Effect of Different Organic Nutrient Sources on Soil properties and Yield ofOrganic rice (*Oryza sativa* L.)

ABSTRACT

A field experiment was conducted during *kharif* season of 2021-22 at organic farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, to study the effect of different organic nutrient sources on rice (*Oryza sativa* L.). The experiment was laid out in Factorial Randomized Block Design with 3 replications. The Factor-A comprised of soil application (S),*i.e.*S_1, 100% RDN through NADEP compost, S_2, 80% RDN through NADEP compostalong with *Azospirillium* and PSB @ 2 l/ha each, S_3, 60% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha each and S_4, Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha, and Factor-B comprised of foliar application (F), *i.e.* F_0, control, F_1, Novel Organic liquid nutrient @ 1% and F_2, *Moringa* leaf extract @ 3%, with 12 treatment combinations of soil and foliar application with organic rice variety ‘GNR-7’. The results indicated that,application of 80% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha each recorded significantly higher organic carbon (80%), available K_2O (520.1 kg/ha), bacterial count (159.3×10^{-5}cfu/g), *Actinomycetes* count (39.8×10^{-3}cfu/g) and straw yield (5442 kg/ha) than the S_4, but it was statistically similar with S_1. Application of 100% RDN through NADEP compost recorded significantly higher available N (269.7 kg/ha) and grain yield (3749 kg/ha) over the S_4, but it was found at par with S_2. In case of foliar application F_2, *Moringa* leaf extract @ 3% produce numerically maximum organic carbon (0.79%), available K_2O (518.3 kg/ha), bacterial count (156.9×10^{-5}cfu/g), Fungal count (12.3×10^{-3}cfu/g) and (*Actinomycetes* count (39.0×10^{-3}cfu/g), it also ensured significantly higher grain (3312 kg/ha) and straw yield (5265 kg/ha). Application of Novel Organic liquid nutrient1% produce numerically maximum available P_2O_5 (61.0 kg/ha). On the basis of results, it can be concluded that the application of 80% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha eachbefore transplanting and foliar application with either 3% *Moringa* leaf extract or 1% Novel Organic liquid nutrient at 15, 30 and 45 days after transplanting may be improved physical and chemical properties of soil, available macronutrients, and organic carbon after harvest may be due to the effect of manures like NADEP compost combined with biofertilizer, which significantly improved physical and chemical properties of soil, available macronutrients, and organic carbon as well as yield compared to manure application alone.

Key words: Organic nutrient sources, Biofertilizers, Soil chemical properties, Organic rice, Microbial population, grain yield

Rice *(Oryza sativa* L.) is the prime source of food for nearly half of the World's population and it is one of the most important food crops in Asia. More than 50 per cent of the global population consume rice particularly. It plays a major role in diet, economy, employment, culture and history.Rice is the staple food for nearly 65 per cent of the population in India. Demand for rice is expected to grow faster than production in most countries. The projected global rice demand for 2025 was 700 million tonnes, but current production was only 545 million tonnes (Pathak,*et al*., 2020). Asia is considered to be 'rice bowl' of the world, where more than 90% of world's rice produced and consumed. It is the world's leading food crop.India is the 2nd and largest producer of rice in the World after china. India grows present status of rice areas 46 million hectares with production of 135.52 million tonnes and average productivity of 3021.14 kg/ha in the year 2022-2023. The leading rice producing states are West Bengal, Uttar Pradesh, Punjab, Odisha, Andhra Pradesh, Bihar, Chhattisgarh, Tamil Nadu and Gujarat (Anonymous., 2023).

Imbalanced and improper use of agricultural chemicals, such as fertilizer and synthetic pesticides, resulted in unhealthy soil, affecting the quality of farm produce. Farm products laced with unnecessary chemicals are thought to be hazardous to consumers' health.Crops cultivated using eco-friendly ways are one of the feasible solutions in such conditions, when demand for higher quality food is increasing by the day. Organic farming practices can help increasing soil fertility as well as improved soil chemical and biological properties (Yadav, *et al*., 2013).The Green Revolution in the1960s introduced the use of agrochemicals, *i.e*., chemical fertilizers and pesticides for increasing crop yield. Increasing use of inorganic chemical pesticides and fertilizers over the years has resulted in degradation of the soil. These toxic chemicals pollute the soil and groundwater by changing the natural composition of the soil, creating pH and nutrient imbalance. Chemical pesticides also lead to the death of both beneficial and harmful microbes, insects, etc., (Fang,*et al*., 2021).

Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, genetically modified organisms and livestock food additives. To the maximum extent possible organic farming system rely upon crop rotations, use of crop residues, animal manures, legumes, green manures, off farm organic wastes, biofertilizers, mechanical cultivation, mineral bearing rocks and aspects of biological control to maintain soil productivity and tilth to supply plant nutrients and to control insect, weeds and other pests.The natural inputs used in organic farming are easily available, releases nutrients slowly, supplies macro and micro nutrients and provides favorable soil environment for microbial population (Verma *et al*., 2019).

The NADEP method of composting is an aerobic process that uses easily available organic matter input sources such as crop residue, weeds, forest litter, kitchen waste, and so on, and it is an excellent alternative to farmyard manure. It is a high-quality black or brown compost that is high in plant nutrients and holds soil moisture well. It lowers cultivation costs because all ingredients are readily available on-site.Such compost can be prepared at half the cost of chemical fertilizers while providing higher quality major and micronutrients (Kumawat *et al*., 2017).

Living microorganisms that enhance our soil health and crops are found in bio fertilizers. These active microorganisms make it easier for plants to get nutrients and give the soil the hardiness it needs to survive wetness or drought stress. Examples of bio-fertilizers include *Azospirillium*,*Azotobacter*, and PSB. Additionally, because bio fertilizers are affordable and environmentally friendly, their long-term use can contribute to a reduction in environmental contamination. These are more profitable and efficient(Agarwal *et al*., 2018).Jeevamrut is widely employed as a method of organic farming and is well-thought-out to be an excellent supply of natural carbon, nitrogen, phosphorus, potassium, and a lot of other micronutrients essential for the crops. Jivamrut is frequently used in conjunction with irrigation water, which helps to improve soil microbial activity, preserve soil fertility, and produce of high quality.The dry solid jivamrut known as ghan-jivamrut (Sreenivasa *et al*., 2011).

Moringa (*Moringa oleifera* L.) popularly called as drumstick belonging to the family moringaceae is a multipurpose tree crop gaining importance during recent times due to its high nutritional values. Because *Moringa* leaf extract contains zeatin, a purine adenine derivative of the plant hormone group cytokinin, which enhances the antioxidant properties of many enzymes and shields cells from the ageing effects of reactive oxygen species, the effect is comparable to that of synthetic hormones. (Abdou, *et al*., 2016).

Banana pseudo stem sap, which is produced as a byproduct of removing the fiber from the pseudo stem, is a new source of novel organic liquid nutrients. By physically pressing scutcher waste or employing a press acquired during the fiber extraction procedure, the banana pseudo stem sap is collected. It is necessary to mix different organic inputs and sap one at a time. After that, the entire combination is put in a bio-digester and allowed to ferment anaerobically (Champaneri,*et al*., 2021).

MATERIALS AND METHODS

The field experiment was conducted during kharif season of 2021-22 at organic farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, (20º 57′ N, 72º 54′ E, 10 m above the mean sea level) in the Gujarat Plains & Hill Zone, Gujarat. The side was well drained, clay soil (57.20%) in texture with good water holding capacity, non-saline (EC 0.28 dS/m) with pH 7.50 (1: 2.5 soil water) and high in organic carbon (0.77%), available phosphorus (60.52 kg/ha), available potassium (495.52 kg/ha) and medium in available nitrogen (266.8 kg/ha).

