Research Article

Soil Physical, Chemical and Biological Properties as Influenced by the Legume Crops and Residue Management Practices in Legume – Maize Sequence

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Abstract

A field experiments carried out to evaluate the soil physical, chemical and microbial population dynamics as influenced by the kharif legume crops, residue management practices and nitrogen levels on maize crop was conducted for two consecutive years on sandy clay soil at Agricultural college, Aswaropet, Khammam (dt.), Telangana state. The treatments consisted of three legumes, viz., cowpea, (M_1) field bean (M_2) and greengram (M_3) as main plot treatments during the kharif season and two residue management practices viz., residue removal (I_0) and residue incorporation (I_1) as sub- plot treatments. Four nitrogen levels 75 kg ha^{-1} (N_1), 150 kg ha^{-1}(N_2), 225 kg ha^{-1} (N_3) and 300 kg ha^{-1}(N_4) as sub- sub plot treatments allocated to maize during rabi season. There is an improvement in the soil physical properties over the initial level. Decrease in the bulk density, increase in soil organic carbon was observed with cultivation of legume crops and incorporation of residues further reduced the bulk density and increased the organic carbon levels, irrespective of the legume crop grown during the kharif season. Improvement in the soil microbial populations was observed over the initial population. However, the highest bacterial count was recorded when cowpea crop was taken as a preceding crop to maize during kharif followed by field bean and greengram. Incorporation of crop residues in conjunction with the highest level of nitrogen has markedly improved the soil microbial population in all the treatment combinations tried. The increase in the microbial activity and number as reflected in the yields of maize where the highest grain yield was recorded with residue incorporation treatment in combination of highest level nitrogen tried.

Keywords: Crop residues, Microbial population, residue incorporation

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Introduction

India has a long history of agricultural activities, produces a vast amount of crop residues, the annual production of crop residues in India are estimated over 500 million tons (Mt). There exists a large variability among the crops with regards to the production of crop residues, Furthermore, the residues production has also increased substantially with intensive agricultural practices. The most common and cheapest method of disposal of crop residues is burning. This is resulting in significant accumulation of harmful gases and pollution [1]. Direct incorporation of crop residues into agricultural land to conserve soil nutrients, soil moisture and organic carbon content can cause considerable crop management problems. However, a long-term field experiment has confirmed that adding crop residues to agricultural land leads to a large increase in soil carbon stocks which serves as a substratum for the growth and development of the microorganisms. Soil microbes play a key role in the nutrient cycling by decomposing the organic matter in to plant available nutrients.

Microorganisms are essential component of soil, directly related to plant growth and soil fertility. Soil microbes are the living portion of soil that plays a vital role in the function of ecosystems through their complex interactions with the environment. These include organic matter decomposition and nutrient cycling, including carbon (C) and nitrogen (N) cycling and soil aggregate formation and maintenance.[2], [3]. Furthermore, the size of the microbial population in agricultural soils can be affected by availability of organic matter and management practices.

Legume-Maize sequence is the important cropping system followed in large extent of area in Andhra Pradesh and Telangana states. Grain legumes were cultivated during the kharif season and after harvesting the economic yield the harvested remnants are either used as an animal feed or else burned to clear the succeeding crop. Since, Maize is an exhaustive crop for nutrients and responds positively with increase in the level of nitrogen fertilizers [4]. Furthermore, Intensive agricultural practices ignoring the addition of organic nutrient sources resulting in the manifestation of nutrient deficiencies. Added to the problem continuous usage of chemical fertilizers leading to the decline in the yield levels and loss of soil physical, chemical and biological properties [5]. Under these circumstances, formulation of ideal nutrient management strategy is very much essential to increase the yields and sustain the soil health. Legume crop residues after the harvest of the economic part can serve as a source of plant nutrients and serves as readily available energy for soil microbes because of their relatively high nutrient content, low lignin content and easy decomposition [6]. Further, they serve as bulky organic manures and can be incorporated into the soil for improving the soil fertility. In this study an attempt was made to know the soil physical chemical and biological properties with incorporation of crop residues in legume- maize sequence.

