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Effect of Physico Microbial Properties of Soil as Influenced by Legume Residue Incorporation on Yield of Maize

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A B S T R A C T

A field experiment was conducted on sandy clay soils of Agricultural College Farm, Aswaraopet, Khammam (dt.) to study the performance of kharif legume crops residue management practices and nitrogen levels on the soil physical and microbial characters as influenced by legume residue management practices in legume maize sequence. The experiment was laid out in split- split plot design and the treatments were replicated thrice with three legumes**,** viz., cowpea, (M_1) fieldbean (M_2) and greengram (M_3) as main plot treatments taken up during the *kharif* season and two residue management practices viz., residue removal (R_0) and residue incorporation (R_1) as sub plot treatments. Four nitrogen levels 75 (N_1), 150 (N_2), 225 (N_3) and 300 kg ha^{-1}(N_4) as sub- sub plot treatments to maize. The experiment was conducted for two consecutive years. Soil physical microbial properties were analysed to know different parameters. Bulk density of the soil, 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 the Ist and the 2nd 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. Improvement in soil microbial population viz., total bacteria, rhizobium, azatobactor, 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 found after the harvest of cowpea followed by field bean and greengram. Incorporation of legume crop residues further increased the different micro flora. The kernel yield of maize was significantly high when cowpea was taken as a preceding crop to maize. Residue incorporation has resulted in significant improvement in yield of maize compared to residue removal in all the three *kharif* legumes during both the years. The Kernal yield of maize was realized with the incorporation of crop residues is 5884 and 6147 $kgha^{-1}$ during first and second year of investigation respectively.

Introduction

Maize (*Zea mays* L.) is one of the important cereal crops grown in the world after wheat and rice. The importance of maize lies in its wide industrial uses besides serving a food and fodder. It is the most versatile crop with wider adaptability to varied agro ecological regions, and has the highest genetic yield potential among the food grain crops grown. Since the demand for the maize is increasing globally due to its multiple uses there is a need to enhance its productivity from same or even less available resources.

Maize is cultivated both in temperate and tropical regions of the world. The full yield potential of maize crop can be exploited through adoption of hybrids with better nitrogen management practices. Further, maize is a heavy feeder of nutrients, especially nitrogen, the deficiency of which limits the growth and yield of the crops. Over dependence on chemical fertilizers alone would lead to gradual decline in organic matter content and native fertility status of the soil and further deteriorating soil physical properties like bulk density which is an indicator of soil compaction and soil health. It affects the infiltration, rooting depth/restrictions, available water capacity, soil porosity, plant nutrient availability and soil micro organisms activity which influence key soil processes and productivity. In addition to soil properties, soil micro-organisms also play essential roles in the nutrient cycles that are fundamentally important to life on the planet. In the past, agricultural practices have failed to promote healthy populations of microorganisms limiting production yields and threatening sustainability

Legume crop residues after the harvest of the economic part are the good 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. Therefore, a strategy of integrated use of nitrogen through fertilizers in combination with cheaper sources of organic matter which is abundantly available should be tried to satisfy the higher nitrogen requirement of the maize crop to produce higher quantity and quality yield of maize without impairing health.

Since, crop residues after the harvest of the economic yield can be profitably utilized as organic manure for the succeeding crop instead of using the residues for non agricultural purposes. Information on the contribution of legume crops as well as their residues for the succeeding cereal in the sequence is quite scarce therefore the present investigation was under taken to study the response of maize to legume crops residue management practices.

Materials and Methods

The experiment was conducted at Agricultural College Farm, Aswaraopet during *kharif* and *rabi* seasons of two consecutive years. The soil of the experimental site was sandy clay in texture, slightly alkaline in reaction (P^H 7.8), low in available nitrogen, (148 kg ha^{-1}), medium in available phosphorus (33 kg ha^{-1}) and high available K (256 kg ha^{-1}). The experiment was laid out in split- split plot design and the treatments were replicated thrice with three legumes, viz., cowpea, (M_1) fieldbean (M_2) and greengram (M_3) as main plot treatments taken up during the *kharif* season and two residue management practices viz., residue removal (I_0) and residue incorporation (I_1) as sub- plot treatments and 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 to maize as 150 kg N ha^{-1} being the recommended dose during *rabi* in Central Telangana Zone, of Telangana state which corresponds to 50,100,150, and 200 per cent recommended dose of nitrogen (RDN), respectively.