The experiment was laid out in Factorial Randomized Block Design with 3 replications. The Factor-A comprised of soil application (S), *i.e.* S_1, 100% RDN through NADEP compost, S_2, 80% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha each, S_3, 60% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha each and S_4, Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha, and Factor-B comprised of foliar application (F), *i.e.* F_0, control, F_1, Novel Organic liquid nutrient @ 1% and F_2, *Moringa* leaf extract @ 3%, with 12 treatment combinations of soil and foliar application with organic rice variety 'GNR-7'. The organic rice hybrid cultivar was transplanted on 27 July 2021 respectively. The field experiment was prepared by ploughing followed by harrowing with tractor drawn implements before one month transplanting and then 5 cm of standing water was impounded for the puddling which was done by tractor drawn puddler followed by planking for proper leveling before transplanting. Twenty-one days old seedlings were transplanted at the spacing of 20 cm row to row and 15 cm plant-to-plant distance. Two to three seedlings per hill were transplanted. Irrigation was done for proper growth and development of rice crops.

Recommended dose of organic manures was applied through NADEP compost, Ghan-jivamrut @ 500 kg/ha applied before transplanting and Jivamrut @ 500 litre/ha, *Moringa* leaf extract @ 3% and Novel Organic liquid nutrient @ 1% applied at 15, 30 and 45 days after transplanting. The climatic data were obtained from weather station of the university. Standard practices were followed to recorded improved the soil properties under various organic sources of nutrient.

Yield observation: All the observation on yield parameters were recorded on five plants tagged for purpose in each treatment and all the three replications were counted manually and averaged to get per plant basis. The panicle length (cm) and no. of grains/panicle in five plants were measured and averaged to get per plant basis. Grain and straw yield per hectare (kg)wereworked out by taking average per plant yield.

Soil chemical parameters: All the soil parameters were determined after harvest of the crop. The soil pH and EC (dS/m) was estimated as per the procedure (Jackson 1973). The soil organic carbon (%) was determined laid down by Walkey and Black (1934). The available nitrogen (Subbiah and Asija 1956), available phosphorus (Olsen *et al*., 1954) and, available potassium (Jackson 1973) in soil were also determined by following standard procedure.

Soil biological parameters: Demography of total microbial count (cfu/g of soil).was estimated by standard serial dilution plate count method (Subba Rao, 1999). The microbial population was calculated as:

$$\text{cfu} \times 10^{n}/\text{g of soil} = \frac{\text{Numberofcolony} \times \text{Dilutionfactor}}{\text{Aliquottaken} \times \text{weightofsoil}}$$

The grain and straw yield (kg/ha) including was worked out by taking average per plant yield and all soil parameters subjected for statistical analysis and interpretation as per Gomes and Gomes (1984). The level of significance used in “F” test was at 5%.

RESULTS AND DISCUSSION

Effect of different organic nutrient sources on soil chemical properties:

Organic carbon (%)

The data pertaining toorganic carbon in soil after harvest that presented in Table 1. Significantly higher organic carbon in soil (0.80%) was recorded application withS_2: *i.e.,* 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha eachthan the S_4, but it was also found statistically similar with S_1: *i.e.,* 100% RDN through NADEP compost.The organic nutrient management improves organic carbon by addition of 80 to 100% RDN NADEP compost and biofertilizer, also building the soil productive. Similar results were reported by Jondhale*et al.* (2014)and Yadav*et al*. (2013) the combine application of NADEP compost and biofertilizer increase the organic carbon content in soil.Foliar application of organic nutrient sources did not produce significant effect on organic carbon in soil after harvest. The result showed that numerically higherorganic carbon (0.79%) was recorded with F_2: *i.e.,Moringa* leaf extract @ 3%.

Available N in soil after harvest (kg/ha)

Soil application of 100% RDN through NADEP compost $S_{1,}$ was recorded significantly higher available N in soil after harvest (269.7 kg/ha) then the S_4, while statistically at par with 80% RDN through NADEP compost along with *Azospirillum* and

PSB @ 2 l/ha each S_2.The improved chemical properties of soil, available macronutrientsafter harvest may be due to the

combination of value-added organic manures such as NADEP compost and biofertilizer, as well as jivamrut, and ghanjivamrt, can be employed to maintain soil fertility by supplying available macro nutrients.Similar results were also reported by the finding of Aswal *et al.* (2012), Tharmaraj*et al*. (2011)and Jondhale*et al*. (2014).