Materials and Methods

A field experiments were conducted at Agricultural College farm, Aswaraopet, Khammam (Dist.) Telangana state for two consecutive years. The experimental site is situated at an altitude of 854 m above mean sea level, 16^0 10´ N latitude, 80^0 29´ E longitude and about 110 km away from Khammam town and falls in the Central Telangana Agro climatic Zone of Telangana State. The experimental site was sandy clay in texture, slightly alkaline in reaction, low in available organic carbon and nitrogen, medium in available phosphorus and potassium. The investigations were carried out with an objective to find out soil physical chemical and microbial properties as influenced by the residue incorporation of *kharif* legumes, residue management practices. The treatments consisted of three legumes, viz., cowpea, (M_1) field bean (M_2) and greengram (M_3) as main plot treatments during the *kharif* season and two residue management practices viz., residue removal (I_0) and residue incorporation (I_1) as sub- plot treatments. Four nitrogen levels 75 kg ha^{-1} (N_1), 150 kg ha^{-1}(N_2), 225 kg ha^{-1} (N_3) and 300 kg ha^{-1} (N_4) as sub- sub plot treatments allocated to maize during *rabi* season. The yield of kharif legumes, growth parameters, yield and yield attributes of rabi maize were recorded. The soil samples were collected from the experimental plots for enumerating the microbial population before sowing and after harvest of different legumes, after incorporation of the crop residues, before sowing of maize and after harvest of maize was estimated by following the standard dilution plate count technique by pour plate technique Nutrient agar (NA) for bacteria, Martin's rose bengal with streptomycin sulphate agar (MRBA) for fungi, Ashby's agar for *Azotobacter*, Yeast Extract Mannitol agar (YEMA) with congo red for *Rhizobium* were used for enumeration. The petri plates were incubated after plating at 30^0C for two to four days and population was counted and expressed as number of cells per gram on dry weight basis for bacteria, *Azotobacter* and *Rhizobium* and cfu g^{-1} of soil for fungi.

Results and Discussion

Soil Bulk Density

Bulk density of soil was estimated at three intervals i.e., initial, after the harvest of legumes and after the harvest of maize during the two years of investigation as shown in the **Table 1**. Bulk density, in general, had decreased over the initial value with the cultivation of all the legumes. The minimum bulk density of 1.31 and 1.30 g cc^{-1} was obtained with the cowpea during I^{st} and 2^{nd} years, respectively and the maximum bulk density (1.33 and 1.30 g cc^{-1}) for the corresponding period was noticed with greengram.

Residue incorporation of all the legumes had shown further decrease in bulk density of the soil over their removal. The lowest bulk density values are obtained with incorporation of residues of cowpea was 1.24 g cc^{-1} and 1.20 g cc^{-1} in first and second year, respectively. While the highest values are obtained with greengram (1.31 g cc^{-1} and 1.22 g cc^{-1}) in both the years.

Table 1 Bulk density of the soil as affected by the legume crops and management practices

Soil bulk density (g cc^{-1})	First year	Second year
Initial	1.41	1.38
Kharif legumes		
Cowpea	1.31	1.30
Field bean	1.36	1.33
Greengram	1.33	1.30
Residue management		
Cowpea	1.24	1.20
Field bean	1.29	1.23
Greengram	1.30	1.22
Harvest of maize	1.31	1.35

Although there is an increase in bulk density values after the harvest of maize, reduction in bulk density was observed when compared to the initial value. The decrease in bulk density when rotated with legumes and when the residues are incorporated in the soil might be due to the root proliferation of the legume crops and addition of biomass to soil. This might have resulted in the increase in pore space and aeration of the soil which, inturn, resulted in decrease in the mass per unit volume of the soil resulting in decreased bulk density over the initial level. These results are in accordance with the findings of [7], [8] and [9].

Soil nitrogen Status

Soil nitrogen status during the growth period of legumes was also assessed to know the nitrogen dynamics. The decrease in soil N values 97 kg ha^{-1} and over the initial value (150 kg ha^{-1}) was observed up to 45 DAS of all the legumes, thereafter, increase in trend was observed till the harvest of legumes. The soil N status after the harvest of cowpea was 193kg ha^{-1} and 210 kg ha^{-1} in first and second year, respectively.

Soil microbial population

Soil microbial population was assessed at three stages viz., initial, after the harvest of the *kharif* legumes as well as after the incorporation of legumes and after the harvest of the *rabi* maize. On perusal of the data presented in the (**Figure 1**) revealed that there was an increase in microbial population compared to the initial population during both the years of study. Improvement in soil microbial population viz., total bacteria, rhizobium, azotobacter, actinomycetes and fungi was observed over the initial population when legumes were grown in *kharif*. Among the legumes, maximum number of soil micro flora was observed after the harvest of cowpea followed by field bean and greengram. The increase in number of soil microorganisms might be due to the abundance of the native bacteria in the soil. Similar results were also reported by [10].

