micro flora in the soil [7]. Studies suggest that yields could be sustained without increasing the nutrient inputs by tightening the nutrient cycles through organic nutrition [8]. One such endeavour is the cultivation of *joha* rice by organic farming methods. Joha rice (*Oryza sativa*), a unique and aromatic variety predominantly grown in the north-eastern region of India. Among different qualities of rice these group have high demand because of their specific aroma, superfine kernels, superior quality of cooking and superfine kernels. These group of rice is specifically used for making various dishes during separate occasions. Joha rice cultivars are renowned for their distinctive aroma, superfine kernels, excellent cooking characteristics, and exceptional palatability. Their inherent fragrance makes them highly sought after and greatly desired for export purposes [9]. Proper selection of a variety and appropriate nutrient management are important in organic rice production [10]. Assam being surrounded by hills on all sides and covered by forests makes it a biodiversity rich zone thereby making it suitable for practicing organic farming as well as natural farming. Hence a study was carried out to generate scientific data on production of *joha* rice by organic and natural farming practices.

2. MATERIALS AND METHODS

A field experiment was conducted at the research farm of Assam Rice Research Institute Assam Agricultural University- Assam Rice Research Institute, Titabar, Jorhat, India during the kharif season of 2022-2023 The soil was clay loam with pH 5.63, organic carbon 8.40 g, available nitrogen 284.12 kg ha $^{-1}$, available P_2O_5 22.52 kg ha^{-1} and available K_2O 127.43 kg ha^{-1}. The number of treatments used were eight in total including control which were T_1 [Absolute control], T_2 [(Natural farming, Beejamrit as root dip treatment (3%) (100 L ha^{-1}) + Jeevamrit as spray (3%) (100 L ha^{-1}) + Ghanajeevamrit as soil treatment at 100 kg ha^{-1} (Jeevamrit and Ghanajeevamrit at 30, 60 and 90 DAT)], T_3 [(Enriched compost (5 t ha^{-1}) + Biofertilizer (*Azospirillum*, PSB as seedling root dip) (4 kg ha^{-1})], T_4 [Enriched compost (5 t ha^{-1})], T_5 [Vermicompost (5 t ha^{-1})], T6 [Enriched compost (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})], T_7 [Fresh azolla as dual crop (400 kg ha^{-1}) + Biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 kg ha^{-1})] and T_8 [Vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4kg ha^{-1}), rock phosphate (10 kg P_2O_5 ha^{-1})]. The experiment was laid in a randomized block design with three replications The variety used for the experiment was *Bokul Joha*. The seedlings were transplanted after 30 days age with spacing of 20 x 15 cm with 2-3 seedlings per hill. Hand weeding was done as and when required. The organic manures and fertilizers were incorporated 2 weeks before transplantation as per the treatment requirement. In case of the natural farming treatments beejamrita was used as a seed treatment before sowing of the seeds where as jeevamrita and ghanajeevamrita were used as spray. The experimental plot received plant protection by application of neem oil and brahmashtra. For the determination of plant height, dry matter content, number of tillers, leaf area index five samples were collected from each plot, the data was averaged out and used for interpretation. The yield attributing characters were determined by randomly selecting five samples from each plot as well and the average value was used for interpretation. In case of the grain ad straw yield determination, it was recorded as per m^2 from each plot and later converted to quintals per hectare. Data related to the experiment were analysed by ANOVA and the significance was determined by using Fisher's least significance difference (p = 0.05%).

3. RESULTS AND DISCUSSION

The application of several organic nutrient sources led to notable changes in growth and yield components. The organic inputs had a favourable impact on the growth and yield-attributing metrics compared to the control. Plants that were noticeably taller were observed with application of vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5) i.e*.,* at 45 DAT (81.78 cm), 90 DAT (128.15 cm) and at harvest (145.71 cm) followed by fresh azolla application as dual crop (400 kg ha^{-1}) + biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 kg ha^{-1}) (Table 1). At harvest, the other inputs, which also included natural farming inputs, did not exhibit a discernible difference in height. Biologically, hereditary elements that are less susceptible to extrinsic influences control plant height. However, the use of vermicompost, rock phosphate, and biofertilizers may have increased the availability of nutrients, which may have contributed to the increase in height. The highest number of tillers at 45 DAT (8.31 m^{-2}), at 90 DAT (13.79 m^{-2}) and at harvest (10.40 m^{-2}) was found in vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5 ha^{-1}) at booting stage (Table 2).