Foliar application of organic nutrient sources did not produce significant effect on available N in soil after harvest, while numerically higheravailable N in soil after harvest (260.8 kg/ha) was recorded F_0.

Available P in soil after harvest (kg/ha)

Different organic nutrient source soil and foliar application did not produce significant effect on available phosphorus in soil after harvest. But numerically higheravailable phosphorus in soil after harvest (62.6 kg/ha) was recorded soil application with S_1: *i.e.*, 100% RDN through NADEP compost and foliar application with F_1: *i.e.*, Novel Organic liquid nutrient @ 1% (61.0 kg/ha), but numerically lowest available phosphorus in soil after harvest observed in S_4 and F_2.

Available K in soil after harvest (kg/ha)

The result indicated that the soil application of organic nutrient sources did produce significant effect on potassium in soil after harvest (Table 1.) The result showed that the soil application with S_2: *i.e.*, 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each was recorded significantly higher potassium in soil after harvest (520.1 kg/ha) then the S_4, while statistically at par with S_1.

In case of foliar application of organic nutrient sources did not produce significant effect on potassium in soil after harvest. The result further showed that numerically highest potassium in soil after harvest (518.3 kg/ha) was recorded with application F_2: *i.e.*,*Moringa* leaf extract @ 3%.

Effect of different organic nutrient sources on soil biological properties:

Bacterial count

The data pertaining tobacterial count in soil after harvest that presented in Table 2. The total bacterial population was significantly enhanced by the application of S_2: *i.e.*,80% RDN through NADEP compost along with*Azospirillum* and PSB @ 2 l/haeach was recorded maximum bacterial count (159.3×10^{-5}cfu/g) followed by S_1 (156.4×10^{-5}cfu/g), S_3 (155.8×10^{-5}cfu/g).Biswas *et al*. (2017) ascribed the higher bacterial count to the positive effects of manure by providing nutrients for the growth of microbes directly or indirectly by stimulating plant growth and enhancing root carbon flow. Also, the organic manures show superiority in enriching the richness and diversity of soil bacteria due to enhanced soil microbial biomass and activities of organic treated soils (Islam *et al*., 2011).

Foliar application total bacterial population was found non-significant. The result showed that numerically maximum total bacterial count (156.9×10^{-5}cfu/g) in *Moringa*leaf extract@ 3% F_2.

Fungal count

The total fungal population was found non-significant enhanced by the soil and foliar application of organic nutrient sources (Table 2.) The result showed that soil application numerically higher fungi population (12.6×10^{-3}cfu/g) was recorded with S_2: *i.e.*,80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/haeach followed by S_1: *i.e.*,100% RDN through NADEP compost and foliar application numerically higher fungi population (12.3×10^{-3}cfu/g) was recorded with F_2: *i.e.*,*Moringa*leaf extract@ 3%.Ingle *et al*. (2014)also reported an increase in fungal population with addition of organics since most of these organisms are *chemoheterotrophs*, which require organic source of carbon as food and oxidation of organic substances provides energy, thereby increasing their population.

***Actinomycetes* count**

The total *Actinomycetes*population was significantly enhanced by the application of organic nutrient sources (Table 2.) The data pertaining to soil bacteria revealed that soil application with S_2: *i.e.*,80% RDN through NADEP compost along with*Azospirillum* and PSB @ 2 l/ha each was recorded maximum *Actinomycetes* count (39.8×10^{-3}cfu/g)followed by S_1(38.9×10^{-3}cfu/g), S_3(37.9×10^{-3}cfu/g). The increased microbial population may be due to the fact that organic manure provided necessary food and micro environment for their quicker multiplication and growth (Kumari and Kumari, 2002). This could be ascribed to the organic sources which supplied large amount of readily available carbon, resulting in more diverse and dynamic microbial system.Similar results were also reported by the finding ofTejada and Gonzalez, 2008. In case of foliar application total *Actinomycetes* population was found non-significant. The result showed that numerically maximum total *Actinomycetes* count (39.0×10^{-3}cfu/g) with F_2: *i.e.*,*Moringa* leaf extract @ 3%, but minimum *Actinomycetes* count was recorded with F_0 (37.7×10^{-3}cfu/g).