The trial was repeated in a separate field in the second year. During two years of study Co-4, HA-3, MGG-295 varieties of cowpea, field bean and greengram respectively, were raised as *kharif* legumes while 30-V-92 a popular maize hybrid was grown during *rabi.* Legume crops are taken up in the *kharif* season, during both the years of study, in half of the plot residues are removed while in the another half the plot residues are incorporated in the of the plot after harvesting the economic yield. The residue was allowed to decompose in the field for one month thereafter field was thoroughly ploughed to sow the succeeding maize. The maize crop test variety 30 V92 was sown by adopting a spacing of 60 cm X 20 cm for the two successive seasons. Nitrogen was applied in the farm of urea as per the treatments in three splits viz., ¼ th at the time of sowing, ½ at knee-high stage and the remaining ¼ at tasselling stage. A common dose of 60 kg P_2O_5 and 50 kg K_2O was applied in the form of single super phosphate and muriate of potash at the time of sowing.

The enumeration of total bacteria, fungi, *Azotobacter* and *Rhizobium* in the soil samples collected from the experimental plots 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 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. Bulk density of the soil samples was estimated by core sampler before and after the sowing of *kharif* and *rabi* crops during both the years as per the method described by Dastane (1972).

Results and Discussion

Bulk density of the soil

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 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 the I^{st} and the 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 were obtained with incorporation of residues of cowpea was 1.24 g cc^{-1} and 1.20 g cc^{-1} in the first and the 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).

Although there was 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, in turn, 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 Mckenzie *et al.,* (2001), Bhushan and Sharma (2002) and Nottidge *et al.*, (2010).

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. 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, Azatobactor, 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 found 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 George *et al.*, (2007).

During both the years of experimentation, microbial population was more in second year compared to fir The Ist year. Increase in the population of total bacteria in the second year over the first year might be attributed to the difference in the levels of P^{H}, nutrient status of the soil, soil moisture, soil and crop management practices. Similar kind of results was reported by Giller (1995).

Soil incorporation of legume crop residues has further improved the microbial population by two folds during first year. The maximum number of bacteria and 352 x 10^{4} g^{-1}) was noticed with incorporation of cowpea residues during the first year followed by greengram in the first year and field bean in the second year. The improvement in soil microbial population might be due to the addition of all the residues which might have added a fair quantity of organic matter to the soil which in turn acted as a substrate for the multiplication and development of microbes either over the initial or against the residue removal during both the years. Similarly, increased trend in soil microbes due to incorporation of residues was also reported by Ocio and Brooks (1990), and Beri *et al.*, (1992).

Table.1 Bulk Density (g cc^{-1}) of the soil as influenced by *kharif* legumes and residue management practices

Soil bulk density (g cc^{-1})	2011-12	2012-13
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**

Table.2 Effect of legume crops and residue management practices on the population dynamics of microbes

Treatments	Total bacterial count (x 10^4 g^{-1} of soil)	Rhizobi u m count (x 10^4 of soil)	azotobact e r count (x 10^4 g-1 of soil)	Actinomycet es (X 10^4 g-1 of soil)	fungal count (x 10^4*cfu g-1of soil)	Total bacterial count (x 10^4 g^{-1} of soil)	rhizobium count (x 10^4) g^{-1} of soil)	Azotobacter count (x 10^4 g^{-1} of soil)	Actinomyce tes (X 10^4 g-1 of soil)	Total fungal count (x 10^4cfu g^{-1} of soil)
Initial	78	17	32	14	52	128	42	51	21	**79**
Cowpea	198	56	72	40	110	233	82	85	56	**159**
Fieldbean	174	53	64	36	103	221	77	82	43	**148**
Greengram	152	41	56	31	95	189	71	68	39	**132**
Incorporation of the legumes										
Cowpea	352	122	116	67	138	368	137	124	81	**148**
Fieldbean	291	107	103	52	125	336	112	121	68	**152**
Greengram	**314**	**96**	**108**	**89**	**103**	**285**	**111**	**106**	**52**	**118**

