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Influence of different cropping systems and residual effect of INM on soil primary, secondary and micro nutrients

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Abstract
A field experiment was conducted to determine the residual effect of integrated nitrogen management and cropping systems on soil nutrient status during two consecutive years (2015-16 & 2016-17) on clay loam soils of Agricultural College Farm, Bapatla. The experiment was laid out in a two sample t-test for rice in *kharif* season with 2 treatments consists of M_1 100% RDF, M_2 (50% RDN+ 25% N through FYM + 25% N through neem cake + Azospirillum + PSB @ 2.5 kg ha^{-1} (INM) and replicated thrice. During the immediate *kharif,* the experiment was laid out in a split plot design without disturbing the soil for succeeding *rabi* crops with the two treatments given to *kharif* rice as main plot treatments and each of these divided into five sub-plots of consisting of five crops as sub treatments by taking popular cultivars of rice (BPT 5204), blackgram (PU 31), maize (Sandhya), Sorghum (NSH-54), Sunflower (Shreshta) and mustard (Konark). Results shown that the highest mean available N, P_2O_5, K_2O, exch.Ca, exch. Mg, S, Fe, Mn, Zn and Cu were recorded in blackgram, which was on par with mustard followed by sorghum and sunflower sequence, which was superior over maize. The lowest values were observed in maize sub plot. Interaction effect of cropping system and residual effect of INM, significantly highest available nutrient values were observed with M_2S_1 treatment i.e. rice-blackgram cropping system in INM treated plots during both the years.

Keywords: Residual effect of INM-cropping systems-soil nutrient status

Introduction
Integrated nitrogen management involving conjunctive use of organic, inorganic and crop residues improves soil productivity and system productivity become sustainable. Therefore, combined use of chemical fertilizers, organic manures and bio fertilizers is essential. Organic manures particularly farmyard manure and neem cake are not only supply macronutrients but also meet the requirement of micronutrients. Using of biofertilizers also have been found to be promising in arresting the decline in productivity through increasing the nutrient solubility and make more availability of macro and micronutrients of soil. Cropping system is an important component of a farming system representing cropping pattern used on a farm, which maintains and enhances soil health. Some crops are nutrient exhausting while others help restore soil nutrient status. However, a diversity of crops will maintain soil fertility, minimize spread of pests and disease and keep production level high.

Material and Methods
A field experiment was conducted for two consecutive years (2015-16 & 2016-17) on clay loam soils of Agricultural College Farm, Bapatla. The experiment was laid out in a two sample t-test for rice in *kharif* season with 2 treatments and replicated thrice. The treatments consists of M_1 100% RDF, M_2 (50% RDN+ 25% N through FYM + 25% N through neem cake + Azospirillum + PSB @ 2.5 kg ha^{-1} (INM). During the immediate *kharif,* the experiment was laid out in a split plot design without disturbing the soil for succeeding *rabi* crops with the two treatments given to *kharif* rice as main plot treatments and each of these divided into five sub-plots. The experiment was repeated in another field (same block) during *kharif* and *rabi* seasons. Popular cultivars of rice (BPT 5204), blackgram (PU 31), maize (Sandhya), Sorghum (NSH-54), Sunflower (Shreshta) and mustard (Konark) were used for this study.

The experimental soils in both locations are clay loam in texture, slightly alkaline in reaction, medium in organic carbon, low in available nitrogen, high in available phosphorus and potassium. The secondary nutrients (Calcium, Magnesium and Sulphur) were also in normal range. All the micronutrients (Iron, Manganese, Zinc and Copper) were sufficient in the soil with the values above their critical limits (Table 1).

Results & Discussion

Influence of Different Cropping Systems and Residual Effect of INM on soil Primary Nutrients

Available Nitrogen

Irrespective of *rabi* crop grown, the highest available nitrogen was found with the M_2 treatment which was given at preceding rice crop. This might be attributed to the fact that with higher fertilizer dose, higher amount of fertilizer N could be converted into available form by the biochemical reaction of fertilizer N with soil organic matter (Kamla *et al*., 2005) [4]. During 2015-16, the highest mean available nitrogen was recorded in blackgram (298.5kg ha^{-1}) which was on par with mustard (298 kg ha^{-1}) followed by sorghum and sunflower sequence, which was superior over maize. The lowest available nitrogen was observed in maize. Similarly during 2016-17, the mean highest available nitrogen was recorded in blackgram sequence (275 kg ha^{-1}) followed by sunflower (255 kg ha^{-1}) and it was on par with mustard and lowest with sorghum and maize crops. Mallareddy and Devenderreddy (2008) [7] also concluded similar results that the ground nut crop got the highest available nitrogen and lowest was found with maize crop. This might be due to fixation of atmospheric nitrogen by legumes in their nodules by *rhizobium* through symbiotic N- fixation process and exhaustive nature of maize. Ali *et al*., (2012) [1] and Porpavai *et al*. (2011) [9] reported that legumes were potentially important to diversify cereal based mono cropping into cereal-legume sequences which had nutrient cycling advantages. Kanwarkamla (2000) [5] concluded that cultivation of legume crops were viewed more as a soil fertility improver than as independent crops grown for their grain output. This is because legume crops are self-sufficient in N supply.

