

The Response of Green Manuring of *Sesbania aculeate* on growth and Yield of Rice in Flood Prone Area of Coastal Odisha

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Authors' contributions

This work was carried out in collaboration among all authors. Author TRS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors PM, NMM and SNM managed the literature searches and analyses of the study. Author FHR managed editing and prepared the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the farmer's field at Ratanpur village of Marshaghai block of Kendrapara, Odisha to evaluate effect of green manuring and other nutrient management on yield and economics of rice. The village is an adopted village by Krishi Vigyan Kendra, Kendrapara, in which various activities in agriculture are going on under National innovations in climate-resilient agriculture (NICRA) program to combat the flood-affected area of the locality. The experiment consists of five treatments like green manuring + NPK (60: 30: 30 Kg/ha), green manuring + NPK (80: 40: 40 Kg/ha), green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha), green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha) and farmer's practice *i.e.*, NPK (80: 40: 40 Kg/ha). Results revealed that green manuring of Dhaincha along with application of FYM @ 5 t/ha clubbed with

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NPK @ 60: 30: 30 Kg/ha recorded highest grain yield (3.95 t/ha), straw yield (4.86 t/ha) and other yield attributing characters. The same treatment resulted in the highest economic return *i.e.*, B:Cratio of 1.51.

Keywords: Green manuring; FYM; yield; economics; microbial population.

1. INTRODUCTION

Rice is the major crop of India as well as a state like Odisha and an indispensable contributor to the food security of global population [1]. After the green revolution application of higher amount of chemical fertilizers enhanced the agricultural production but at the same time it deteriorated the soil quality and total factor productivity. Rice crop can use about 30 to 50% of the applied nitrogenous fertilizer while more than 50% is lost from the soil plant system through leaching, volatilization and denitrification [2]. Also, application of only chemical fertilizers reduces the biological properties and quality of soil. In the long run the productivity of soil decreases. Under the situation to reduce the losses of chemical fertilizers, substituting apart of chemical fertilizers an organic source or integrated use of organic and inorganic sources of nutrients may be a viable option for increasing productivity in a sustainable manner while maintaining the soil quality. In this context, field experiment was conducted to evaluate green manuring as an organic source along with chemical fertilizers in rice to know the ill advantages and its effect on soil biological properties.

2. MATERIALS AND METHODS

The field experiment was conducted in the farmers' field at Ratanpur, Marshaghain Kendrapara district of Odisha. This village is an adopted village by Krishi Vigyan Kendra Kendrapara in which various climate-resilient activities on agriculture and allied sector are going on under the national innovations in climate-resilient agriculture (NICRA) program. The experiment was laid out in a randomised block design with 5 number of treatments and 5 replications. There were five integrated nutrient management strategies *i.e.*, T₁- green manuring + NPK (60: 30: 30 Kg/ha), T₂- green manuring + NPK (80: 40: 40 Kg/ha), T₃- green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha), T₄- green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha) and T₅- NPK (80: 40: 40 Kg/ha) which is the common farmer's practice in the locality. The crop grown was rice variety *Swarna sub- 1*. In green manuring, Dhaincha (*Sesbania aculeata*)

was grown in the main field with seed rate at 25 kg per hectare. The method of establishment of rice was conventional transplanting method and during final land preparation, Dhaincha was incorporated into the field at 45 DAS. The require fertilizer dose was applied in the form of DAP (18: 46: 0), MOP (0: 0: 60) and Urea (46: 0: 0) with all phosphorus and potassium as basal and nitrogen in three splits *i.e.*, 50% as basal, 25% at tillering and 5% at panicle initiation stage. The yield and yield parameters of rice were recorded and subjected to statistical analysis [3]. The soil microbial population was estimated following is standard procedure of serial dilution plate count method by using specific media as described by Rolf and Bakken [4]. Total MBC was estimated by a standard procedure [5]. The initial and final soil nutrient status was estimated by using a standard protocol as described by Jackson [6].

3. RESULTS AND DISCUSSION

The results obtained in the experiments are depicted in this section. Appropriate reasons for the obtained results are discussed as well. The yield attributing characters of rice are presented in Table 1 with respect to an effective number of panicles per meter square. Significantly higher number of panicles (232 per m²) was obtained in green manuring+ FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha) which was followed by Green manuring +NPK (80: 40: 40 kg/ha) with 228 panicles perm² and green manuring+ NPK 60: 30: 30 Kg/ha (226 panicles per m²). The treatments having green manuring with a combination of chemical fertilizers were with each other. A significantly lower number of panicles (218 per m²) were with farmers practice in which only NPK (60: 40:40) was applied. Similar trend was observed in other yield attributing characters also (Table 1). Significantly higher panicle length (21.9 cm), grains per panicle (112 numbers), filled grains per panicle (98 numbers) and 1000 grain weight (23.2 g) were observed in green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 kg/ha) which was followed by the treatment where chemical fertilizers were added along with green manuring. The higher yield attributing characters are the result of higher growth rate and maximum dry

matter assimilation as well as partitioning in this treatment. Green manuring along with application of FYM builds the soil fertility and adds organic matter to the soil.

