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Fertilization of rice crop in pot culture with vermicompost, farm yard manure and RDF in Namakkal district of Tamil Nadu

Senthamizhkumaran V R [1, *], Kishore kumar M.C [2], Kishore S [2], Kisore Gopy S [2], Kolanchinadhan A [2], Krishnaveni K [2], Lokesh B [2] and Sathiyanathan M.R [2]

[1] *Department of Soil Science and Agricultural Chemistry, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, India.*
[2] *B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, India.*

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Abstract

Rice is an efficient crop with significant response of fertilizing both organic and inorganic source of fertilizers. The research was carried out at PGP College of Agricultural Sciences, Namakkal affiliated with Tamil Nadu Agricultural University, Coimbatore. The pot experiment was laid out in a completely randomized design with sixteen treatments with rice variety of ADT 45 and the treatment comprised of 75 and 100 % RDF (Based on STCR approach) with two organic sources of nutrient such as vermicompost @ 5 t/ha and FYM @ 12.5 t/ha + seed treatment with *Azospirillum* and Phosphobacteria (*Bacillus megaterium var phosphaticum)* + nursery soil application of AM fungi. Findings concealed that grain (35.2 g^{-1} pot) and straw yield (42.0 g^{-1} pot), nutrient uptake in grain (0.30 g^{-1} pot of N, 0.094 g^{-1} pot of P and 0.30 g^{-1} pot of K) and straw (0.45 g^{-1} pot of N, 0.034 g^{-1} pot of P and 0.71 g^{-1} pot of K) and the total nutrient uptake i.e. N (0.74 g^{-1} pot), P (0.129 g^{-1} pot) and K (1.01 g^{-1} pot) were significantly enhanced by the combined application of application of a recommended dose of fertilizer 100 % (based on STCR approach) + Vermicompost @ 5 t ha^{-1} + Seed treatment with *Azospirillum* and Phosphobacteria *(Bacillus megaterium var phosphaticum)* + Nursery soil application of AM fungi with irrespective of other treatments. Based on the findings it can be concluded that, application of FYM or Vermicompost in suitable combination with the RDF is effective in increasing the growth, yield and nutrient uptake.

Keywords: STCR; Grain and Straw Yield; Vermicompost; FYM

1. Introduction

Approximately 3.5 billion people around the globe rely on rice as a staple food crop (Khush, 2013). On a global scale, rice is cultivated in 158 million ha and global annual production is 470 million tons (Fahad *et al*., 2019). Different climate conditions are conducive for rice cultivation, including temperate, tropical and subtropical, varying from arid to humid (Mbava *et al*., 2020). Rice production reached 759.6 million tonnes (MT) in 2017, with Asia providing for 90% of the totalled (FAOSTAT, 2018). The task of achieving even higher rice production levels persists as global grain imploration is expected to treble by 2050. Rice is the most important and widely farmed crop in India, with 437.8 lakh hectares under cultivation, production of 118.4 million tonnes, and an average yield of 2.7 tonnes per hectare in 2020-21 (DACFW, 2020). It is dominantly cultivated in the states of West Bengal, Uttar Pradesh, Punjab, Tamil Nadu, and Andhra Pradesh. These five states contribute about 94 per cent of the total area and 90 per cent of total production. In Tamil Nadu, the production is 4.04 million tons from an area of 1.44 million hectares with a productivity of 2796 kg ha^{-1} (DES, 2017).

* Corresponding author: Senthamizhkumaran V R

During 2020-21, the total area under rice in Tamil Nadu would be 18.75 lakh hectares, with a production of 75 lakh tonnes and a productivity of 4.0 t ha^{-1} (DES, 2020). To meet the rising demand for rice grain, a combination of organic and inorganic fertilizers must be used to ensure crop sustainability (Datta and Singh, 2010). In India, rice is the most primary and broadly grown crop occupying an area of 437.8 lakh hectares with a production of 118.4 million tonnes with an average productivity of 2.7 t ha^{-1} during 2020-21 (DACFW, 2020). The expanding demand in rice grain production must be accomplished by utilizing the incorporation of organic and inorganic fertilizer to sustain the stability in crop production. The ultra-sources for restocking plant nutrients in agricultural soils are a succession of organic, inorganic, and bio-fertilizers (Masarirambi *et al*., 2012).

Higher productivity of rice is needed in India by adopting effective nutrient management measures. Currently, rice production in India is not meeting local demand due to the increasing population. Rice cultivation is very much dependent on nutrient management, as it has very high nutrient requirements. Optimizing nutrient management is the key to rice production. Due to the increasingly high yield of hybrid varieties, soil nutrients are being removed at a greater rate, making proper management of nutrients absolutely necessary. With addition and proper management of combined application of organic and inorganic source of nutrients greatly support the sustainable productivity of rice.

2. Materials and Methods

2.1. Research Area

The present experiment was carried out during Navarai (December-March) 2025 at pot house, Department of Soil Science and Agricultural Chemistry, PGP College of Agricultural Sciences, Namakkal, Tamil Nadu, India. The region belongs to North-western Agro-climatic zones of Tamil Nadu.