Effect of different organic nutrient sources on yield parameters

Grain yield (kg/ha)

The data on grain yield (kg/ha) of rice was recorded at harvest that presented in Table 3. The higher grain yield (3749 kg/ha) was recorded under S_1, 100% RDN through NADEP compost then the S_4, and also it was found statistically at par with S_2, 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each. The significant increase in rice yield might be due to attributed to the fact that it acts as a nutrient reservoir and, upon decomposition, produces organic acids; thus, absorbed nutrient ions are released slowly throughout the growth period, resulting in higher yield.Similar positive effect of organic nutrient sources applied to rice plant was reported by Sahare and Mahanpatra (2015), Ghube *et al*. (2018) and Rameshwar *et al*. (2018).

In case of Foliar application higher grain yield (3312 kg/ha) was recorded under F_2, *Moringa* leaf extract @ 3% then the control (2959 kg/ha), and also it was found statistically at par with F_1, Novel Organic liquid nutrient @ 1%. The improvement in growth and yield of crop at foliar application of *Moringa* leaf extract might be due to the presence of growth promoting substances as well as nutrient elements in *Moringa* as suggested by Jhilik *et al*. (2017) and Biswas *et al*. (2016).

Straw yield (kg/ha)

The data on straw yield (kg/ha) of rice was recorded at harvest that presented in Table 3. The maximum Straw yield (5442 kg/ha) was recorded under S_2, 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each than the S_4,but it was found statistically at par with S_1. The positive influence of straw yield production might be attributed to the slow and consistent supply of nutrients through organic nutrient sources NADEP compost and biofertilizers throughout the crop growth period, which improved suitable biomass production and resulted in higher straw yield. These findings are in agreement with those of Sahare and Mahapatra (2015), Parmar *et al*. (2017) and Safiullah *et al*. (2018b).

Foliar application the maximum straw yield (5265 kg/ha) was achieved under F_2, *Moringa* leaf extract @ 3% then the control (4605 kg/ha), but it was found statistically at par with F_1, Novel Organic liquid nutrient @ 1%. The significant increase in rice straw yield production might be supply of nutrient through organic liquid nutrient like *Moringa* leaf extract, novel organic liquid nutrient application as a foliar spray containing numbers of different micronutrients and natural plant growth hormones such as zeatin, gibberellic acid and cytokinin those helps to enhances the growth and yield attributes as well as grain and straw yield of rice plant. These findings are in agreement with those of Abusuwar and Abohassan (2017) and Abdalla (2013).

CONCLUSION

Based on result, it can be concluded that the application of 80% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha eachbefore transplanting and foliar application with either 3% *Moringa* leaf extract or 1% and Novel Organic liquid nutrient at 15, 30 and 45 days after transplantingmay be improved physical and chemical properties of soil, available macronutrientsand organic carbon after harvest may be due to the effect of manures like NADEP compost combined with biofertilizer, which significantly improved physical and chemical properties of soil, available macronutrients, and organic carbon as well as yield compared to manure application alone.

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Table 1: Effect of different organic nutrient sources on soil fertility status after harvest

Treatments	**Organic carbon (%)**	**Avail. N (kg/ha)**	**Avail. P_2O_5 (kg/ha)**	**Avail. K_2O(kg/ha)**
Factor I: Soil application (S)				
S_1 - 100% RDN through NADEP compost	0.79	269.7	62.6	514.1
S_2 - 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	0.80	265.5	60.3	520.1
S_3 - 60% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	0.76	258.7	59.9	513.0
S_4 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	0.75	246.2	57.7	483.2
SEm±	0.01	2.0	1.2	9.5
CD at 5%	0.04	5.8	NS	27.7
Factor II: Foliar application (F)				
F_0 – Control	0.76	260.8	60.0	504.6
F_1 - Novel Organic liquid nutrient @ 1%	0.78	259.1	61.0	499.9
F_2 - *Moringa* leaf extract@ 3%	0.79	260.3	59.4	518.3
SEm±	0.01	1.7	1.1	8.2
CD at 5%	NS	NS	NS	NS
Interaction				
S×F	NS	NS	NS	NS
Initial	0.77	266.8	60.5	495.5
CV (%)	4.8	2.2	6.1	5.6