The addition of organic matter releases essential elements in balanced manner for better growth and development of the plant. Slow release of nutrients along with all trace elements from organic source and readily availability of major nutrients from inorganic source facilitates better growth and higher yield contributing characters of rice. Similar results were also reported by Jeet et al. [7] and Amanullah [8].

Significantly higher grain yield (3.95 t/ha) and straw yield (4.86 t/ha) were obtained in green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 kg/ha) which was followed by green manuring+ NPK (80: 40: 40 kg/ha) and green manuring + NPK (60: 30: 30 kg/ha) as depicted in Table 2. Significantly lower grain yield (3.23 t/ha) and straw yield (3.91 t/ha) were recorded with farmers practice where only NPK at the rate 80: 40: 40 kg/ha was applied. Higher grain yield and straw yield were achieved as a result of higher yield attributing characters like effective panicle

per m², panicle length, lower sterility percentage and higher test weight in the treatment where FYM (5 t/ha) was applied along with green manuring of Dhaincha and application of NPK at the rate 60: 30: 30 kg/ha. Green manuring builds the soil physical properties and organic matter supplied acts as a substrate for soil microbes. Green manuring and addition of farmyard manure reduce the loss of nutrients and supply available essential nutrients in a slow and continued manner for longer period which creates congenial soil rhizosphere for better plant growth. Similar results were also found by Mahendra et al. [9] and Mohanty et al. [10].

With respect to economics, higher gross returns (Rs. 71495/-), net returns (Rs. 24295/-) and benefit cost ratio (1.51) were obtained in green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 kg/ha) as presented in Table 3. It is because higher yield contributed higher gross returns, net returns and B:C ratio. Lower gross returns, net returns and BC ratio were recorded with farmers practice. Similar results were depicted in the studies done by Jeet et al. [7] and Mahendra et al. [9].

Table 1. Yield parameters of rice as influenced by nutrient management practices

Treatment details	Panicles per m ²	Panicle length (cm)	Grains per panicle	Filled Grains per panicle	1000 grain weight (g)
T ₁ Green manuring + NPK (60: 30: 30 Kg/ha)	226	21.2	108	93	22.7
T ₂ Green manuring + NPK (80: 40: 40 Kg/ha)	228	21.3	109	94	22.8
T ₃ Green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha)	232	21.9	112	98	23.3
T ₄ Green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha)	220	20.7	105	89	22.4
T ₅ NPK (80: 40: 40 Kg/ha)	218	20.1	103	86	22.2
SEm	1.18	0.17	0.85	0.89	0.21
CD	3.6	0.54	2.7	2.8	0.68

Table 2. Grain yield, Straw yield and Harvest Index as influenced by nutrient management practices in rice

Treatment details	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
T ₁ Green manuring + NPK (60: 30: 30 Kg/ha)	3.67	4.43	45.3
T ₂ Green manuring + NPK (80: 40: 40 Kg/ha)	3.72	4.60	44.7
T ₃ Green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha)	3.95	4.86	44.8
T ₄ Green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha)	3.44	4.15	45.4
T ₅ NPK (80: 40: 40 Kg/ha)	3.23	3.91	45.2
SEm	0.68	0.76	0.04
CD	2.12	2.53	NS

Table 3. Economics of rice as influenced by nutrient management practices

Treatment details	Cost of cultivation (Rs.)	Gross returns (Rs.)	Net returns (Rs.)	B: C Ratio
T ₁ Green manuring + NPK (60: 30: 30 Kg/ha)	45500	66427	20297	1.46
T ₂ Green manuring + NPK (80: 40: 40 Kg/ha)	46300	67332	21032	1.45
T ₃ Green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha)	47200	71495	24295	1.51
T ₄ Green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha)	44300	62264	19764	1.40
T ₅ NPK (80: 40: 40 Kg/ha)	42500	58463	15963	1.37

Higher microbial population *i.e.*, bacteria (37×10^5 CFU/g of soil), fungi (29×10^4 CFU/g of soil), actinomycetes (32×10^3 CFU/g of soil) and total MBC ($153.8 \mu\text{C/g}$ of soil) were obtained with green manuring+ FYM (2.5t/ha) + NPK (60: 30: 30 Kg/ha). Farmers practice where only chemical fertilizers were applied recorded lowest bacteria (28×10^5 CFU/g of soil), fungi (18×10^4 CFU/g of soil), actinomycetes (22×10^3 CFU/g of soil) and total MBC ($132.7 \mu\text{C/g}$ of soil) as depicted in Table 4. This might be due to the addition of carbon source in the form of green manure and farmyard manure which acts as ready food source of microbes. The higher microbial

population was found with green manuring and FYM application. This result was in line with the results reported by Alagappan and Venkataswamy [11] where higher microbial population was obtained when nutrients were applied through organic source as compared to application through RDF. Meena et al. [12] also reported significantly higher MBC was recorded with the application of two third RDN + bio fertilizer + compost @ 5 t/ha over chemical fertilizers. Similar results were also reported by Watts et al. [13] and Krishna Kumar et al. [14] where addition of organic matter increases the microbial population.

