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Effect of combined application of organic manures, biofertilizers and inorganic fertilizers on soil fertility after harvest of paddy

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Abstract
A field experiment was conducted at college farm, S.V. Agricultural College, Tirupati, ANGRAU during *kharif*, 2022 to study the effect of integrated use of organic manures, biofertilizers and inorganic fertilizers on soil properties after harvest of paddy. The experiment was laid out in a split-plot design with seven main plots and three sub plots replicated thrice. The main plots comprised of different combination of organic manures and biofertilizers *viz.*, M_1: FYM @ 10 t ha^{-1} M_2: Green manure seed (dhaincha) @ 25 kg ha^{-1}), M_3: FYM @ 5 t ha^{-1}+ green manures seed @ 12.5 kg ha^{-1}, M_4: FYM@10 t ha^{-1}+ *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each, M_5: green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each, M_6: FYM @ 5 t ha^{-1} + green manures @ 12.5 kg ha^{-1} + *Azospirillum* + + KRB @1.25 l ha^{-1} each and M_7: Control. Sub-plots comprised of three levels of inorganic fertilizers *viz.*, S_1: 50% RDF, S_2: 75% RDF and S_3:100% RDF. The results revealed that the application of organic manures decreased the soil pH, increased EC and organic carbon over control. Application of chemical fertilizers has not influenced significantly the EC and organic carbon, but pH was significantly influenced by application of chemical fertilizers. Soil chemical properties *viz.*, available nitrogen, phosphorus and potassium were significantly influenced by combined application of organic manures, biofertilizers and chemical fertilizers. Among the organic manure combinations, the highest soil available nitrogen, phosphorus and potassium were recorded with application of application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_6), which was statistically on par with the application of green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_5) and FYM @ 10 t ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_4) and the lowest were recorded in control (M_7). However, among different levels of fertilizer, significantly the highest soil available nutrients were recorded with the application of 100% RDF (S_3) followed by 75% RDF (S_2) and the lowest were recorded in 50% RDF (S_1). The interaction between various organic manures and different levels of inorganic fertilizers were found to be significant. Application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each along with application of 100% RDF (M_6S_3) recorded the highest soil available nutrients which was on par with M_5S_3, M_6S_2, M_4S_3, M_5S_2 and M_6S_1. The lowest was found in M_7S_1. It can be concluded that integrated application of organic manures, biofertilizers and inorganic fertilizers helps in increasing the availability of soil nutrients to crop apart from maintains soil organic carbon.

Keywords: Inorganic fertilizers, soil fertility, harvest of paddy

1. Introduction

Rice (*Oryza sativa* L.) is the principal food crop for the world's billions of people. It plays a vital role in our national food security. In India, it is grown in an area of 46.28 million hactares with a production of 129.47 million tonnes and productivity of 2798 kg ha^{-1}. In Andhra Pradesh, it is grown in an area of 2.23 million hactares with a production of 7.76 million tonnes and productivity of 3392 kg ha^{-1} (www.indiastat.com., 2022-23).

Rice based cropping systems are the major production systems contributing to food production. Current crop production systems are characterized by inadequate and imbalanced uses of fertilizers. Crop demand for nutrients is met by a combination of inherent soil fertility and externally applied nutrients. For high yielding crops with high rates of dry matter accumulation removing higher rates of nutrients such as rice and maize, soil must allow unrestricted root growth be able to absorb nutrients at the rate for maximum growth. In order to cope with the food demand of a growing population, 60 per cent increase in rice production will be necessary during the next 25 years (Arth and Frenzel, 2000) [2].

Continuous practice of rice cultivation involves heavy removal of nutrients, which diminishes the soil health and inturn productivity. The cereal-cereal sequence for longer periods with low system productivity, and often with poor crop management practices, results in loss of soil fertility due to emergence of multiple nutrient deficiencies, deterioration of soil physical properties and decline of crop yields in high productivity areas. To compensate this, there is a need to develop Integrated Nutrient Management (INM) system. The INM refers "a system which aim to improving and maintaining soil fertility for sustaining crop productivity, and involves the use of chemical fertilizers in conjunction with organic manure through biological process". Incorporation of organic sources, *i.e.* farmyard manure (FYM), green manures, and biofertilizer along with chemical fertilizers is effective in increasing the nutrient availability in soil, improving physical properties of soil and its organic carbon status. On account of continuing world energy crisis and spiraling price of chemical fertilizer the use of organic manure as a renewable source of plant nutrients is assuming importance (Yadav *et al.*, 2018) [22]. In this endeavor proper balance of organic and inorganic fertilizer is important not only for increasing yield but also for sustaining soil health. The integrated nutrient management favorably affects the physical, chemical and biological environment of soils. Organic manures improve soil physical properties through increased soil aggregation, decrease in the volume of micropores while increasing macropores, increased saturated hydraulic conductivity and water infiltration rate and improved soil water holding capacity. It also improves the chemical and biological condition of soil by increasing cation exchange capacity and providing various hormones and organic acids which are very important for soil aggregation and for beneficial micro-organism involved in various biochemical processes and release of nutrients. A judicious combination of organic sources and inorganics has been found to mutually reinforce the efficiency of both the sources resulting in higher productivity and soil fertility. Keeping in this view, the present study was emphasized on effect of combined application of organic manures, biofertilizers and chemical fertilizers on soil properties.