2.2. Research Design & Treatment Details

The present study was carried out using a Completely Randomized design (CRD) in which the evaluation of different rice cultivation techniques are being assessed. Sixteen treatments Viz., T_1 – Control, T_2 – RDF 100 % (based on STCR approach), T_3 - RDF 100 % + FYM @ 12.5 t ha-1, T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}, T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + Seed treatment with *Azospirillum brasilense* and Phosphobacteria (*Bacillus megaterium var phosphaticum)* (2 g per kg of seeds) + Nursery soil application of AM fungi (100 g per sq.m), T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1}+ Seed treatment with *Azospirillum brasilense* and Phosphobacteria *(Bacillus megaterium var phosphaticum)* (2 g per kg of seeds) + Nursery soil application of AM fungi (100 g per sq.m), T_7- RDF 75 % (based on STCR approach), T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}, T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}, T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + Seed treatment with *Azospirillum brasilense* and Phosphobacteria *(Bacillus megaterium var phosphaticum)* (2 g per kg of seeds) + Nursery soil application of AM fungi (100 g per sq.m), T_{11}- RDF 75% + Vermicompost @ 5 t ha^{-1} + Seed treatment with Azospirillum brasilense and Phosphobacteria *(Bacillus megaterium var phosphaticum)* (2 g per kg of seeds) + Nursery soil application of AM fungi (100 g per sq.m)., T_{12}- FYM @ 12.5 t ha^{-1}+ Seed treatment with Azospirillum brasilense and Phosphobacteria *(Bacillus megaterium var phosphaticum)* (2 g per kg of seeds) + Nursery soil application of AM fungi (100 g per sq.m), T_{13} - Vermicompost @ 5 t ha^{-1} + Seed treatment with Azospirillum brasilense and Phosphobacteria (*Bacillus megaterium var phosphaticum*) (2 g per kg of seeds) + Nursery soil application of AM fungi (100 g per sq.m), T_{14} - FYM @ 12.5 t ha^{-1}, T_{15} - Vermicompost @ 5 t ha^{-1} and T_{16} - Seed treatment with Azospirillum brasilense and Phosphobacteria *(Bacillus megaterium var phosphaticum)* (2 g per kg of seeds) + Nursery soil application of AM fungi (100 g per sq.m).

2.3. Collection of soil

A bulk soil sample (0-15cm) was collected from wetland farm of PGP College of Agricultural Sciences at located at 11.22° latitude and 78.20° longitude. The collected soil was air-dried, sieved through a 2mm sieve and utilized for pot experiment @ 10 kg per pot.

The experimental soil was found to have a clay loam texture belonging to the Noyyal series. The soil is taxonomically classified as Typichaplustalf in the USDA classification. The composite soil sample collected before the experiment was analyzed for various Physico-chemical and biological characteristics. The initial soil analysis of the experimental site revealed that the soil was slightly alkaline (pH = 8.15) with low soluble salts (EC = 0.63 dSm^{-1}), the medium organic carbon content of 0.62 percent, medium available nitrogen (268 kg ha^{-1}), high in phosphorous (22.5 kg ha^{-1}) and high in available potassium (780 kg ha^{-1}) status. The detailed analytical data on all the parameters were furnished in Table 1.

Table 1 Characteristics of the Initial soil (Pot Experiment)

S .No	Particulars	Units	Values
Physical Properties			
1.	Sand	Per cent	42.3
2.	Silt	Per cent	21.5
3.	Clay	Per cent	45.9
4.	Bulk density	(Mg m^{-3})	1.32
5.	Particle density	(Mg m^{-3})	2.16
6.	Total porosity	Per cent	38.8
7.	Texture	Clay loam	
Physico-chemical properties			
5.	pH		8.15
6.	EC	(dS m^{-1})	0.63
7.	Organic carbon	Per cent	0.62
Chemical properties			
8.	Available nitrogen	(kg ha^{-1})	268
9.	Available phosphorous	(kg ha^{-1})	22.5
10.	Available potassium	(kg ha^{-1})	780

2.4. Observations

2.4.1. Nutrient Management

Organic manures

Farmyard manure and vermicompost were incorporated into the soil one week before transplanting as per the treatment schedule.

Inorganic fertilizers

Based on the STCR approach, the fertilizer requirement for rice crops was calculated as Nitrogen 108 kg ha^{-1}, Phosphorous 37.35 kg $ha^{-1}$and Potassium 25 kg ha^{-1}. Correspondingly for 10 kg of soil, the fertilizer dose was calculated and applied as Urea, SSP, and MOP. Nitrogen and potassium were applied in three splits viz., 50% at basal, 25% at active tillering, and 25% at fifty percent flowering stage of the rice crop. Phosphorous was applied fully as a basal dose at the time of transplanting.

2.4.2. Biofertilizers

Seed treatment

The pre-germinated seeds were treated with *Azospirillum brasilense* and Phosphobacteria *(Bacillus megaterium var phosphaticum)* 2 g kg^{-1} of seeds.

Nursery application of AM fungi

Arbuscular Mycorrhizae 100 g/m^2 were applied in the Nursery bed to impose treatments.

Plant protection

Appropriate and need-based plant protection measures were taken up to control the pest and diseases by following the recommended package of practices.

Cultural practices

During the cropping period, irrigation and weeding (hand weeding) operations were followed.

2.4.3. Biometric observation

SPAD Chlorophyll reading

Chlorophyll content was recorded using a SPAD meter at different growth stages of the rice crop. The topmost fully expanded leaf was chosen and SPAD readings were taken on one side of the midrib in the leaf blade.

2.4.4. Plant growth characteristics

Plant Height

Plant height is measured by taking the distance from ground level to the tip of the longest leaf stretched and the mean height was worked out and expressed in centimeters (cm). It was measured at active tillering, panicle initiation, flowering, and harvest stage of the crop.