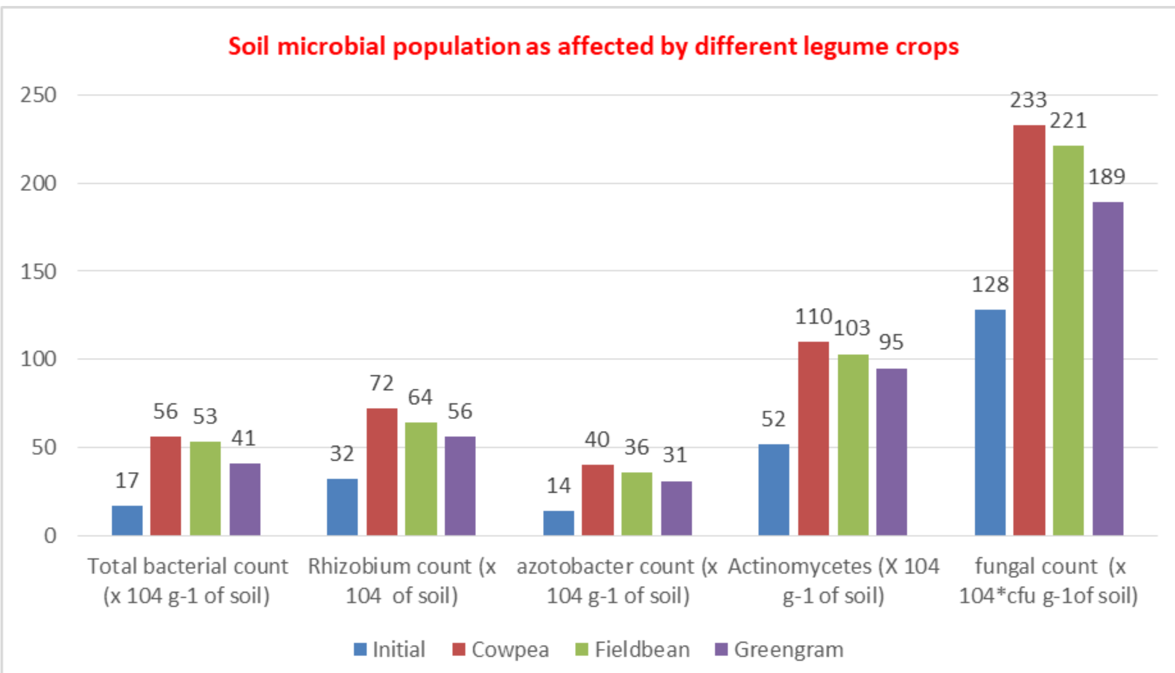

Figure 1 Soil microbial population as influenced by different types of legume crops

The decreasing in trend in the entire micro flora was noticed after the harvest of *rabi* maize during both the years by maintaining more or less similar trend as that was observed in the initial as well as at the end of harvest of *kharif* crops. Increase in microbial population was seen with the incorporation of crop residues over the removal.

On perusal of the data present in the **Tables 1-3** revealed that, cultivation of legume crops, residue management practices and nitrogen levels had a positive influence in increasing the microflora. (Plate 1). Among the legume crops, cultivation of cow pea as a preceding crop to maize had shown its superiority over Field bean and Greengram. Incorporation of crop residues further increased the microbial population over their removal in all the treatment combinations. Increase in the population of microflora was observed with increase in the level of nitrogen application up to the highest level tried irrespective of the legume crop grown during the kharif season. The highest total bacterial count of 333 $X10^4g^{-1}$ of soil was recorded with incorporation of cowpea crop residues with N application at 300 kg ha^{-1}. While the lowest count of total bacteria 61 X10^{4}g^{-1} was obtained in greengram with N application at 75 kg ha^{-1} in removal of greengram residue treatments.