2. Materials and Methods

The experiment was conducted during *kharif*, 2022 at college farm, S.V. Agricultural College farm, Tirupati, Acharya N.G. Ranga Agricultural University, which is geographically situated at 13° 36' 761" N latitude and 79° 20' 704" E longitude with an altitude of 182.9 m above the mean sea level, which falls under Southern Agro Climatic Zone of Andhra Pradesh. The soil of experimental site was sandy clay loam in texture, neutral in reaction, low in electrical conductivity, low in organic carbon low in available nitrogen, medium in available phosphorus and available potassium. The experiment was laid out in a split-plot design with seven main plots and three subplots replicated three times. The main plots comprises combinations of various organic sources *viz.*, M_1: FYM @ 10 t ha^{-1}, M_2: green manure seed (dhaincha) @ 25 kg ha^{-1},M_3:FYM @ 5 t ha^{-1}+ green manures seed @ 12.5 kg ha^{-1}, M_4: FYM @10 t ha^{-1}+ *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each, M_5: green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each, M_6:FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each, M_7: Control. Whereas, the subplots comprises three levels of inorganic fertilizers *viz.*, S_1: 50% RDF, S_2: 75% RDF and S_3: 100% RDF.

The area selected for raising nursery was thoroughly ploughed and leveled. Well-filled seed of rice cultivar, NLR 34449 was treated with thiram @ 3g kg^{-1} of seed and was broadcasted uniformly over puddled area @ 5 kg for 40 m^{-2} area and the nursery was raised under irrigation upto the age of 25 days. Dhaincha crop (3.40, 0.62 and 1.40% N, P and K) was raised with the seed rate of 25 kg ha^{-1} as per treatment and it was incorporated 2 weeks before transplanting of rice at 50% flowering stage. The field was ploughed at optimum moisture condition with tractor drawn disc plough and was leveled with wooden plank. The plots were laid out as per experimental plan with irrigation cum drainage channels around the field. Then water was let into the each plot 15 days before transplanting and was followed by puddling with power tiller. Well decomposed FYM (0.70, 0.25 and 0.57% N, P and K) was applied as per treatment two weeks before transplanting of paddy in the main field. Biofertilizers *viz.*, *Azospirillum*, PSB and KRB @ 1.25 l ha^{-1} each were mixed with 100 kg FYM separately and applied as per treatment. The recommended dose of fertilizers for paddy crop in Southern Agro-Climatic Zone of Andhra Pradesh is 120-60-40 kg of N, P_2O_5 and K_2O ha^{-1}. Nitrogen was applied in three equal splits in the form of urea for *kharif* rice at transplanting, tillering and panicle initiation, while phosphorus was applied entirely as basal through SSP and potassium in two equal splits as basal and at panicle initiation stage was applied though MOP Soil samples were collected at a depth of 0-15 cm from each treatment plot after harvest of paddy and processed for analysis. The physico-chemical (pH, EC and OC) and chemical properties of soil *viz.*, available nitrogen, phosphorus and potassium was analyzed by different methods as per standard procedures.

The pH of the soil was determined in 1:2.5 soil-water suspension using Systronics pH system 361 with a glass electrode as described by Jackson (1973) [6]. The electrical conductivity of the soil was determined in 1:2.5 soil water extract using conductivity meter as described by Jackson (1973) [6] and was expressed as dSm^{-1}. The organic carbon content in the 0.5 mm sieve soil sample was estimated by the method given by Walkley and Black (1934) [21] as outlined by Jackson (1973) [6] and was expressed in percentage. Available nitrogen was estimated by alkaline permanganate method by using macro Kjeldahl distillation unit as described by Subbiah and Asija (1956) [18] and was expressed as kg ha^{-1}. Available phosphorus in the soil samples was extracted with 0.5 M $NaHCO_3$ buffered at pH 8.5 and the phosphorus in the extract was estimated by ascorbic acid method using spectrophotometer at 660 nm as described by Olsen *et al*. (1954) [12] and was expressed as kg ha^{-1}. Available potassium was extracted with neutral normal ammonium acetate and estimated with the help of flame photometer as described by Jackson (1973) [6] and was expressed as kg ha^{-1}.