Table 2: Effect of different organic nutrient sources on soil biological properties total microbial count status after harvest

Treatments	Bacteria count (x 10^{-5} cfu/g)	Fungal count (x 10^{-3} cfu/g)	*Actinomycetes* count (x 10^{-3} cfu/g)
Factor I: Soil application (S)			
S_1 - 100% RDN through NADEP compost	156.4	12.0	38.9
S_2 - 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	159.3	12.6	39.8
S_3 - 60% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	155.8	11.7	37.9
S_4 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	150.7	10.9	36.7
SEm±	1.7	0.4	0.58
CD at 5%	4.9	NS	1.7
Factor II: Foliar application (F)			
F_0 – Control	153.4	11.1	37.7
F_1 - Novel Organic liquid nutrient @ 1%	156.3	11.9	38.3
F_2 - *Moringa* leaf extract@ 3%	156.9	12.3	39.0
SEm±	1.4	0.3	0.50
CD at 5%	NS	NS	NS
Interaction			
S×F	NS	NS	NS
Initial	156	14	36
CV (%)	3.21	10.18	4.52

Table 3: Effect of different organic nutrient sources on grain and straw yield

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)
Factor I: Soil application (S)		
S_1 - 100% RDN through NADEP compost	3749	5437
S_2 - 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	3538	5442
S_3 - 60% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	2908	4774
S_4 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	2511	4329
SEm±	96	149
CD at 5%	281	437
Factor II: Foliar application (F)		
F_0 – Control	2959	4605
F_1 - Novel Organic liquid nutrient @ 1%	3257	5117
F_2 - *Moringa* leaf extract@ 3%	3312	5265