Interaction between INM and different *rabi* crops was non-significant. Even though, it was non-significant, the highest nitrogen content (M_1S_1) because of S_1 (blackgram) is being a leguminous crop, and had the nitrogen fixing capacity, so the effect of INM was not specific and not prominent in blackgram crop compared to other crops.

Available phosphorus

The highest available phosphorus was obtained with INM treatment which was applied during *kharif*. During 2015-16, the highest mean available phosphorus was recorded in blackgram (72.8 kg ha^{-1}) which was on par with sunflower sequence followed by mustard and maize and superior over sorghum sequence. Sorghum, mustard and sunflower sequences showed on par difference among them. During 2016-17, the highest available P_2O_5 was recorded in blackgram sequence (55.5 kg ha^{-1}) followed by sunflower and mustard (55.15 kg ha^{-1} and 54.8 kg ha^{-1}) and it was superior over maize system. Bhargavi *et al*. (2007) [2] also reported that the highest available phosphorus was recorded with sunhemp-rice-rice and buildup of available phosphorus in soil was due to release of organic acids during microbial decomposition of green manure or greengram haulms which help in the solubility of native phosphorus in soil. As the phosphorus requirement of rice was meager and organic and inorganic additions increased the soil phosphorus content, the availability of phosphorus has been increased. During decomposition of organic manures, various organic acids would be produced which solubilized phosphatase and other phosphate bearing minerals and thereby lowered the phosphate fixation and increased its availability (Vidyavathi *et al*., 2011 and Megha dubey *et al*., 2015) [11, 8]. Interaction between main treatments and different *rabi* crops (sub plots) was non-significant. Even though, the highest available phosphorus was obtained in M_2S_1, followed by M_2S_4 and superior over M_2S_5, M_2S_2 and lowest was obtained in M_2S_3.

Available Potassium

Irrespective of *rabi* crop grown, the highest available potassium was found with the M_2 treatment which was given at preceding rice crop. The significantly highest available potassium was obtained with M_2 (677 and 682 kg ha^{-1}) both the years and followed by M_1 (661 and 662 kg ha^{-1}). The higher availability of potassium due to FYM may be ascribed to the reduction of potassium fixation and release of potassium due to the interaction of organic matter with clay. Similar results were reported by Jagadeeswari and Kumaraswamy (2000) [3]. During 2015-16, the highest available potassium was recorded in blackgram (815 kg ha^{-1}) followed by sorghum sequence, which was on par with other sequences. During 2015-16, the highest available potassium was recorded in maize sequence (703 kg ha^{-1}) followed by followed by sunflower and mustard sequences and it was on par with maize sequence and lowest was recorded in sorghum cropping sequence. During 2016-17, the highest available potassium was recorded in blackgram sequence, followed by sunflower and mustard sequences and it was on par with maize and lowest was obtained in sorghum cropping sequence.

Regarding to interaction effect of cropping sequence and INM, significantly highest available potassium values were observed with M_2S_1 treatment (709 and 774 kg ha^{-1}) i.e. rice-blackgram cropping system in INM treated plots during 2015-16 and 2016-17 years, respectively.

Exchangeable Calcium

The mean maximum exchangeable calcium of 24.61 cmol (p+) kg^{-1} and 25.40 cmol (p+) kg^{-1} was recorded in M_2 treatment in both the years of study. Significant difference was observed in between residual INM treatment and 100% RDFN treatment. Even though it was non-significant, in subplot treatments, the blackgram sequence had showed the mean highest calcium content (27.7 c mol (p+)kg^{-1}) followed by mustard sequence and mean lowest calcium content was showed in maize (21.08 c mol (p+)kg^{-1}) and sorghum sequence. During 2016-17 also showed the similar trend. Khusbhoo Srivastava *et al*., (2016) [6] stated that positive buildup of Ca in vegetable system might be due to the combined use of FYM and *insitu* green manuring after last picking of vegetables, which resulted in higher biomass accumulation in the system. The maximum amount of Ca in the surface soil was 3.20meq L^{-1} under vegetable cropping system. Interaction effect of cropping system and nitrogen management is also non-significant. The highest exchangeable calcium (28.8 Cmol (p+) kg^{-1}) was noticed in M_2S_1 and lowest (21.1 Cmol (p+) kg^{-1}) in M_1S_3 during 2016 and the highest calcium (29.55 cmol (p+) kg^{-1}) was noticed in M_2S_1 and lowest (21.16 Cmol (p+) kg^{-}) in M_1S_3.

Exchangeable magnesium

The mean maximum exchangeable magnesium of 5.97 Cmol (p+) kg^{-1} and 5.95 Cmol (p+) kg^{-1} was recorded in plots treated with M_2 treatment in both the years of study, respectively. The effect of subplots on soil available magnesium was non-significant. During first year, the highest mean magnesium content was recorded in blackgram (6.32 Cmol (p+) kg^{-1}) followed by sunflower sequence. During second year, the highest magnesium content was recorded in blackgram (6.04 kg ha^{-1}) sequence followed by mustard (6.08 Cmol (p+) kg^{-1}) sequence and on par with remaining sequences. Khusbhoo Srivastava *et al*. (2016) [6] concluded that the maximum amount of calcium and magnesium under vegetable system might be due to the combined use of FYM and in-situ green manuring after last picking of vegetables, which resulted in higher biomass accumulation in the system. Interaction effect of main treatments and sub plots were also non-significant.