3. Results and Discussion

3.1. Effect of INM practices on physico-chemical properties of soil: Data pertaining to the soil physico-chemical properties after harvest of paddy was presented in the Table 1. Application of various organic manures and inorganic fertilizers significantly influenced soil pH, while their interaction effect was non-significant. It was observed that the soil pH decreased in all treatments as compared to before sowing of the crop (7.64).

However, it was decreased less in control. Among various organic sources, the lowest soil pH (7.02) was recorded with the application of FYM @ 10 t ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_4), which was statistically on par with the application of FYM @ 10 t ha^{-1} (M_1), FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_6) and FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} (M_3) and the highest (7.62) was recorded in control (M_7). Among different levels of chemical fertilizer, the lowest soil pH (7.00) was recorded with the application of 100% RDF (S_3) which was comparable with 75% RDF (S_2) and the highest (7.59) was recorded in 50% RDF (S_1). The addition of organics in the form of FYM and green manuring reduces the soil pH, this might be due to the release of organic acids during the process of decomposition of the organic compounds. Similar results were reported by Pattanayak *et al.* (2001) [13] and Yaduvanshi (2001) [23]. Prasad *et al.* (2010) also reported decrease in pH at harvest of rice crop due to use of inorganic fertilizers.

Similarly, application of various organic manures significantly influenced soil EC, while application of various levels of inorganic fertilizers as well as interaction effect was non-significant. It was noticed that soil EC after harvest of paddy increased when compared to before sowing of crop (0.43 dS m^{-1}). Among various organic sources, the highest soil EC (0.55 dS m^{-1}) was recorded with the application of FYM @ 10 t ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_4), which was statistically on par with the application of FYM @ 10 t ha^{-1} (M_1), FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_6) and FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} (M_3) and the lowest (0.39 dS m^{-1}) was recorded in control (M_7). Use of organics showed higher values for electrical conductivity, which might probably be due to solubilising effect of organic acids on various compounds in soil. The decomposition of organic materials released acids or acid forming compounds that reacted with the sparingly soluble salts already present in the soil and either converted them into soluble salts or at least increased their solubility (Sarwar *et al.*, 2009) [16]. Niklasch and Joergensen (2001) [11] which indicated the increased EC in soil when organic materials of different nature were applied. But the increase in soil EC was not much which might be due to good infiltration rate of soil mitigating the increase in soil EC.

Organic manures significantly influenced on soil organic carbon, but application of various levels of inorganic fertilizers as well as combined effect was not significant. Close observation of data revealed that the increase of soil organic carbon in all the treatments as compared to before sowing of paddy crop (0.40 %). Among various organic sources, the highest soil organic carbon (0.61%) was recorded with the application of FYM @ 10 t ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_4), which was statistically on par with the application of FYM @ 10 t ha^{-1} (M_1) and FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_6) and the lowest (0.43%) was recorded in control (M_7). The increase in soil organic carbon in FYM along with biofertilizers might be attributed to higher contribution of biomass to the soil. The higher content of lignin and phenol in FYM led for formation of stable complexes with protein of plant origin. Further it might have created an environment conducive for formation of humic acid which stimulated the activity of soil microorganisms resulting in an increase in the organic carbon content of the soil (Meena *et al.*, 2014 and Goutami *et al.*, 2015) [10, 5].