Because it is correlated with the number of final productive tillers at harvest, tiller output is crucial for rice. As a result, it might be seen as an additional benefit of using organic inputs to increase yield through changed canopy growth. The dry weight was found to be significantly enhanced in vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5 ha^{-1}) at the booting stage i.e., at 45 DAT (29.34 g $plant^{-1}$), 90 DAT (79.11 g $plant^{-1}$) and at harvest (92.29 g $plant^{-1}$) (Table 3). These might be due to the adequate absorption of nutrients by the roots. Phosphorus being a root growth enhancer helped in gaining dry matter content and the other sources of nutrient proved to be efficient. Likewise, vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5 ha^{-1}) produced highest number of panicles (346.67 m^{-2}), filled grains (256.42 $panicle^{-1}$) over the control. Thus, it is seen that application of the above-mentioned nutrient sources showed overall superiority over the other organic and natural farming inputs in influencing the growth parameters. Similar findings were also observed by [11,12,13]

Application of various bio-inputs significantly influenced *joha* rice grown organically. In control, the *joha* rice production is incredibly low and it is not sufficient to meet the national and global need from limited organic area of Assam. However, an overall increase (0.27 t ha^{-1}) caused by the addition of bio-inputs under the same organic system clearly justifies the search for effective organic input for yield manipulation. The application of vermicompost (1 tha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4kg ha-1), rock phosphate (10 kg P_2O_5 ha^{-1}) resulted noticeable change in grain (34.62 q ha^{-1}) and straw (70.30 q ha^{-1}) yield (Table 6). It was followed by fresh *azolla* as dual crop (400 kg ha^{-1}) + biofertilizers (*Azospirillum*, *PSB* and *KSB* mix as seedling root dip) (4 kg ha^{-1}) (Table 5). The improved availability of nutrients, which eventually preserved a favourable soil physical, chemical, and biological environment may be responsible for the higher grain and straw production using vermicompost, rock phosphate, and biofertilizers.

Table 1. Effect of organic and natural inputs on plant height (cm) of rice

Treatments	45 DAS	90 DAS	At harvest
T_1: Absolute Control	63.06	89.35	109.59
T_2: NF, Beejamrit as root dip treatment (3%) (100 L ha^{-1}) + Jeevamrit as spray (3%) (100 L ha^{-1}) + Ghanajeevamrit as soil treatment at 100 kg (Jeevamrit and Ghanajeevamrit at 30, 60 and 90 DAT)	70.06	104.56	112.95
T_3: Enriched compost (5 t ha^{-1}) + Biofertilizer (*Azospirillum*, PSB as seedling root dip) (4 kg ha^{-1})	76.31	119.55	139.92
T_4: Enriched compost (5 t ha^{-1})	73.32	115.21	135.07
T_5: Vermicompost (5 t ha^{-1})	74.15	112.99	134.21
T_6: Enriched compost (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	75.45	113.65	137.75
T_7: Fresh azolla as dual crop (400 kg ha^{-1}) + Biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 kg ha^{-1})	77.88	122.89	141.10
T_8: Vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5)	81.38	128.15	145.71
Sem (±)	4.25	6.06	5.68
CD (p=5%)	12.84	18.21	17.06

Here, T= Treatment, PSB = Phosphate Solubilizing Bacteria, KSB=Potassium Solubilizing Bacteria, DAT = Days After Transplanting and NF=Natural Farming

Table 2. Effect of organic and natural inputs on number of tillers/ m^2 of rice

Treatments	45 DAS	90 DAS	At harvest
T_1: Absolute Control	2.95	9.72	7.99
T_2: NF, Beejamrit as root dip treatment (3%) (100 L ha^{-1}) + Jeevamrit as spray (3%) (100 L ha^{-1}) + Ghanajeevamrit as soil treatment at 100 kg (Jeevamrit and Ghanajeevamrit at 30, 60 and 90 DAT)	5.53	10.59	8.77
T_3: Enriched compost (5 t ha^{-1}) + Biofertilizer (*Azospirillum*, PSB as seedling root dip) (4 kg ha^{-1})	6.78	11.85	9.80
T_4: Enriched compost (5 t ha^{-1})	5.37	11.64	9.12
T_5: Vermicompost (5 t ha^{-1})	4.89	10.64	9.02
T_6: Enriched compost (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	6.07	9.33	9.22
T_7: Fresh azolla as dual crop (400 kg ha^{-1}) + Biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 kg ha^{-1})	7.03	12.05	10.17
T_8: Vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5)	8.31	13.79	10.40
Sem (±)	0.40	0.53	0.36
CD (p=5%)	1.23	1.63	1.10