SEm±	83	129
CD at 5%	243	378
S×F	NS	NS
CV (%)	9.0	8.9

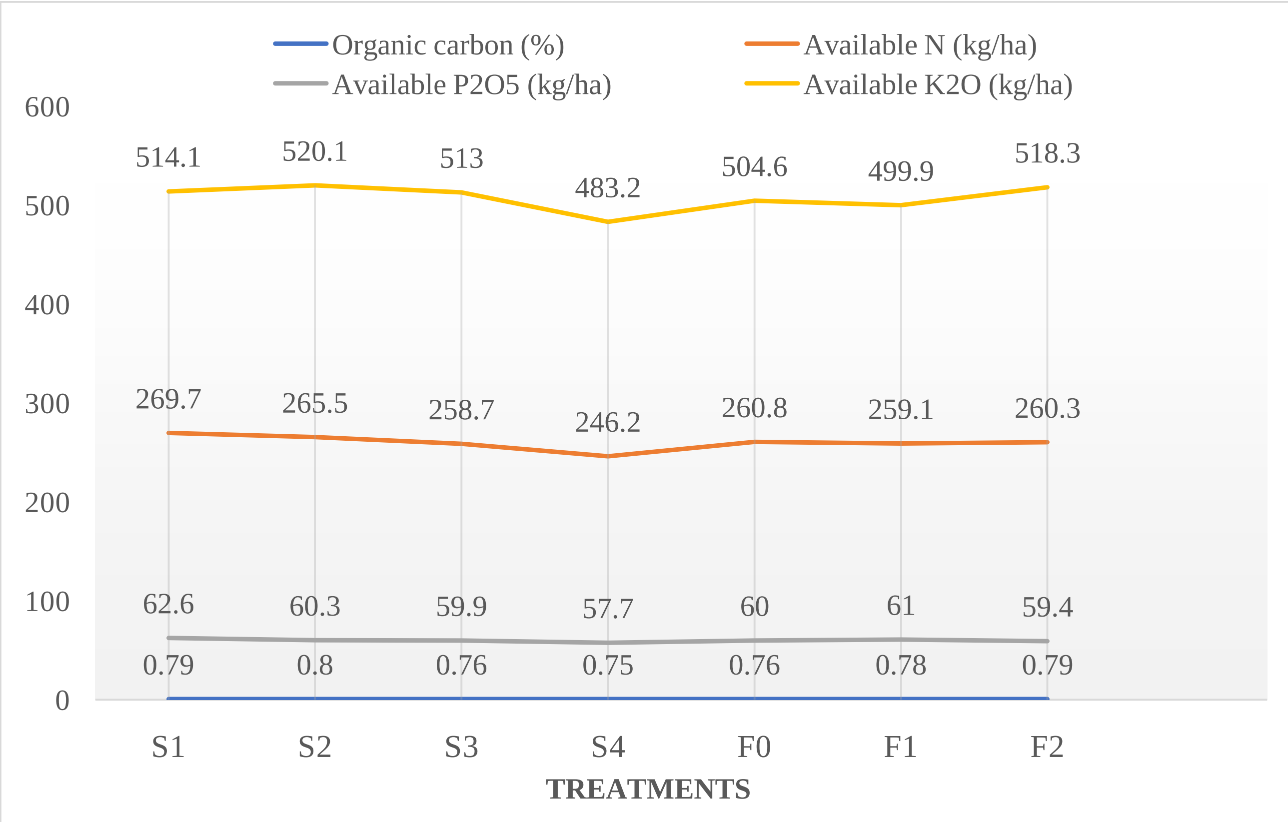

Fig. 1.Effect of different organic nutrient sources on soil fertility status after harvest