Table.3 Kernel Yield (kg ha^{-1}) of maize as influenced by legume crops, residue management practices and nitrogen levels

Legume crops (LC)		**N level (k**	**g ha^{-1})**		**Mean**		**N level (kg ha^{-1})**			**Mean**
	75	**150**	**225**	**300**		**75**	**150**	**225**	**300**	
Cowpea	4733	5650	6744	7120	**6092**	4819	5899	7511	7511	**6316**
Field bean	4268	5157	6483	6675	**5646**	4469	5511	6515	6960	**5864**
Greengram	4135	4964	6078	6491	**5417**	4407	5302	6274	6748	**5683**
Mean	**4379**	**5257**	**6495**	**6762**		**4565**	**5571**	**6608**	**7073**	
Residue management Practices (RMP)										
Residue removal (I_1)	3206	5119	6224	6578	**5532**	4406	5351	6380	5742	**5742**
Residue incorporation (I_2)	4552	5395	6646	6945	**5884**	4723	5790	6336	7318	**6167**
Mean	**4379**	**5257**	**6435**	**6762**		**4565.3**	**5571**	**6608**	**7073**	
	SEm±	**CD**	**CV**			**SEm±**	**CD**	**CV**		
		(0.05%)	**(%)**				**(0.05)**	**(%)**		
LC	116.7	458	18.4			93.2	366	**20.8**		
RMP	95.0	329	20.8			100.6	348	**20.2**		
N L	186.4	534	15.3			195.3	560	**14.1**		
LC XRMP	80.81	NS	16.2			174.3	NS	**15.2**		
LC XNL	322.9	NS	15.8			338.2	NS	**13.1**		
RMP X NL	**263.6**	**NS**	**14.6**			**296.2**	**NS**	**11.5**		

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 after removal. Further increase in microbial count was observed due to increase in level of N application. The highest total bacterial count of 333 x 10^4 g^{-1} and 352 x 10^4 g^{-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 x $10^4 g^{-1}$ and 91 x 10^4 g^{-1} in the first and the second year, respectively was obtained in greengram with N application at 75 kg ha^{-1} due to removal of greengram residue treatments. The changes due to the population of microbes in different cropping systems and sequences were well established by Kushwaha *et al.,* (2000), Sridevi *et al.,* (2003) and Yadvinder Singh *et al.,* (2005).

Kernal yield of Maize

Kernel yield of maize was the affected by *kharif* legume crops, residue management practices during the both the year of experimentation. However, the interactions of these factors were found to be non significant. Among different *kharif* legume crops tested, cowpea preceded to maize resulted in the highest kernel yield of 6092 kg ha^{-1} and 6317 kg ha^{-1} during the first and the second year of study, respectively, while the kernel yield of maize with field bean and greengram as preceding crops were comparable during both the years of study. Residue incorporation resulted in significant increase in kernel yield of succeeding maize during both the years. The per cent increase in kernel yield of maize due to residue incorporation was 6 and 7 per cent during the first and second year, respectively, over no incorporation. Nodulated roots and the above ground residues of legumes after the harvest of seed represent the potentially viable source of nitrogen for the soil microbes when these residues were incorporated into the soil. The increase in soil microbial population with residue incorporation was better evident in the present investigation. This might have increased the nutrient availability to the succeeding maize in sequence. These results are in conformity with the findings of Arif *et al.,* (2011) and Sharma and Behera (2009). Incorporation of the residues after picking the economic yield interacted positively with the soil and the release of nutrients which might have enabled the maize to get assured ensured and continuous nitrogen supply distributed during entire crop growth period. Decomposition and mineralization of residues might have coincided with the early growth stages of succeeding maize which might have contributed for the better performance of the maize over no residue incorporation. The present findings are in corroboration with the results reported by Dasaraddi *et al.,* (2002), Tiwari *et al.,* (2004) and Safi *et al.,* (2007).

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