3.2. Effect of INM practices on chemical properties of soil

Data pertaining to the soil chemical properties after harvest of paddy was presented in the Table 2. Application of various organic manures, biofertilizers and chemical fertilizers and their interaction exerted a significant influence on soil available nitrogen. Among various organic sources, the highest soil available nitrogen (228 kg ha^{-1}) was recorded with the application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_6), which was statistically on par with the application of green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_5) and FYM @ 10 t ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_4) and the lowest (121 kg ha^{-1}) was recorded in control (M_7). Among different levels of fertilizer, significantly the highest soil available nitrogen (206 kg ha^{-1}) was recorded with the application of 100% RDF (S_3) followed by of 75% RDF (S_2) and the lowest (177 kg ha^{-1}) was recorded in 50% RDF (S_1). The combined application of various organic manures with biofertilizers and inorganic fertilizers showed significant influence on soil available nitrogen. Application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each along with application of 100% RDF (M_6S_3) recorded the highest soil available nitrogen (235 kg ha^{-1}), which was on par with M_5S_3, M_6S_2, M_4S3, M_5S_2 and M_6S_1. The lowest was found in M_7S_1 (104 kg ha^{-1}). The results of the present study revealed that combined application of organic manures and inorganic fertilizers recorded the highest available nitrogen. This might be due to positive response of green manuring, FYM and biofertilizers along with inorganic fertilizers on soil N status and may be attributed to N mineralization from organic sources and greater multiplication of soil microbes, which could convert organically bound nitrogen into readily available form leading to building up of higher available N. The inclusion of green manure in rice based cropping sequence reduced the loss of native nitrate N accumulated during aerobic cycle and also conserved nitrate nitrogen, which would be lost upon flooding (Alagappan and Venkataswamy, 2016) [1]. Biofertilizers enhanced the microbial activity leading to consequent release of organic complex substances (chelating agents) which turned into greater solubility of available nutrients. The enhanced available nitrogen content of soil might also be due to favourable soil conditions under organic manure with multi inoculation of biofertilizers which might have helped in the mineralization of soil nitrogen resulting in higher buildup of available N. These results were in conformity with the findings of Rao *et al*. (2019) [15].

Soil available phosphorus was significantly influenced by application of various organic sources and fertilizer levels as well as their combined application. Among various organic manures, the highest soil available phosphorus (48.48 kg ha^{-1}) was recorded with the application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_6), which was statistically on par with the application of green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_5) and FYM @ 10 t ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_4) and the lowest (26.47 kg ha^{-1}) was recorded in control (M_7). However, among different levels of fertilizer, significantly the highest soil available phosphorus (206 kg ha^{-1}) was recorded with the application of 100% RDF (S_3) followed by (41.67 kg ha^{-1}) of 75% RDF (S_2) and the lowest (35.67 kg ha^{-1}) was recorded in 50% RDF (S_1). The combined application of various organic manures with biofertilizers and inorganic fertilizers showed significant influence on soil available phosphorus.

Application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each along with application of 100% RDF (M_6S_3) recorded the highest soil available phosphorus (49.01 kg ha^{-1}), which was on par with M_6S_2, M_5S_3, M_5S_2, M_6S_1 and M_4S_3. The lowest was found in M_7S_1 (17.98 kg ha^{-1}). The significant increase in P status of soil in these treatments could be due direct addition phosphorus as well as to the fact that organic acids released during decomposition of FYM and green manures might have converted the unavailable forms of phosphorus to available forms besides mineralization of organic form of phosphorus. These results confirm the findings of Mallareddy and Devenderreddy (2008) [9] and Verma *et al.* (2012) [20]. The increase of available phosphorus by solubilization of phosphate rich compound. A number of organic acids is secreted by PSB which may form chelates resulting in effective solubilization of phosphate, helped higher increase in P availability (Bhabai *et al.*, 2019) [4].

Application various organic manures and inorganic fertilizers significantly influenced soil available potassium and their interaction was also significantly traceable. Among various organic manures, the highest soil available potassium (275 kg ha^{-1}) was recorded with the application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_6), which was statistically on par with the application of green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_5) and FYM @ 10 t ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each (M_4) and the lowest (191 kg ha^{-1}) was recorded in control (M_7). Among different levels of fertilizer, significantly the highest soil available potassium (254 kg ha^{-1}) was recorded with the application of 100% RDF (S_3) followed by 75% RDF (S_2) and the lowest (231 kg ha^{-1}) was recorded in 50% RDF (S_1). The combined application of various organic manures with biofertilizers and inorganic fertilizers showed significant influence on soil available potassium.

Application of FYM @ 5 t ha^{-1} + green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each along with application of 100% RDF (M_6S_3) recorded the highest soil available potassium (285 kg ha^{-1}), which was on par with M_6S_2, M_5S_3 and M_5S_2. The lowest was found in M_7S_1 (154 kg ha^{-1}). Combined application organic manures and inorganic fertilizers registered significantly highest available potassium in soil due to its easy decomposition of mineral constituents and their effect on dislodging the exchangeable K into the soil solution. These results were in conformity with the findings of Maiti *et al.* (2006) [8] and Upadhyay *et al.* (2011) [19]. When acid forming compounds are added to the soil, these acids affect potassium availability. The effect is positive resulting in more availability of potassium to the plants. The hydrogen ions released from organic materials are exchanged with K on exchange site or set free from the fixed site of the clay micelle. The beneficial effect of green leaf manuring and FYM on available potassium might be due to reduction of potassium fixation, solubilisation and release due to the interaction of organic matter with clay besides the direct potassium addition to the potassium pool of soil. Similar results was also observed by Karunakaran *et al.* (2021) [7]. The beneficial effect potassium biofertilizers on available potassium might also attributed to the organic acids released due to microbial activity which might have mobilized the native or non-exchangable form of K and charge the soil solution with K ions, so that it may be readily available. Similar results are perceived by Sharma *et al.* (2013) [17].