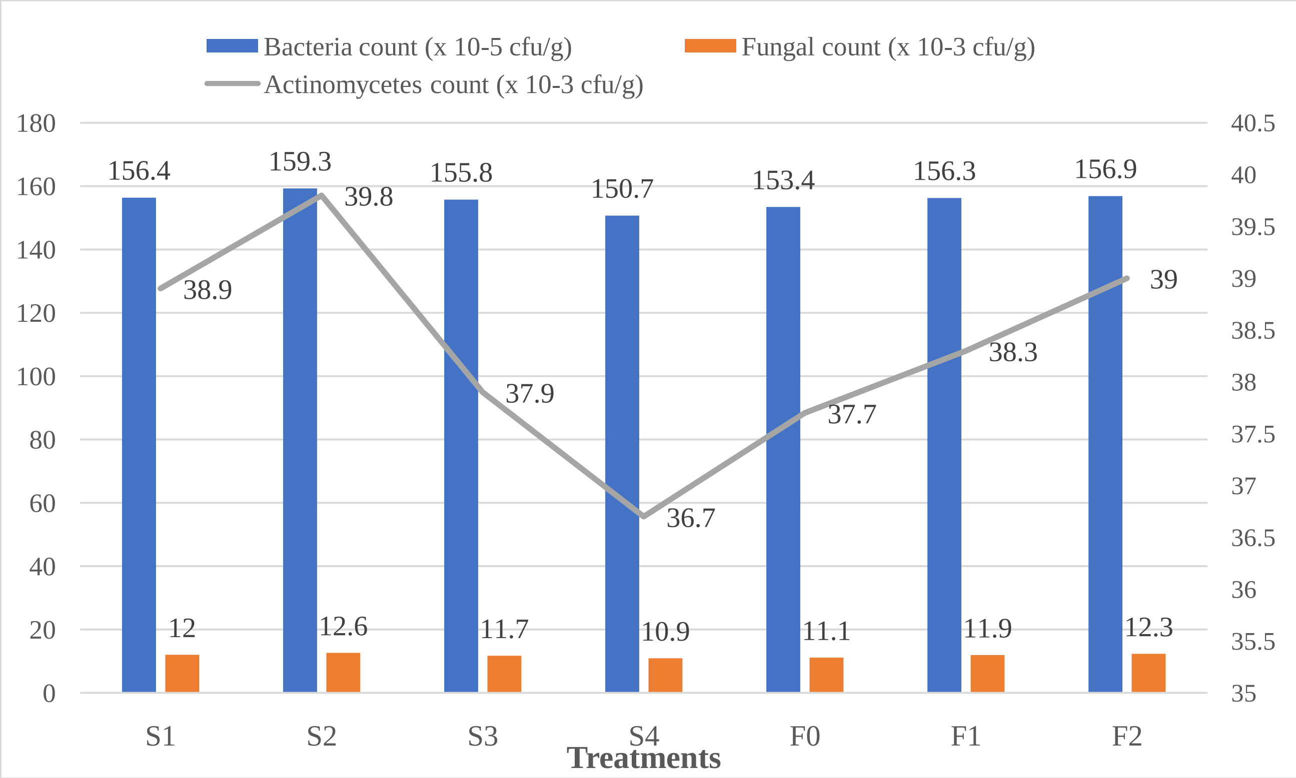

Fig. 2.Effect of different organic nutrient sources on soil biological properties total microbial count status after harvest

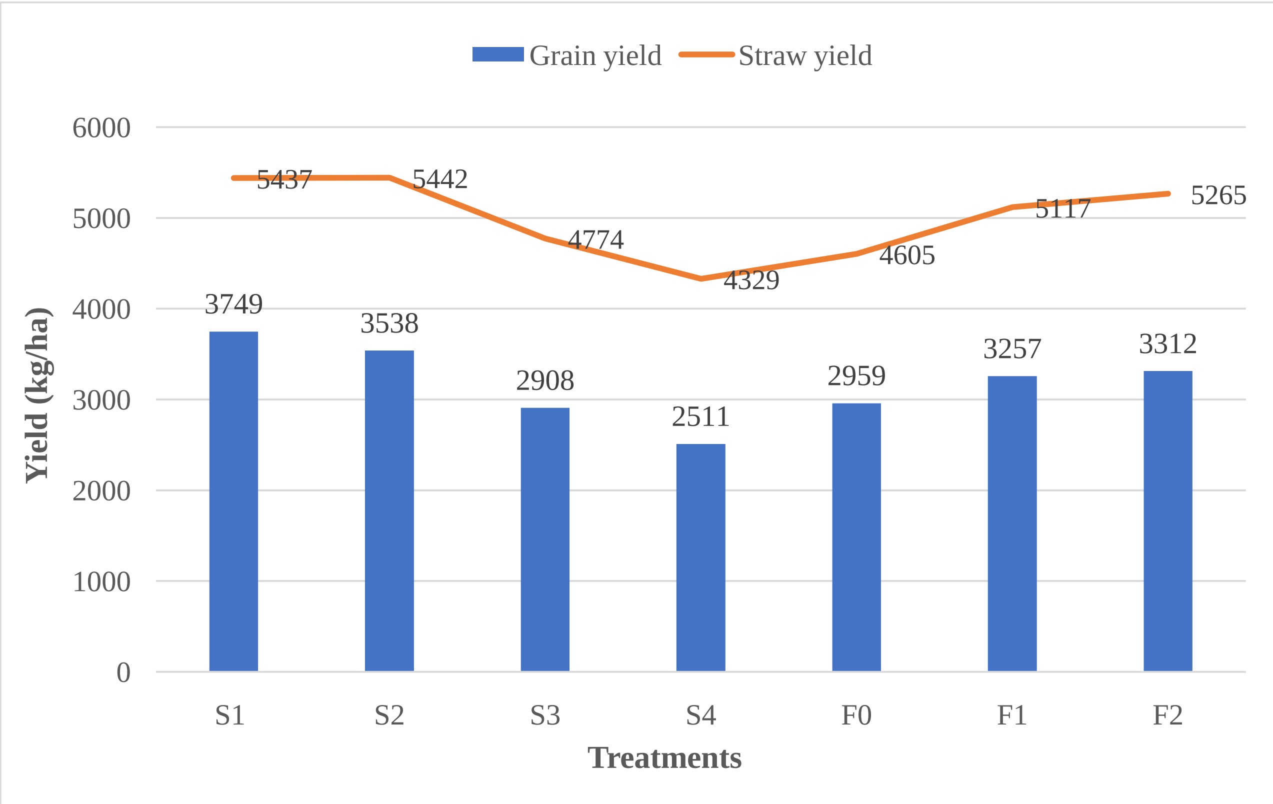

Fig. 3.Effect of different organic nutrient sources on grain and straw yield