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Effect of organic, natural and inorganic farming practices on growth, yield and economics of paddy

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Abstract
Chemical-free farming practices, such as natural and organic farming aim to reduce external agricultural inputs of synthetic origin while relying on ecosystem management. In order to fulfil the food needs of expanding population, it has been determined that heavy use of pesticides, inorganic fertilizers and other inputs for maximizing agri-production is necessary. Achieving a balance and sustainable food production is a challenging issue for the increasing food demand of rapid population growth. Taking this into account, an On Farm Trial (OFT) on the effect of organic and natural farming practices on paddy growth, yield attributes, yield and economics was conducted in 5 locations at Krishi Vigyan Kendra (KVK) operated mandals in Kalyandurg during the late *Kharif* season of 2023-24 on 2.0 ha of irrigated alfisols. The study revealed that farmers practice of conventional farming recorded higher yield attributes, grain yield, gross return, net return and return per rupee invested than organic and natural farming practices. The grain yield reduction was -17.2 and –39.8% in organic and natural farming practices, respectively over conventional farming. The higher net returns (Rs. 30455/ha) and return per rupee invested (1.58) was observed in natural farming practice than organic farming practice (Rs. 30455/ha and 1.38, respectively), owing to the low cost of cultivation in natural farming practice. In order to achieve the same economic benefit of conventional farming when compared to return per rupee invested, premium price for paddy should be 17.6% higher (Rs. 35.3/kg) in natural farming and 34.3% higher (Rs. 40.4/kg) in organic farming practice.

Keywords: Organic, natural, inorganic farming practices, growth, yield, economics of paddy

Introduction
Rice (*Oryza sativa* L.) is one of the most cultivated and consumed staple foods in Asia and more particularly in South Asia, where rice accounts for more than 40% of calorie intake in the Indian subcontinent (Shankar *et al*. 2021) [7]. In India, rice is grown in an area of 43.86 million ha making it the second-largest producer worldwide with a production of 117.94 million tons with an average productivity of 2576 kg/ha (GOI,2021) [7]. Sustaining rice production has become a significant concern, particularly in locations where rice productivity is declining despite of implementing recommended nutrient management practices (Mondal *et al*. 2016) [7]. Unbalanced fertilization and reduced usage of organic inputs have raised concerns about the potential long-term negative impact on production and environmental quality (Panhwar *et al.* 2019) [7] and this detrimental effects of intensive chemical use in agriculture had made possible to embrace organic farming worldwide (Prasad 2005 [7], Das *et al* 2020 [7]). Organic farming is a popular practice for reducing the environmental and ecological impact of long-term development. The use of more organic materials in agricultural practices can reduce the negative effects on the environment while by preserving its natural cycles of recovery (Gamage *et al* 2023) [7] and also boosting and maintaining rice productivity (Mondal *et al* 2015) [7]. Long-term experiments have shown that use of organic nutrient sources has been found to be more effective in maintaining higher productivity and stability through correction of deficiencies of secondary and micronutrients in the course of mineralization on one hand and favorable physical and soil ecological conditions on the other (Mallikarjun and Maity. 2017) [7]. Though organic farming is considered as sustainable agricultural alternative, it is frequently criticised for producing lower yields (Boschiero *et al* 2023) [7].

Therefore, yield production is one of the primary constraint in organic farming, which would imply that more area should be farmed organically to generate the same amount of yield as conventional farming to meet food demands of rising population (Azarbad 2022) [7]. On the other hand, demand for organic rice in recent years have created considerable gap between demand and supply. Thus, there is a need for a significant increase in the area covered and production of organic rice in order to capitalize on the worldwide organic rice market (Hazra *et al* 2018) [7]. In recent years, a new cost-effective idea known as Zero Budget Natural Farming (ZBNF), has been claimed to continue productivity and maintain ecological balance. This farming is based on the philosophy of utilizing cheap and locally accessible inputs. Jeevamrit, which is made on-site, is essential to this practice since it increases microbial activity in the soil and aids in soil fertility enhancement besides meeting crop nutritional needs (Saharan *et al* 2023) [7]. To increase crop output in organic farming without large land-use changes and agricultural expansion, a microbial-based method can be utilised to ensure improved productivity, especially in a changing climate (Azarbad 2022) [7]. Considering all the farming methods, a comparative study on assessment of performance of organic, natural and inorganic farming practices on growth and yield of rice was investigated.

Materials and Methods

A On Farm Trial (OFT) was conducted in 5 locations at KVK operated mandals of Krishi Vigyan Kendra (KVK), Kalyandurg during the late *Kharif* season of 2023-24 in 2.0 ha area to assess the impact of organic farming and natural farming practices on growth, yield attributes, yield and economics of paddy on irrigated alfisols. A high yielding paddy variety Telangana Sona (RNR 15048) was used for the trial. The recommended dose of fertilizer (RDF) was 120:60:60 kg N: P_2O_5: K_2O ha^{-1}. Package of practices recommended for the region was followed. Treatment wise source of nutrition, application, seed treatment chemical and plant protection measures followed were depreciated in Table1. The observation on panicles m^{-2} was recorded from 10 plants, which were randomly selected from each location at the time of harvest. Yield components like number of seeds/panicles were recorded by collecting 10 panicles randomly in each plot at maturity. At the time of maturity, the net plots (25 m^2) were harvested and threshed and sundried in the field. After threshing, cleaning and drying the seed yield was recorded and expressed in kg/ha.