Leaf area index

LAI is the measure of leaf area surface per unit of land area surface by taking the length and width of the leaf. It is expressed by the total area of a leaf to the ground surface area.

$$L \times W \times N \times K$$

LAI = Ground surface area (cm2)

Where,
L - Length of the leaf in (cm)
W - Width of the leaf in (cm)
N -Number of leaves per plant
K - Correction factor

The value of K varies among crops, varieties, and growth stages. Under most of the conditions, the K value became constant at 0.75 at all stages of the crop except for the seedling and mature stage.

2.5. Yield attributes of rice

2.5.1. Number of tillers hill^{-1}

The numbers of tillers were counted at active tillering, panicle initiation & maturity stage and the mean value was used to compute and expressed as the number of tillers per hill.

2.5.2. Panicle length

At the maturity stage of the rice crop, the panicle length was recorded from the panicle neck to the apex as suggested by (Xiao *et al*., 1998) and is expressed in cm.

2.5.3. Panicle weight

At the maturity stage of the rice crop, the panicle weight was recorded and is expressed in grams.

2.5.4. Number of grains per panicle

The number of grains per panicle was counted and expressed as the number of filled grains per panicle.

2.5.5. Thousand-grain weight

After harvest, grains were dried at a moisture content of 14 percent, and one thousand grains were counted from the filled grains and it was expressed in grams.

2.5.6. Grain yield

At the maturity stage, the rice crop was harvested at ground level and thrashed. The separated grains were dried at 14 percent moisture level, weighed, and expressed as grain yield in g pot^{-1} as suggested by (Yoshida *et al*., 1976).

2.5.7. Straw yield

The rice crop was harvested and the grains were separated, the straw was dried in a hot air oven at 70˚C for about 24 hours to attain a constant weight, and recorded the weight and expressed in g pot^{-1}.

2.5.8. Dry matter production

Harvested plant samples were collected based on the treatment and those samples were first shade dried, then the samples were dried in a hot air oven at 70˚C for about 24 hours to attain a constant weight, and the recorded dry weight of the sample was expressed in g pot^{-1}.

2.5.9. Nutritive parameters

The grain and straw samples of rice crops were subjected to macronutrients (N, P, and K) analysis as per standard procedures outlined in Table 2.

2.5.10. Nutrient Uptake

Grain and straw samples were analyzed and nutrient uptake was calculated by using the following formula.

Nutrient uptake (g pot^{-1}) = Nutrient content (%) × DMP (g pot^{-1})

2.6. Statistical analysis

The data on various characters studied during the investigation were statistically analyzed by the method given by Gomez and Gomez (1984) using the Computer Software AGREES. The critical difference was worked out at 5 percent (0.05) probability levels. The relationships among the various parameters were worked out using simple correlation studies.

Table 2 Details of fertilizer used in the pot experiment

S. No.	Particulars	Pot Experiment
1.	RDF	150:50:50 NPK kg ha^{-1}
2.	RDF Based on STCR Approach	108:37.35:25 kg of N, P_2O_5 & K_2O
3.	Targeted yield	7 t ha^{-1}
4.	Vermicompost	5 t ha^{-1}
5.	Nutrient composition(%)	2.76:1.20:1.23 NPK
6.	FYM	12.5 t ha^{-1}
7.	Nutrient composition(%)	0.45:0.18:0.68 NPK
8.	VAM	100g/m^{-2}
9.	Spore count	100g/ 10,000 spores
10.	Time of application	All the treatments received an equal amount of recommended dose of fertilizer. Entire dose of phosphorus was applied as basal and the remaining N & K were applied as the split application respectively. However, vermicompost was applied three days before transplanting and Nursery soil application of vesicular arbuscular mycorrhiza.

3. Result and Discussion

3.1. Growth Attributes

3.1.1. Plant Height

The application of different sources of organic and inorganic sources of nutrients with a recommended dose of fertilizers had significantly increased the plant height in all stages of crop growth (Table 3.). The plant height ranged from 40.6 to 68.6, 47.5 to 74.3, 60.2 to 95.3, and 65.5 to 102.5 cm at active tillering, panicle initiation, flowering, and harvest stages respectively. Among the treatments, T6 recorded the tallest plant at active tillering, panicle initiation, flowering and at harvest of 68.6, 74.3, 95.3 and 102.5 cm on par with T_{11} registered 67.4, 73.1, 93.1 and 100 cm of plant height at active tillering, panicle initiation, flowering and at harvest stages followed by (T_5) (64.3, 70.2, 90.0 and 95.7 cm) respectively. The increased rice plant height is ascribed to applied vermicompost, which might have accelerated the metabolic and physiological activity of the plant and put up more growth by assimilating more amounts of major nutrients and ultimately increased the plant height. Nishi *et al*. (2019) reported that the application of vermicompost @ 10 tons per ha + N12P4K10 kg/ha significantly promotes rice growth both directly and indirectly by increasing the population of plant-friendly microorganisms and decreasing soil-borne illnesses. This might be attributed to the fact that higher doses of fertilizers resulted in higher availability of nutrients in the soil for plant nourishment.