Table 4. Microbial population and total microbial carbon (MBC) in rice soil as influenced by nutrient management practices

Treatment details	Bacterial count (10^5 CFU/g of soil)	Fungal count (10^4 CFU/g of soil)	Actinomycetes count (10^3 CFU/g of soil)	Total MBC ($\mu\text{C/g}$ of soil)
T ₁ Green manuring + NPK (60: 30: 30 Kg/ha)	36	29	28	149.6
T ₂ Green manuring + NPK (80: 40: 40 Kg/ha)	35	28	29	148.7
T ₃ Green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha)	37	29	32	153.8
T ₄ Green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha)	34	25	26	142.7
T ₅ NPK (80: 40: 40 Kg/ha)	28	18	22	132.7

Table 5. Soil fertility status of rice after harvest as influenced by nutrient management practices

Treatment details	N (Kg/ha)	P ₂ O ₅ (Kg/ha)	K ₂ O (Kg/ha)	pH	Organic carbon (%)
T ₁ Green manuring + NPK (60: 30: 30 Kg/ha)	151.4	14.3	212.8	6.3	0.63
T ₂ Green manuring + NPK (80: 40: 40 Kg/ha)	150.8	14.6	210.5	6.2	0.63
T ₃ Green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha)	153.6	14.8	208.3	6.2	0.64
T ₄ Green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha)	158.3	15.3	214.5	6.1	0.62
T ₅ NPK (80: 40: 40 Kg/ha)	160.2	15.6	216.4	6.0	0.62
Initial	172.8	16.3	236.2	6.1	0.62

Table 6. Change in soil fertility status over initial after harvest of rice crop as influenced by nutrient management practices

Treatment details	Change in N (Kg/ha)	Change in P ₂ O ₅ (Kg/ha)	Change in K ₂ O (Kg/ha)	Change in pH	Change in organic carbon (%)
T ₁ Green manuring + NPK (60: 30: 30 Kg/ha)	-21.4	-2.0	-23.4	0.2	0.01
T ₂ Green manuring + NPK (80: 40: 40 Kg/ha)	-22.0	-1.7	-25.7	0.1	0.01
T ₃ Green manuring + FYM (2.5 t/ha) + NPK (60: 30: 30 Kg/ha)	-19.2	-1.5	-27.9	0.1	0.02
T ₄ Green maturing + FYM (5 t/ha) + NPK (60: 30: 30 Kg/ha)	-14.5	-1.0	-21.7	0.0	0.0
T ₅ NPK (80: 40: 40 Kg/ha)	-12.6	-0.7	-19.8	-0.1	0.0
Initial	172.8	16.3	236.2	6.1	0.62

3.1 Soil Fertility Status

The initial and final soil fertility status and change over initial was reported in Table 5 and Table 6. The initial pH was slightly acidic (6.1) and organic carbon was 0.62 percent which were in medium range. The initial nitrogen, phosphorus and potassium content of the soil was 172.8 Kg /ha, 16.3 Kg /ha and 236.2 Kg/ha, respectively. After harvest of the crop higher nitrogen (160.2 Kg/ha), phosphorus (15.6 Kg/ha) and potassium (216.4 Kg/ha) was obtained in farmers practice where only chemical fertilizer was applied. This might be due to lower uptake of nutrients from this treatment by rice crop.

With respect to change, there was a slight increase in pH towards neutrality in green manuring plots which might be ascribed to the reason of addition of organic matter. Also, a slight increase in organic carbon in soil due to addition of organic matter inform of green manure and farmyard manure. Compared to the initial, there is a negative balance of Nitrogen, phosphorus and potassium in the soil after harvest of the crop due to crop removal.

4. CONCLUSION

It may be concluded that green manuring in Dhaincha with the application of FYM (2.5 t/ha) and NPK (60: 30: 30 Kg/ha) recorded higher rice yield (3.95 t/ha) and B:C ratio (1.51). This also builds the soil fertility by increasing soil microbial properties indicated by increasing bacterial, fungal, actinomycetes population and total microbial biomass carbon (MBC). Green manuring also reduces the dosage of FYM and chemical fertilizers while sustaining the yield level.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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