Studies on the economics of paddy production were conducted by keeping a record of operations performed, labour employed, power and inputs used. The authors calculated the costs of various cultural operations using fixed and variable costs. The costs of common cultural operations for all treatments, such as seeds, field preparation, irrigation are fixed, while those that vary with treatments, such as fertilizer and organic input costs, plant protection measures and their application and harvesting are variable. The cost of inputs on account of different treatments was added to the common cost of cultivation of rice crop to arrive at the total cost of cultivation. The gross return was computed using the selling price by farmers. Net return was estimated by subtracting total cultivation costs from gross return. The return per rupee invested was, thus, calculated by dividing gross return with total cost of cultivation. The economics on premium pricing of the paddy grown under organic and natural farming practice were depreciated in table 4. and that shows at what premium pricing should the product be sold so as make the organic farming or natural farming more profitable at farm level.

Results and Discussions

Growth and Yield

Tillering ability is one of the most important characteristics of the rice plant since it significantly influences grain yield. Data pertaining to tiller number in rice (Table 2) showed significant variation under different farming practices. Among the farming practices, conventional farming practice recorded higher number of tillers per unit area (258 m^{-2}) over the other two farming practices (Organic and natural farming). Effective tillering that ensures successful panicle production is critical for good crop yield in rice. From the data (Table 2), it is found that conventional farming practice of inorganic nutrient management recorded higher number of panicles per unit area (176) and higher number of filled grains per panicle (140). The conventional farming practice recorded 15.7% & 27.5% higher number of panicles and 9.4% & 11.1% higher number of filled grains per panicle over organic farming and natural farming practices respectively. The organic farming performed better than natural farming by recording 10.1% higher number of panicles per unit area and however there is no much variation in number of filled grains per panicle with respect to organic and natural farming practices. The data on grain yield of rice (Table 2) shows that, the yield in conventional farming (3938 kg/ha) was higher than compared to organic farming (3375 kg/ha) and natural farming (2813 kg/ha) practices. Tested farming practices of organic and natural farming recorded -17.2 and –39.8% lower grain yield than conventional paddy, respectively. The higher number of growth, yield attributes and yield associated to conventional farming could be due to the fact that chemical fertilizers can promptly provide the appropriate quantity of nutrients in a balanced proportion that coincides with the crop's growth demand, hence improving yield attributes and yield. The less productivity of organic farming and natural farming in rice than inorganic farming could be attributed due to lower number of panicles per unit area and fewer grains in panicle. Our results agreed with the study by Ruan *et al* (2023) [7] which showed that organic cultivation was less productive than conventional cultivation in terms of yield of fragrant rice. The study by Amrutha *et al* (2021) [7] also showed that the tiller number, number of panicles per unit area, number of filled grains per panicle and grain yield in organic and natural farming practices was lower than conventional farming practice.

Economics

The economics of rice cultivation grown under different farming practices was calculated on the basis of prevailing market price of different inputs and outputs. The data on cost of cultivation, gross return, net return and return per rupee invested were analyzed statistically and presented in the table 3. The results on cost of cultivation showed very striking effect of added nutrients on economics of rice cultivation. Among the treatments, natural farming has the lowest cultivation cost (Rs. 53920 ha-1), which is 18% lower (savings of Rs. 12500) than conventional paddy production cost. Organic farming practice had the highest cultivation cost (Rs. 73910 ha-1), which is 11.2% (an additional cost of Rs. 7500/-) higher than the cost of production for conventional practice. The high cost of cultivation in organic packages was due to the fact that chemical fertilisers contain more nutrients per unit weight of product than organic fertiliser. To reach the same soil nutrient levels as a unit weight of chemical fertiliser, many units of organic fertiliser are necessary, making organic farming more expensive than inorganic. The low cost of production in natural farming was mainly due to use of on-farm inputs (Jeevamrutha and cow urine). Similar

observations of high production cost in organic farming and low production cost in natural farming was also observed by Behera and Chandrashekara (2022) [7]. The farmers practice i.e. Inorganic farming registered higher gross returns (Rs. 118125/ha), net returns (Rs. 53945/ha) and return per rupee invested (1.84) than other two farming practices. The enhanced yield under farmers practice of inorganic nutrient management had resulted in economic advantage. Higher gross returns were observed in organic farming practice (Rs. 1101250/ha) than natural farming practice (Rs. 84375/ha), which was mainly due to higher grain yield the organic farming practice over natural farming. However, the higher net returns (Rs. 30455/ha) and return per rupee invested (1.58) was observed in natural farming practice than organic farming practice (Rs. 30455/ha and 1.38, respectively), owing to the low cost of cultivation in natural farming practice. Similar observation of higher net returns and B:C ratio in ZBNF even though with lower yields was noticed by Babalad *et al* (2021) [7] and Deka and Goswami (2021) [7]. The present selling price of paddy at farmers field and local market was Rs. 30 per kg in all the three farming practices (Table 4). As a result, under the various farming practices analysed, conventional rice farming is more profitable than rice produced using organic and natural farming practices. Considering the premium prices into account, in order to achieve the same economic benefit of conventional farming when compared to return per rupee invested, premium price for paddy should be Rs. 35.3/kg in natural farming and Rs. 40.4/kg in organic farming practice (Table 4). A similar observation was made by Tashi *et al*. (2016) [7] and Sharma *et al*. (2023) [7] regarding paying farmers higher premium prices as a trade-off cost due to the possibility of output reductions of up to 3-5 years under organic and natural farming.