Table 3 Effect of organics and inorganics on plant height @ active tillering, panicle initiation, flowering and at harvest stages of rice (ADT 45) in pot experiment

Treatments	Active Tillering	Panicle Initiation	Flowering	At Harvest
T_1 – Control	40.6	47.5	60.2	65.5
T_2 – RDF 100 % (based on STCR approach)	53.5	59.4	75.1	79.0
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	55.7	61.9	78.3	82.6
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	60.2	65.7	84.6	89.2
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	64.3	70.2	90.0	95.7
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	68.6	74.3	95.3	102.5
T_7- RDF 75 % (based on STCR approach)	52.6	58.1	73.6	78.1
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	54.3	60.3	76.5	80.3
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	59.0	64.1	82.7	86.9
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	63.5	69.0	88.2	93.5
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	67.4	73.1	93.1	100.0
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	50.2	56.2	68.2	75.8
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	51.3	57.0	70.0	77.2
T_{14} - FYM @ 12.5 t ha^{-1}	46.7	52.6	65.0	71.5
T_{15} - Vermicompost @ 5 t ha^{-1}	48.3	54.4	67.5	73.4
T_{16} - ST + SA	43.6	50.7	63.8	69.8
CD@ 5%	2.09	2.62	2.81	3.30
SEd	1.02	1.28	1.38	1.62

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.1.2. Leaf area index (LAI)

The effect of integrated nutrient management had shown significant influence on LAI is presented in Table 4. The result on the leaf area index of the plant attained higher value of about 2.55, 6.50 and 8.47 in (T_6) which was on par with (T_{11}) (2.51, 6.44 and 8.41) on active tillering, panicle initiation and at flowering stages followed by the (T_5) (2.43, 6.41 and 8.38) which was on par with the (T_{10}) (2.40, 6.31 and 8.32). Lower LAI was pragmatic in T_1 control (1.30, 5.36, and 7.11). Kenchaiah (1997) reported increased LAI and LAD due to higher nutrient uptake resulting in increased leaf area and improved LAI and LAD towards the reproductive stage of rice crop resulting from the application of organic sources of nutrients. The application of VAM would have increased the LAI as the water uptake and nutrients would have been increased and hence would have improved the photo-synthesis process resulting in increasing the leaf area. This result is supported by Sowarnalisha *et al*. (2017), who stated that the presence of VAM will increase the availability of phosphorus uptake, which will be useful for photosynthesis. The higher LAI in all periods of growth, the more yield will be obtained as it leads to higher production and yield of biomass.

Table 4 Effect of organics and inorganics on leaf area index @ active tillering, panicle initiation and flowering stages of rice (ADT 45) in pot experiment

Treatments	**Active Tillering**	**Panicle Initiation**	**Flowering**
T_1 – Control	1.30	5.36	7.11
T_2 – RDF 100 % (based on STCR approach)	2.10	6.09	8.02
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	2.28	6.21	8.11
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	2.31	6.29	8.22
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	2.43	6.41	8.38
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	2.55	6.50	8.47
T_7- RDF 75 % (based on STCR approach)	2.02	6.04	7.79
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	2.21	6.13	8.09
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	2.29	6.26	8.18
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	2.40	6.31	8.32
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	2.51	6.44	8.41
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	1.77	5.81	7.56
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	1.94	5.97	7.62
T_{14} - FYM @ 12.5 t ha^{-1}	1.44	5.69	7.41
T_{15} - Vermicompost @ 5 t ha^{-1}	1.55	5.78	7.49
T_{16} - ST + SA	1.32	5.57	7.32
CD@ 5%	0.091	0.068	0.314
SEd	0.034	0.034	0.156

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.1.3. Dry matter production (g^{-1} pot)

Various nutrient sources ushered significant variation in DMP of rice at all the crop growth stages are presented in Table 5.

The higher dry matter production (DMP) was registered under T_6 (24.9, 64.4 and 102.5 g^{-1} pot) which was on par with T_{11} (22.8, 61.2 and 93.6 g^{-1} pot) followed by T_5 (20.3, 54.8 and 82.7 g^{-1} pot) and T_{10} (18.2, 51.6 and 73.8 g^{-1} pot) on active tillering, flowering and at harvest stages. DMP was found numerically lower under T_1 control (6.3, 22.6, and 40.5 g^{-1} pot) respectively.

Comparatively, at active tillering, addition of vermicompost at 2 t ha^{-1} was sufficient for rice growing in organic situation, which had increased plant height, effective tillers per hill, DMP and yield (Vasanthi and Kumaraswamy, 1999). Continuous slow release of nutrients might have allowed plants to extend leaf area duration, allowing them to increase photosynthetic rates and thereby accumulate more dry matter. Accordingly, inorganic fertilizers combined with organic manure caused more photosynthates to be translocated from the source to the sink site of rice, causing higher yields (Barik *et al*. 2008).