Table 2 Soil available nitrogen status (kg ha^{-1}) at different intervals during the crop growth period of legumes during 2011- 2012

Legume crops	2011						2012					
	Days after Sowing (DAS)						Days after Sowing (DAS)					
	15	30	45	60	75	Harvest	15	30	45	60	75	Harvest
Cowpea	155	132	97	128	145	193	173	145	125	138	173	210
Field bean	168	144	126	156	163	186	184	150	130	158	181	195
Greengram	160	152	134	152	169	170	166	158	127	163	192	182

Table 3 Soil microbial population as affected by different treatments after the harvest of maize

Treatment	First Year					Second year				
	Total bacterial count (x 10^4 g-1 of soil)	Rhizobium count (x 10^4 of soil)	azotobacter count (x 10^4 g-1 of soil)	Actino mycetes (X 10^4 g-1 of soil)	fungal count	Total bacterial count (x 10^4 g-1 of soil)	Rhizobium count (x 10^4 of soil)	Azotobacter count (x 10^4 g-1 of soil)	Actino mycetes (X 104 g-1 of soil)	fungal count
M1I0N1	98	25	42	19	99	145	35	51	51	105
M1I0N2	145	42	64	32	112	199	50	72	72	123
M1I0N3	186	76	98	65	145	299	82	104	104	155
M1I0N4	224	102	133	102	182	410	120	141	141	191
M1I1N1	115	36	50	21	102	178	48	60	60	111
M1I1N2	186	59	73	44	125	245	69	82	82	133
M1I1N3	293	94	108	79	160	353	104	118	118	173
M1I1N4	333	121	106	98	202	352	130	115	101	213
M2I0N1	75	22	22	11	85	119	35	35	35	93
M2I0N2	122	39	44	25	94	163	50	54	54	101
M2I0N3	163	63	61	52	108	229	75	70	70	114
M2I0N4	206	94	95	86	141	329	104	105	105	146
M2I1N1	87	31	34	15	90	144	46	43	43	99
M2I1N2	147	50	53	34	109	194	62	61	61	117
M2I1N3	228	76	79	60	135	270	86	86	86	145
M2I1N4	256	85	92	65	167	302	103	108	82	173
M3I0N1	61	15	22	10	61	91	21	28	28	69
M3I0N2	112	28	36	25	84	151	39	47	47	94
M3I0N3	186	46	60	42	108	204	54	68	68	117
M3I0N4	233	78	91	65	126	300	88	98	98	136
M3I1N1	67	15	34	10	78	119	21	40	40	87
M3I1N2	129	35	54	30	98	176	46	59	59	106
M3I1N3	203	59	78	54	122	258	71	87	87	129
M3I1N4	255	80	76	84	152	263	84	81	89	132

The dynamic changes that are occurring in the soil microbial populations (**Figures 3-5**) and their interactions in the soil might be due to the fact that the soil microbial communities play an important role in soil ecosystem processes and biogeological cycle of basic elements such as nitrogen and carbon. Crop residue returning can increase the content of organic matter in the soil and provide good environment for the growth and proliferation of microorganisms. It is better evident from the **Figures 1-3**. The changes in the population of microbes in different cropping systems and sequences were well established by [11], [12], and [13].