Table 1: Treatment wise source of nutrition, seed treatment and plant protection measures followed

Treatments	Source of nutrition	Weed management	Seed treatment	Plant protection
Organic	- Green Manuring Insitu-Dhiancha 37.5 kg per acre, -Basal application of FYM @ 10 t/ha, - Bio-fertilizer application (Azotobacter and PSB) @ 5 kg/ha each, - Neem cake or vermicompost @ 500 Kg /ha at tillering and PI stage.	Azolla mulch along with hand weeding twice at 25 and 50 DAT	Biofertilizer (*Azotobacter* and PSB)	- Application of *P. fluorescence* spray @10 g/l for the control of blast - Applications of neem formulations (Azaderactin1500 ppm at nursery and at 10, 25 DAT) 5 ml/L for control of Leaf Folder - *Trichogramma japonicum* (Trichocards) @ 40,000 /acre release and erection of bird perches @ 20/ acre - Installation of pheromone traps @ 8 per acre for the control of stemborer - For BPH- formation of alleyways, alternate wetting and drying and NSKE (Neem seed kernel extract) 1500 ppm spraying @ 5 ml/L and water management
Natural farming	- Beejamrutham 5l/ha - Ghanajeevamrutham:3t/ha - Dravajeevamrutham 1500 l/ha	Azolla mulch along with hand weeding twice at 25 and 50 DAT	Beejamrith	- Formation of alleyways; Seed and seedling Treatment-Beejamrutham @ 5 ltrs/ 25-30 kg seed; Erection of Bird Perches 10-15/acre; Clipping of leaf tips during transplantation; Release of Trichogramma egg parasite - Erection of Pheromone traps @8/acre for stemborer; Spraying of Neemastram – 200 lit/acre; Erecting of white/yellow sticky traps 20-25/acre;Planting of Marigold plants on buds - Spraying of Neemasthram (for minor Insect pests); Agnasthram (Borers)/ Bhrahmasthram (Major Insect Pests) for insect pest control. For Disease control use sour butter milk (6 L in 100 L water).
Inorganic	N through urea, P through SSP and K through MOP	Herbicides	Insecticide (Imidachloprid 5 ml/kg)	Insecticides and fungicides

Table 2: Effect of Organic, Natural and Inorganic farming practices on Growth, Yield attributes and Yield of rice.

Treatments	Tiller (number m^{-2})	No. of panicles m^{-2}	Filled grains $panicle^{-1}$	Grain yield (kg ha^{-1})
TO_1: Organic farming	237	152	128	3375
TO_2: Natural farming	226	138	126	2813
FP: Inorganic	258	176	140	3938

*FP-Farmers Practice

Table 3: Effect of Organic, Natural and Inorganic farming practices on Economics of rice

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Return Re^{-1} invested
TO_1: Organic farming	73910	101250	27340	1.38
TO_2: Natural farming	53920	84375	30455	1.58
FP: Inorganic	64180	118125	53945	1.84

*FP-Farmers Practice, *Sale price of paddy at farmers field was Rs. 3,000/- per quintal.

Table 4: Economics of premium pricing for rice grown under Organic and Natural farming practices.

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Market price (Rs. 30/kg)			17.6% higher premium price (Rs. 35.3kg)			34.3% higher premium price (Rs. 40.4/kg)		
			GR (Rs/ha)	NR (Rs/ha)	BCR	GR (Rs/ha)	NR (Rs/ha)	BCR	GR (Rs/ha)	NR (Rs/ha)	BCR
TO_1: Organic farming	3375	73910	101250	27340	1.37	119138	45228	1.61	136013	62103	1.84
TO_2: Natural farming	2813	53920	84390	30470	1.57	99299	45379	1.84			
FP: Inorganic	3938	64180	118140	53960	1.84						

*GR-Gross Returns, * NR-Net Returns, *BCR- Benefit: Cost Ratio

Conclusion

From the study it can be concluded that, performance of paddy under organic and natural farming practices had showed higher gap in growth, yield attributes and yield than conventional farming. Organic farming practices of paddy production demands higher cost of production and natural farming demands higher labour for regular monitoring. It can be concluded that, under present circumstances premium price for paddy produced under organic and natural farming should be considered to achieve the higher economic benefit than conventional paddy that will encourage more farmers to shift to organic and natural farming. In the future, it is likely that rice produced under organic and natural farming will fetch premium price and will outcompete the conventional system.

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