Table 3. Effect of organic and natural inputs on dry weight (g/plant) of rice

Treatments	45 DAS	90 DAS	At harvest
T_1: Absolute Control	15.83	60.31	76.09
T_2: NF, Beejamrit as root dip treatment (3%) (100 L ha^{-1}) + Jeevamrit as spray (3%) (100 L ha^{-1}) + Ghanajeevamrit as soil treatment at 100 kg (Jeevamrit and Ghanajeevamrit at 30, 60 and 90 DAT)	22.34	61.60	81.33
T_3: Enriched compost (5 t ha^{-1}) + Biofertilizer (*Azospirillum*, PSB as seedling root dip) (4 kg ha^{-1})	25.49	70.15	88.26
T_4: Enriched compost (5 t ha^{-1})	21.93	64.56	86.17
T_5: Vermicompost (5 t ha^{-1})	20.72	58.50	85.03
T_6: Enriched compost (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	23.70	69.18	87.05
T_7: Fresh azolla as dual crop (400 kg ha^{-1}) + Biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 kg ha^{-1})	26.12	71.07	90.14
T_8: Vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5)	29.34	79.11	92.29
Sem (±)	0.60	1.25	0.67
CD (p=5%)	1.82	3.79	2.03

Under organic situation the availability of essential nutrients is lower at initial stages but organic sources such a vermicompost, enriched compost can provide sustained release of nutrients over the entire crop growth period though at a slower rate than chemical fertilizers. Similar observation on yield improvement under organic systems were observed by [14,15,16].

Table 4. Effect of organic and natural inputs on yield attributing characters of rice

Treatments	Panicles/m^2	Filled grains/panicle	Test weight(g)
T_1: Absolute Control	266.33	160.73	11.01
T_2: NF, Beejamrit as root dip treatment (3%) (100 L ha^{-1}) + Jeevamrit as spray (3%) (100 L ha^{-1}) + Ghanajeevamrit as soil treatment at 100 kg (Jeevamrit and Ghanajeevamrit at 30, 60 and 90 DAT)	292.33	181.06	11.02
T_3: Enriched compost (5 t ha^{-1}) + Biofertilizer (*Azospirillum*, PSB as seedling root dip) (4 kg ha^{-1})	326.67	228.16	11.31
T_4: Enriched compost (5 t ha^{-1})	316.33	214.39	11.08
T_5: Vermicompost (5 t ha^{-1})	310.67	211.03	11.12
T_6: Enriched compost (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	320.67	225.90	11.07
T_7: Fresh azolla as dual crop (400 kg ha^{-1}) + Biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 kg ha^{-1})	339.01	237.85	11.38
T_8: Vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5)	346.67	256.42	11.45
Sem (±)	1.84	5.78	0.08
CD (p=5%)	5.60	17.54	NS

Table 5. Effect organic and natural inputs on grain yield, straw yield and harvest index

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest Index (%)
T_1: Absolute Control	15.50	28.01	35.63
T_2: NF, Beejamrit as root dip treatment (3%) (100 L ha^{-1}) + Jeevamrit as spray (3%) (100 L ha^{-1}) + Ghanajeevamrit as soil treatment at 100 kg (Jeevamrit and Ghanajeevamrit at 30, 60 and 90 DAT)	19.47	35.71	35.31
T_3: Enriched compost (5 t ha^{-1}) + Biofertilizer (*Azospirillum*, PSB as seedling root dip) (4 kg ha^{-1})	28.50	55.90	33.77
T_4: Enriched compost (5 t ha^{-1})	25.30	48.33	34.38
T_5: Vermicompost (5 t ha^{-1})	24.52	46.36	34.62
T_6: Enriched compost (2.5 t ha^{-1}) + Vermicompost (2.5 t ha^{-1})	27.07	52.21	34.15
T_7: Fresh azolla as dual crop (400 kg ha^{-1}) + Biofertilizers (*Azospirillum*, PSB and KSB mix as seedling root dip) (4 kg ha^{-1})	31.12	61.58	33.60
T_8: Vermicompost (1 t ha^{-1}), mixed inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4 kg ha^{-1}), rock phosphate (10 kg P_2O_5)	34.62	70.30	32.99
Sem (±)	0.55	0.87	-
CD (p=5%)	1.69	2.64	-

4. CONCLUSION

The use of organic source of nutrients influenced the physical, chemical, and biological processes in the soil thereby making the nutrients available for the crop. Combined application of vermicompost (1 t/ha) along with inocula of *Azospirillum amazonense* A-10 and *Bacillus megaterium* P-5 (4kg/ha) and rock phosphate (10 kg P_2O_5) can be used as a suitable treatment for attaining higher growth, yield attributes and yield in *Bokul Joha* variety of rice. The use of chemical fertilizers can be replaced with organic fertilizers for the increase in productivity. Thus, organic farming should be promoted among the farmers fraternity as a reliable source for cultivation of *joha* rice which provides adequate nutrition by maintaining the soil health and long-term sustainability of soil resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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