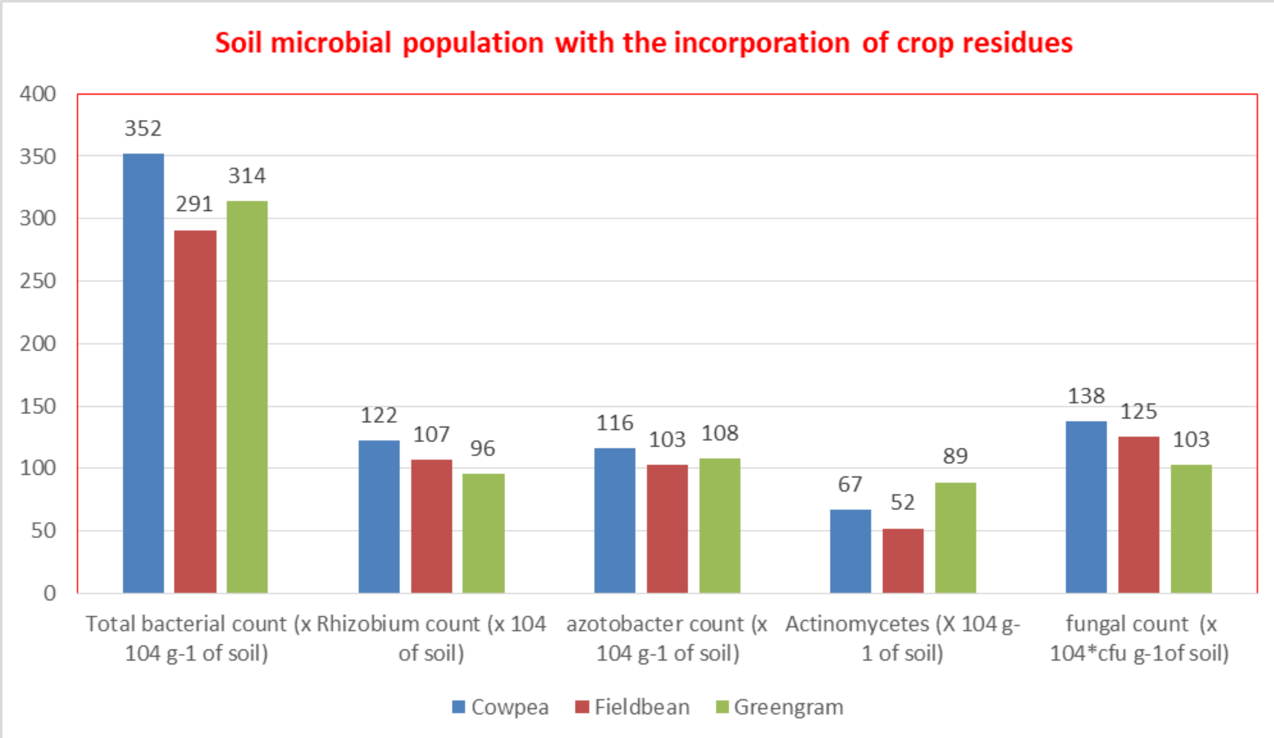

Figure 2 Soil microbial population as influenced by crop residue incorporation

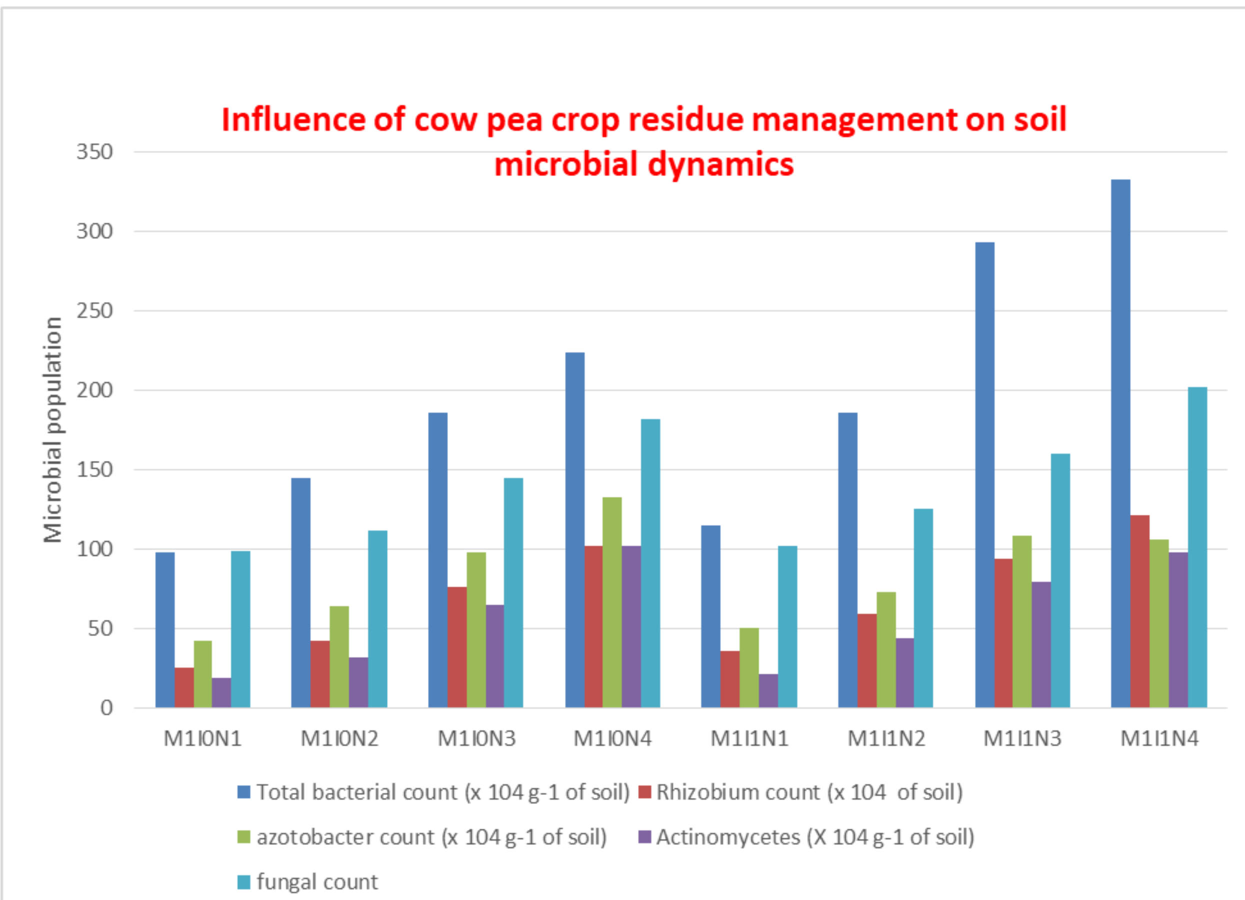

Figure 3 Influence of cowpea, residue