4. Conclusion

From the results it can be concluded that conjunctive and combined application of organic manures, biofertilizers and chemical fertilizers improves the soil physico-chemical and chemical properties of the soil. Hence, organic manures and biofertilizers may be utilised as an alternative source to minimise the consumption of inorganic fertilizers.

Table 1: pH, EC and OC of soil at harvest of paddy as influenced by INM practices

Treatments	**pH**	**EC (dS m^{-1})**	**OC (%)**
Manure combinations			
M_1:FYM @ 10 t ha^{-1}	7.04	0.53	0.60
M_2: Green manure seed (dhaincha) @ 25 kg ha^{-1}	7.36	0.44	0.47
M_3: FYM @ 5 t ha^{-1}+ Green manures seed @ 12.5 kg ha^{-1}	7.25	0.49	0.55
M_4: FYM @10 t ha^{-1}+ *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each	7.02	0.55	0.61
M_5: Green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each	7.34	0.45	0.50
M_6: FYM @ 5 t ha^{-1} + Green manureseed @ 12.5 kg ha^{-1} + *Azospirillum*+ PSB + KRB @1.25 l ha^{-1} each	7.09	0.51	0.57
M_7: Control	7.62	0.39	0.43
SEm±	0.105	0.019	0.021
CD (P=0.05)	0.30	0.06	0.07
Fertilizer levels			
S_1: 50% RDF	7.59	0.46	0.51
S_2: 75% RDF	7.15	0.49	0.53
S_3: 100% RDF	7.00	0.50	0.54
SEm±	0.167	0.010	0.010
CD (P=0.05)	0.48	NS	NS
Interactions			
S at M			
SEm±	0.441	0.027	0.026
CD (P=0.05)	NS	NS	NS
M at S			
SEm±	0.295	0.032	0.033
CD (P=0.05)	NS	NS	NS
Initial (before sowing of crop)	7.64	0.43	0.40

Table 2: Soil available nitrogen, phosphorus and potassium (kg ha^{-1}) at harvest of paddy as influenced by INM practices

Treatments	**Available nitrogen**				**Available phosphorus**				**Available potassium**			
	Fertilizer levels				**Fertilizer levels**				**Fertilizer levels**			
Manure combinations	**S_1:50% RDF**	**S_2:75% RDF**	**S_3:100% RDF**	**Mean**	**S_1:50% RDF**	**S_2:75% RDF**	**S_3:100% RDF**	**Mean**	**S_1:50% RDF**	**S_2:75% RDF**	**S_3:100% RDF**	**Mean**
M_1: FYM @ 10 t ha^{-1}	154	179	197	177	32.33	33.41	35.70	33.81	227	233	238	233
M_2: Green manure seed (dhaincha) @ 25 kg ha^{-1}	158	191	205	185	32.58	36.71	38.94	36.08	231	241	244	239
M_3: FYM @ 5 t ha^{-1}+ Green manures seed @ 12.5 kg ha^{-1}	173	199	211	195	33.55	39.38	41.40	38.11	239	247	251	246
M_4: FYM @10 t ha^{-1}+ *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each	212	214	224	216	42.69	43.51	46.52	44.24	250	258	263	257
M_5: Green manure seed @ 25 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each	213	222	230	222	42.84	48.27	48.61	46.57	252	270	274	265
M_6: FYM @ 5 t ha^{-1} + Green manure seed @ 12.5 kg ha^{-1} + *Azospirillum* + PSB + KRB @1.25 l ha^{-1} each	221	228	235	228	47.69	48.73	49.01	48.48	261	279	285	275
M_7: Control	104	119	139	121	17.98	24.52	31.50	24.67	154	200	220	191
Mean	177	193	206		35.67	39.22	41.67		231	247	254	
	SEm±		CD (P=0.05)		Sem±		CD (P=0.05)		Sem±		CD (P=0.05)	
M	6.4		20		1.624		5.00		6.4		20	
S	2.1		6		0.540		1.56		2.1		6	
S at M	5.4		15		1.429		4.94		5.4		15	
M at S	9.6		29		2.440		7.37		9.6		29	
Initial (before sowing of crop)	205				30				218			

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