Table 5 Effect of organics and inorganics on dry mater production (g-1 pot) @ active tillering, flowering and at harvest stages of rice (ADT 45) in pot experiment

Treatments	**Active Tillering**	**Flowering**	**Harvest**
T_1 – Control	6.3	22.6	40.5
T_2 – RDF 100 % (based on STCR approach)	10.6	39.2	61.9
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	11.4	41.8	65.7
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	15.8	45.3	70.0
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	20.3	54.8	82.7
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	24.9	64.4	102.5
T_7- RDF 75 % (based on STCR approach)	10.3	39.0	60.2
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	10.9	39.7	63.4
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	13.7	43.5	68.2
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	18.2	51.6	73.8
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	22.8	61.2	93.6
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	9.7	35.8	57.7
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	10.2	37.5	59.2
T_{14} - FYM @ 12.5 t ha^{-1}	9.0	31.2	52.1
T_{15} - Vermicompost @ 5 t ha^{-1}	9.3	32.5	55.3
T_{16} - ST + SA	8.7	30.5	46.2
CD@ 5%	2.23	5.23	9.82
SEd	1.09	2.55	4.82

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.1.4. SPAD (Chlorophyll meter reading)

The SPAD (Chlorophyll meter reading) in the plant sample was significantly different in various treatments. On active tillering, panicle initiation, and flowering, SPAD was significantly higher in T_6 (46.9, 45.7 and 35.2) which was on par with T_{11} (45.6, 44.4 and 34.3) and (45.3, 44.1 and 34.3). A numerically lower value was retained under T_1 control (35.1, 33.5, and 22.7). Chlorophyll meter (SPAD) readings indicated leaf N status (Pasha and Ramireddy, 2016). The SPAD reading is a measure of total chlorophyll content indicating greenness of leaves influencing the physiological functions. It also gives an idea about leaf nitrogen concentration, as nitrogen is an essential constituent of chlorophyll (Yoshida, 1981) (Table 6).

Table 6 Effect of organics and inorganics on SPAD @ active tillering, flowering and at harvest stages of rice (ADT 45) in pot experiment

Treatments	Active Tillering	Flowering	Harvest
T_1 – Control	35.1	33.5	22.7
T_2 – RDF 100 % (based on STCR approach)	41.8	40.6	30.8
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	42.7	41.5	31.7
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	43.4	42.2	32.4
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	45.3	44.1	34.3
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	46.9	45.7	35.2
T_7- RDF 75 % (based on STCR approach)	41.6	40.4	30.6
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	41.9	40.7	30.9
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	43.1	41.9	32.1
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	44.7	43.5	33.7
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	45.6	44.4	34.3
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	40.1	38.9	29.1
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	40.9	39.7	29.9
T_{14} - FYM @ 12.5 t ha^{-1}	39.1	37.9	28.6
T_{15} - Vermicompost @ 5 t ha^{-1}	39.7	38.5	29.0
T_{16} - ST + SA	37.2	36.0	26.8
CD@ 5%	1.257	1.154	0.839
SEd	0.625	0.573	0.417

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.2. Yield attributes

3.2.1. Thousand-grain weight

The thousand-grain weight significantly differed due to treatments and ranged from 10 to 17.6 g. Among the treatments, T_6 recorded the maximum weight of thousand seeds (17.6 g). The next maximum weight of thousand seeds (17.4 g) was registered in the T_{11}. These two treatments were on par with each other. The minimum weight of thousand seeds (10 g) was recorded in control (T_1) (Table 7). This could be owing to the vermicompost being applied at a higher rate to the soil, which would have helped maintain a higher level of nutrient availability and better nutrient assimilation by the plants. Increased levels of photosynthesis and enzymes are crucial to the creation of energy, carbohydrates, fat metabolism, and plant respiration. Hence high levels of inorganic fertilizers are regarded to be a rationale for the greater yield attributes. If organic manures operate as slow-release nitrogen sources and provide other nutrients to meet rice crops' needs more precisely, this could reduce nitrogen losses and enhance nitrogen use efficiency (Becker *et al*., 1994) (Table 7).

Table 7 Effect of organics and inorganics on thousand grain weight (g) of rice (ADT 45) in pot experiment

Treatments	**1000 grain weight (g)**
T_1 – Control	10.0
T_2 – RDF 100 % (based on STCR approach)	12.0
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	14.3
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	15.6
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	16.8
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	17.6
T_7- RDF 75 % (based on STCR approach)	11.8
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	13.9
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	15.2
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	16.5
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	17.4
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	10.9
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	11.5
T_{14} - FYM @ 12.5 t ha^{-1}	10.7
T_{15} - Vermicompost @ 5 t ha^{-1}	10.8
T_{16} - ST + SA	10.4
CD@ 5%	0.478
SEd	0.237

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.2.2. Panicle length (cm) & Panicle weight (g)

The panicle length was significantly influenced by integrated nutrient management. Among the treatments, T_6 attained higher panicle length of 28.5 cm which was on par with T_{11} (28 cm). It was followed by the application of a recommended dose of fertilizer 100 % (based on STCR approach) + FYM @ 12.5 t ha^{-1} + Seed treatment with Azospirillum and Phosphobacteria (Bacillus megaterium var phosphaticum) + Nursery soil application of AM fungi T_5 (27.3 cm). Lower was received under T_1 (20.5 cm) control (Table 8). The panicle weight was significantly influenced by integrated nutrient management. Among the treatments, T_6 attained a higher panicle weight of 4.59 g which was on par with the T_{11} (4.50 g) followed by T_5 (4.25 g). Lower was received under T_1 (3.0 g) control. Singh *et al.* (2015), who reported that enhanced nitrogen effect on growth and root formation resulted in greater nutrient uptake, increasing the number of panicles, panicle mass, and grains per panicle of rice. This could be owing to the vermicompost microbial stimulation and the N given through slow mineralization. The most significant attribute of yield is thousand grain weight, where the change of individual grain weight will make the variations in yield

Table 8 Effect of organics and inorganics on no. of grains per panicle, panicle weight (g) and panicle length (cm) of rice