management and nitrogen levels on soil microbial population

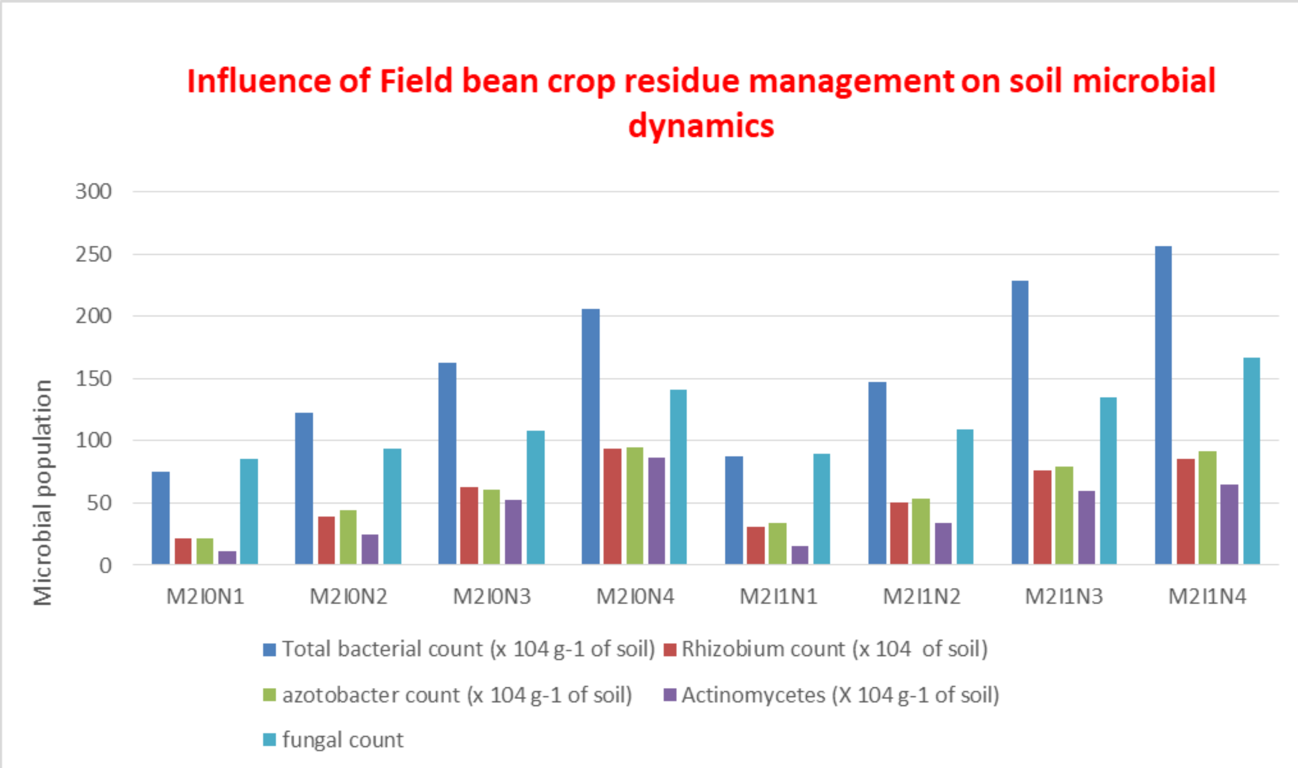

Figure 4 Influence of Field bean, residue management and nitrogen levels on soil microbial population

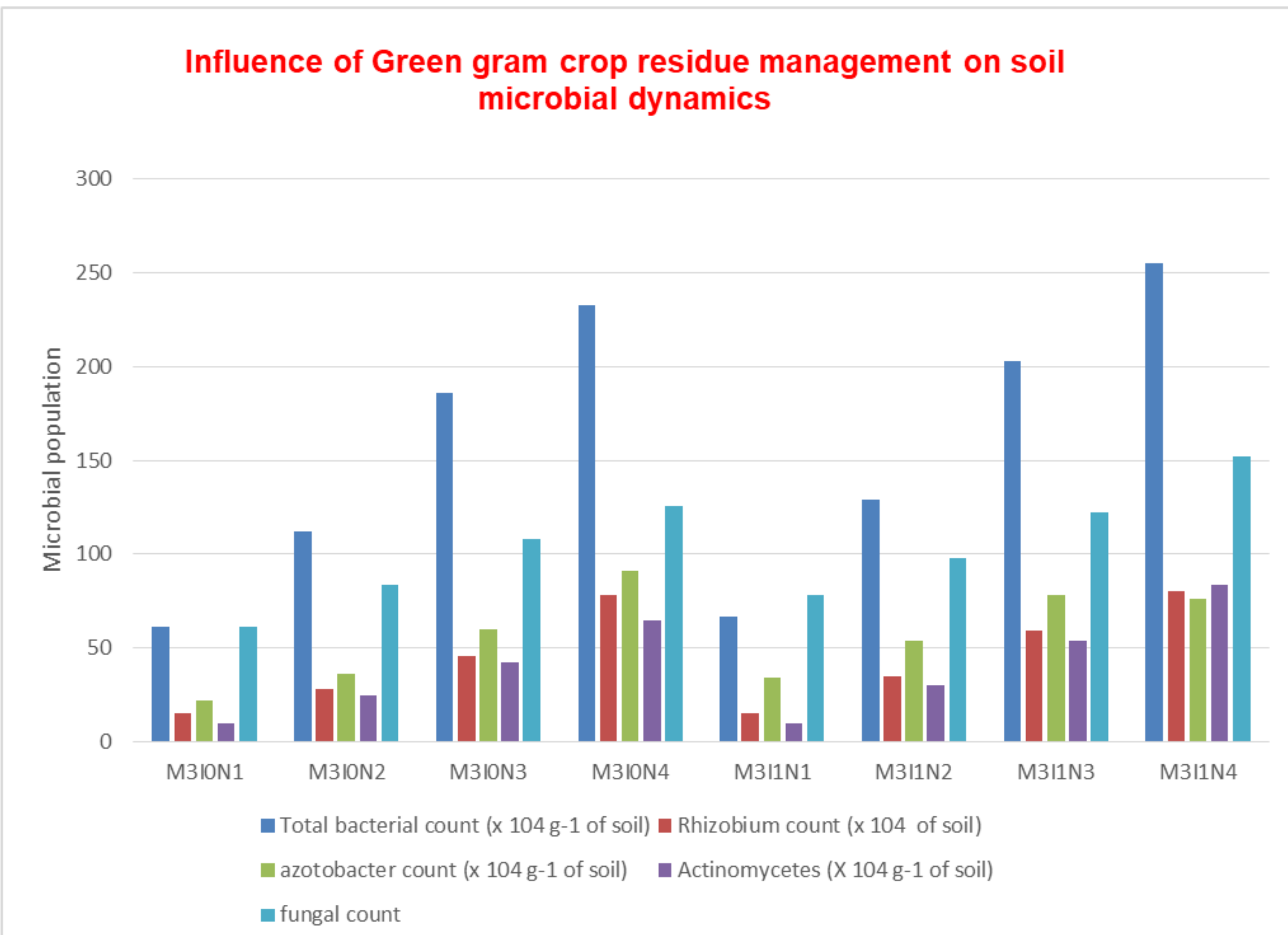

Figure 5 Influence of Greengram, residue management and nitrogen levels on soil microbial population