Treatments	No. of grains per panicle	Panicle weight (g)	Panicle length (cm)
T_1 – Control	185	3.00	20.5
T_2 – RDF 100 % (based on STCR approach)	221	3.54	24.0
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	236	3.70	24.7
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	255	4.02	25.9
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	271	4.25	27.3
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	287	4.59	28.5
T_7- RDF 75 % (based on STCR approach)	215	3.51	23.6
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	230	3.60	24.2
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	249	3.90	25.0
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	265	4.19	26.8
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	282	4.50	28.0
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	210	3.48	23.0
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	213	3.50	23.1
T_{14} - FYM @ 12.5 t ha^{-1}	203	3.41	22.7
T_{15} - Vermicompost @ 5 t ha^{-1}	206	3.46	22.9
T_{16} - ST + SA	197	3.34	21.4
CD@ 5%	6.21	0.10	0.67
SEd	3.05	0.05	0.33

*ST – Seed treatment with Azospirillum brasilenseand Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.2.3. No. of grains per panicle

Results showed that the number of grains panicle-1 was experimentally higher under T_6 (287 nos.) which was on par with (T_{11}) (282 nos.) which was comparable with (T_5) (271 nos.) and T_{10} (265 nos.). T_1 control (185 nos.) received a lower number of grains per panicle (Table 8). Singh et al. (2015), who reported that enhanced nitrogen effect on growth and root formation resulted in greater nutrient uptake, increasing the number of panicles, panicle mass, and grains per panicle of rice. This could be owing to the vermicompost microbial stimulation and the N given through slow mineralization.

3.2.4. No. of tillers per hill

The effect of integrated nutrient management practices on the number of tillers per hill during the critical stages is furnished in Table 9.

During the investigation, more number of tillers were noted at the flowering stage. Even though it was higher, the rate of increase was mild from active tillering to flowering stages. Effect of different sources of organic and inorganic sources of nutrients with a recommended dose of fertilizers had significantly increased the no. of tillers per hill in all stages of crop growth. The no. of tillers per hill ranged from 9.1 to 18.8, 16.7 to 30.8, and 18.0 to 36.2 at active tillering, panicle initiation, and flowering stages respectively. Among the treatments, T6 recorded the maximum no. of tillers per hill at active tillering, panicle initiation and at the flowering of 18.8, 30.8 and 36.2 on par with T_{11} registered 18.5, 30.2 and 35.6 of no. of tillers per hill at active tillering, panicle initiation and at flowering stages followed by the T5 (17.2, 29.0 and 34.3) respectively. The minimum no. of tillers per hill (9.1, 16.7, and 18.0) was recorded in control (T_1). This could be owing to the vermicompost being applied at a higher rate to the soil, which would have helped maintain a higher level of nutrient availability and better nutrient assimilation by the plants. Increased levels of photosynthesis and enzymes are crucial to the creation of energy, carbohydrates, fat metabolism, and plant respiration. Hence high levels of inorganic fertilizers are regarded to be a rationale for the greater yield attributes. If organic manures operate as slow-release nitrogen sources and provide other nutrients to meet rice crops' needs more precisely, this could reduce nitrogen losses and enhance nitrogen use efficiency (Becker *et al.*, 1994).

Table 9 Effect of organics and inorganics on no. of Tillers per hill @ active tillering, panicle initiation and flowering stages of rice (ADT 45) in pot experiment

Treatments	**Active Tillering**	**Panicle Initiation**	**Flowering**
T_1 – Control	9.1	16.7	18.0
T_2 – RDF 100 % (based on STCR approach)	14.4	22.9	28.0
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	15.5	25.1	30.4
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	16.4	27.2	32.5
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	17.2	29.0	34.3
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	18.8	30.8	36.2
T_7- RDF 75 % (based on STCR approach)	13.9	21.8	27.3
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	15.2	24.6	29.8
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	16.1	26.8	31.8
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	16.9	28.4	33.8
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	18.5	30.2	35.6
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	12.4	19.7	24.6
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	13.5	20.5	25.6
T_{14} - FYM @ 12.5 t ha^{-1}	11.7	18.5	22.0
T_{15} - Vermicompost @ 5 t ha^{-1}	12.0	19.1	23.8
T_{16} - ST + SA	11.5	18.0	21.1
CD@ 5%	0.38	0.68	1.08
SEd	0.19	0.33	0.53

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.2.5. Grain and Straw yield (g^{-1} pot)

The impact of different sources of organic and inorganic nutrients exhibited significant variation ranging from 20.6 g^{-1} pot to 35.2 g^{-1} pot in grain yield.

Among the different treatments tried, though with the T6 recorded higher grain yield of 35.2 g^{-1} pot which was on par with the T_{11} (34.3 g^{-1} pot) and followed by the T_5 (33.2 g^{-1} pot) which was on par with T_{10} (33.0 g^{-1} pot). Among all, the lower value was registered in T_1 of 20.6 g^{-1} pot. The results of integrated nutrient application showed that, though grain yield got increased with the T_6 compared to T_2. The results indicate that the combined application of RDF along with Vermicompost and FYM registered significantly higher grain yield than inorganic fertilizer alone.