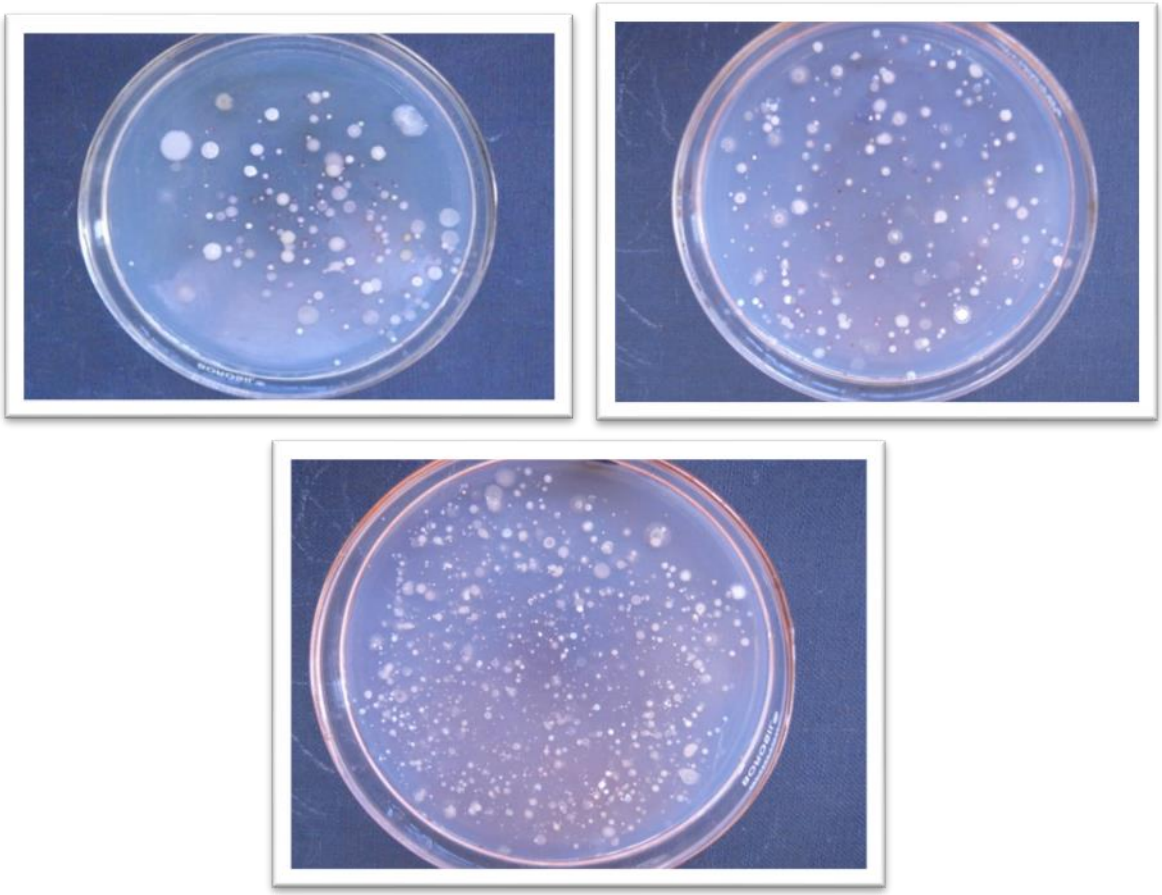

Plate 1 Soil microbial population after harvest of the legumes

Conclusion

From the foregoing study it can be concluded that, intensive agricultural practices and excessive usage of inorganic nutrient sources coupled with ignoring the addition of organic manures leading to the decline in the productive capacity of the soil. Under these circumstances, exploring and utilization of organic sources which are readily and cheaply available is very much crucial for maintaining the soil fertility. Present investigation highlights the importance effective utilization of crop residues. In different cropping systems and crop sequences, when there is a time gap of at least 20 days between two successive crops, the residues of the previous crop after harvesting the economic yield can profitably be incorporated in to the soil to meet the nitrogen economy of succeeding cereal crop. Further, the residue management practices ensure the nutrient requirement of the succeeding crop besides improving the soil physical, chemical and biological properties and reducing environmental problems caused due to crop residue burning.

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Publication History

Received	12.11.2022
Revised	31.12.2022
Accepted	31.12.2022
Online	31.12.2022