The straw yield had significantly enhanced by the combined application of organic and inorganic sources of nutrients. Irrespective of other treatments, T_6 realized higher straw yield of about 42.0 g^{-1} pot which was on par with the T_{11} (41.5 g^{-1} pot) followed by T_5 which was on par T_{10} (39.8 g^{-1} pot). The lowest straw yield was recorded under control (T_1) (28.0 g^{-1} pot) respectively (Table 10). Application of Vermicompost or FYM along with recommended dose of fertilizers + Seed treatment with Azospirillum and Phosphobacteria + Soil application of AM fungi enhanced the nutrient availability and thereby increasing the yield. They have positive influence on the macro and micro element absorption, improving water distribution in plants and finally producing plant hormones which have important role in plant growth. This might have also resulted in increase in number of productive tillers, length of panicle, weight of panicle and number of panicles. Similar findings are reported by Naderifar and Daneshian (2012).

Table 10 Effect of organics and inorganics on grain and straw yield (g^{-1} pot) of rice (ADT 45) in pot experiment

Treatments	**Grain yield (g^{-1} pot)**	**Straw yield (g^{-1} pot)**
T_1 – Control	20.6	28.0
T_2 – RDF 100 % (based on STCR approach)	29.7	36.5
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	30.3	37.0
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	32.8	38.3
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	33.2	40.0
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	35.2	42.0
T_7- RDF 75 % (based on STCR approach)	29.5	36.3
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	30.0	36.8
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	31.5	37.8
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	33.0	39.8
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	34.3	41.5
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	27.5	34.3
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	28.6	35.4
T_{14} - FYM @ 12.5 t ha^{-1}	25.1	31.9
T_{15} - Vermicompost @ 5 t ha^{-1}	27.0	33.8
T_{16} - ST + SA	23.1	29.9

CD@ 5%	1.310	1.23
SEd	0.643	0.60

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.2.6. Crop Nutrient Uptake by Grain and Straw

The nutrient uptake of various nutrients by grain and straw was depicted in Table 11.

There was an increased concentration of N in grain and straw due to graded levels of N application. This could be as a result of increase in N absorption by plant. These findings corroborate with the findings of Bezbaruha *et al.* (2011) who reported that higher nitrogen uptake with the application of nitrogen fertilizer might be due to higher nutrient concentration along with higher biomass production. The combined application of vermicompost along with N recorded highest N uptake significantly by rice grain and straw may be due to increased availability of nutrients in soil through vermicompost and N addition.

The P uptake by rice grain and straw were recorded highest for the application of RDF 75 % + Vermicompost @ 5 t ha-1 + Seed treatment with Azospirillum and Phosphobacteria + Soil application of AM fungi which was on par with RDF 75 % + FYM @ 12.5 t ha-1 + Seed treatment with Azospirillum and Phosphobacteria + Soil application of AM fungi under three different agro climatic zones of Tamil Nadu. Vermicompost might be responsible for the higher P content in grains and straw in combination with the increased P uptake by solubilizing the native phosphorus. As grain and straw contains more N as a result of the synergistic effect between N and P, the P content would be higher. By split application of nitrogen, rice grains and straw could have acquired more P because the application of N promotes phosphorus translocation from the vegetative organs to the grain.

Enhanced P uptake with judicious application of organic manures and inorganic fertilizers might be due to a combination of factors that enhance P availability in soils. These include production of organic acids through decomposition of organic matter and subsequent releases of phosphate ions, formation of phosphor-humic complexes and isomorphic replacement of phosphate ions by humate ions and also by synergistic effect existing between N and P due to application of organic manures. Such effects on soil P and plant uptake were also reported by Singh et al. (1994), Subbiah et al. (2000) and Satheesh and Balasubramanian (2003).

The data indicated that K uptake by rice grain and straw were observed highest for the application of RDF 75 % + Vermicompost @ 5 t ha-1 + Seed treatment with Azospirillum and Phosphobacteria + Soil application of AM fungi which was on par with RDF 75 % + FYM @ 12.5 t ha-1 + Seed treatment with Azospirillum and Phosphobacteria + Soil application of AM fungi under three different agro climatic zones of Tamil Nadu. This could be attributed to higher K content and better availability of nutrient K ion from the vermicompost and also available nutrient content of vermicompost as well as their rate of release were much higher over other treatments (Goswami, 1996).

An increasing trend of K in grain and straw may be due to applied N release more NH_4^+-N and NO_3^--N in soil which might have occupied the selective exchange sites in the 2:1 layer clay minerals and replaced the K^+ from exchange sites thereby K registered the highest available K in soil solution concentration leading to higher absorption by rice. It may be due to similar ionic radii of both N and K ions.

Higher uptake of K might be due to the priming effect of organic manure on decomposition related release of organic acids that solubilize native K. In addition, higher magnitude of increases in K uptake by conjunctive use of organic manures and inorganic fertilizers showed that organic manures presumably play key role in enhancing the use efficiency of applied fertilizer as well as inherent nutrient availability in the soil. This was also documented earlier by Bhagavathi Ammal and Muthiah (1995).

These findings are in confirmity with Meena et al. (2010), Balamurugan and Sudhakar (2012). Increased uptake of nitrogen as a result of NPK application is understood in view of its nitrogen fixing capacity. Positive effect of NPK and vermicompost on nitrogen content and uptake by rice crop. The best treatment of current field experiment with higher availability of nutrients might be due to the conjugative effect of all the sources of nutrients, which favoured the soil complex with more availability. The mere application of N, P and K through fertilizer alone might have involved with several processes of losses in the soil and also fixation to unavailable form were the reasons with less availability under application of inorganic fertilizers alone in the integrated nutrient management practices.

Table 11 Effect of organics and inorganics on nutrient uptake (NPK) (g-1 pot) in grain and straw at harvest stages of rice

Treatments	**At Harvest**								
	N uptake		**Total N uptake**	**P uptake**		**Total P uptake**	**K uptake**		**Total K uptake**
	Grain	**Straw**		**Grain**	**Straw**		**Grain**	**Straw**	
T_1 – Control	0.05	0.19	0.24	0.041	0.014	0.055	0.08	0.32	0.40
T_2 – RDF 100 % (based on STCR approach)	0.14	0.30	0.44	0.073	0.025	0.098	0.18	0.53	0.71
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	0.21	0.34	0.55	0.076	0.026	0.103	0.21	0.56	0.76
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	0.26	0.36	0.62	0.085	0.026	0.111	0.25	0.60	0.85
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	0.27	0.41	0.69	0.087	0.031	0.118	0.26	0.66	0.92
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	0.30	0.45	0.74	0.094	0.034	0.129	0.30	0.71	1.01
T_7- RDF 75 % (based on STCR approach)	0.13	0.29	0.43	0.063	0.024	0.088	0.18	0.52	0.70
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	0.19	0.33	0.53	0.075	0.025	0.100	0.19	0.55	0.74
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	0.25	0.35	0.60	0.081	0.028	0.109	0.22	0.58	0.80
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	0.27	0.38	0.65	0.086	0.030	0.116	0.25	0.64	0.89
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	0.29	0.43	0.72	0.091	0.033	0.124	0.29	0.69	0.98
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	0.11	0.27	0.38	0.056	0.020	0.076	0.16	0.47	0.62
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	0.13	0.28	0.41	0.059	0.021	0.081	0.17	0.49	0.66
T_{14} - FYM @ 12.5 t ha^{-1}	0.07	0.24	0.31	0.050	0.018	0.068	0.12	0.41	0.53
T_{15} - Vermicompost @ 5 t ha^{-1}	0.09	0.26	0.35	0.054	0.019	0.074	0.14	0.44	0.58
T_{16} - ST + SA	0.06	0.22	0.28	0.046	0.016	0.062	0.10	0.35	0.45
CD@ 5%	0.007	0.012	0.026	0.0031	0.0010	0.004	0.010	0.025	0.031
SEd	0.004	0.006	0.013	0.0015	0.0005	0.002	0.005	0.012	0.015

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

3.3. Economics

The application of a recommended dose of fertilizer 75 % (based on STCR approach + FYM @ 12.5 t ha^{-1} + Seed treatment with *Azospirillum* and Phosphobacteria *(Bacillus megaterium var phosphaticum)* + Nursery soil application of AM fungi was the best treatment with a net income of 1,48,190 ha^{-1} with B: C ratio of 3.27 (T_{10}) followed by the treatment RDF 75 % (based on STCR approach) (T_7) with next best net income of (1,48,594 ha^{-1}) with the B: C ratio of 3.22 and T_2 with net income of (1,63,930 ha^{-1}) with B: C ratio of 3.15. The poor net income and benefit: cost ratio was obtained from control (57580 and 2.08) (Table 12).

Table 12 Effect of organics and inorganics on economics of rice ADT 45 in pot experiment

Treatments	**Cost of cultivation (₹ ha^{-1})**	**Gross income (₹ ha^{-1})**	**Net income (₹ ha^{-1})**	**B:C Ratio**
T_1 – Control	57580	177420	119840	2.08
T_2 – RDF 100 % (based on STCR approach)	52010	215940	163930	3.15
T_3 - RDF 100 % + FYM @ 12.5 t ha^{-1}	50560	198546	147986	2.93
T_4- RDF 100 % + Vermicompost @ 5 t ha^{-1}	61810	213876	152066	2.46
T_5 - RDF 100 % + FYM @ 12.5 t ha^{-1} + ST + SA	53040	217224	164184	3.10
T_6- RDF 100 % + Vermicompost @ 5 t ha^{-1} + ST + SA	64290	230064	165774	2.58
T_7- RDF 75 % (based on STCR approach)	46160	194754	148594	3.22
T_8- RDF 75 % + FYM @ 12.5 t ha^{-1}	49530	196680	147150	2.97
T_9- RDF 75 % + Vermicompost @ 5 t ha^{-1}	60780	206010	145230	2.39
T_{10}- RDF 75 % + FYM @ 12.5 t ha^{-1} + ST + SA	45280	193470	148190	3.27
T_{11}- RDF 75 % + Vermicompost @ 5 t ha^{-1} + ST + SA	63260	224526	161266	2.55
T_{12}- FYM @ 12.5 t ha^{-1} + ST + SA	48810	180630	131820	2.70
T_{13} - Vermicompost @ 5 t ha^{-1}+ ST + SA	60060	187692	127632	2.13
T_{14} - FYM @ 12.5 t ha^{-1}	46330	165222	118892	2.57
T_{15} - Vermicompost @ 5 t ha^{-1}	42580	136692	94112	2.21
T_{16} - ST + SA	45060	152382	107322	2.38

*ST – Seed treatment with Azospirillum brasilense and Phosphobacteria (Bacillus megaterium var phosphaticum) (2 g per kg of seeds); *SA – Nursery soil application of AM fungi (100 g per sq.m)

4. Conclusion

The study confirmed that integration of FYM or vermicompost with the recommended dose of fertilizers significantly enhanced growth performance, yield attributes, and economic returns of rice. Adoption of such integrated nutrient management practices sustains productivity while maintaining and improving soil health.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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