Sulphur

The highest mean available sulphur content was observed in M_2 treatment of 16.12 mg kg^{-1} during 2015-16 and 15.94 mg kg^{-1} during 2016-17 over M_1 treatment, irrespective of *rabi* crops grown.

Regarding subplot treatments, there was a non-significant effect of subplots on soil sulphur. The highest available sulphur was recorded in rice-blackgram (16.70 mg kg^{-1}) cropping system followed by sunflower sequence and superior over other systems during 2015-16. The highest available sulphur was recorded in rice-blackgram cropping system (16.20 mg kg^{-1}) which was on par with sunflower and superior over other systems of sorghum and rice-maize system during 2016-17 due to maize and sorghum crops are more exhaustive crops than others.

Interaction effect was also non-significant. However, M_2S_1 had showed the more available sulphur compared to other cropping systems.

Available Iron

The highest mean available iron content was observed in M_2 treatment of 30.99 mg kg^{-1} at first year and 30.01 mg kg^{-1} at second year over M_1 treatment, irrespective of *rabi* crops grown. These results were in concide with Prasad *et al*., 2010. Sub plots effect on soil available iron was non-significant. Regarding subplots, the highest mean available iron was recorded in rice-blackgram (32.65 mg kg^{-1}) cropping system, followed by mustard (30.00 mg kg^{-1}) and sunflower (29.70 mg kg^{-1}) crops and superior over other sorghum and maize cropping systems during first year. Same trend was followed in second year also i.e. rice-blackgram sequence had showed the mean highest available Fe (32.65 & 30.80 mg kg^{-1}) in both the years of study. This might be due to higher capacity of intake of micronutrients by rice-blackgram cropping system over other systems. The enhancement in the available Fe due to the residual effect of organic substances might be ascribed to their ability to form stable water soluble complexes preventing the reaction with other soil constituents and also increasing the Fe content by releasing it from the native reserves. Interaction effect was also non-significant among different cropping systems.

Available Manganese

Irrespective of *rabi* crops grown, the status of available Mn after harvest of *rabi* crops was significantly higher in INM preceding rice crop during both the years of study. The available Mn status increased with the addition of farm yard manure. This might be due to the release of Mn^{+2} bound to organic ligands in the organic matter and acceleration of the reduction of Mn^{+4} to Mn^{2+}. The enhancement in the available Mn due to the addition of organic substances might be ascribed to their ability to form stable water soluble complexes preventing the reaction with other soil constituents and also increasing the Fe content by releasing it from the native reserves.

Regarding to sub plots, there was a non-significant effect observed. The rice-blackgram sequence had showed mean highest available manganese (6.02 & 5.7 mg ka^{-1}) in both the years of study. It was superior over the other cropping systems. Interaction effect was non-significant among different cropping systems.

Available Zinc

The significant highest available Zn (3.10 mg kg^{-1}) was recorded with residual effect of INM compared to only inorganic treatment. Regarding subplots, the highest available Zinc was observed with 3.20 mg kg^{-1} with S_2 (blackgram) and 2.94 mg kg^{-1} followed by mustard (S_5) and sunflower S_4 and superior over remaining two cereal crops of sorghum and maize crops. Even though, there was a non-significant effect observed. Interaction effect was also non-significant within cropping systems. The same results were recorded with Shanti *et al*. (2008) [10].

Available copper

The data on post-harvest status of available Cu in soil are presented in table 4.31. It was indicated a significant improvement in the available copper content at harvest due to residual INM treatment which is given preceding rice crop. The highest (0.66 mg kg^{-1}) and (0.75 mg kg-^{1}) copper content had been observed with INM during 2015-16 and 2016-17 years respectively. The available Cu status increased with the addition of farm yard manure. The enhancement in the available Cu due to the addition of organic substances might be ascribed to their ability to form stable water soluble complexes preventing the reaction with other soil constituents and also increasing the Cu content by releasing it from the native reserves. Irrespective of *rabi* crops grown, the status of available Cu after harvest of *rabi* crops was non-significantly higher following INM than that of inorganic alone given to preceding rice crop during both the years of study. Even though it was non- significant difference between different *rabi* crops, blackgram crop has showed the highest (1.00 mg kg^{-1}) copper content during first and 0.87 mg kg^{-1} during second years respectively than other *rabi* crops. Interaction effect was also non-significant among different cropping systems.

Conclusion

Cropping systems and residual effect of INM were significantly increased the availability of primary, secondary and micronutrients in the soil after harvest of *rabi* crops. During two years of experimentation the highest mean available N, P_2O_5, K_2O, exch.Ca, exch. Mg, S, Fe, Mn, Zn and Cu were recorded in blackgram, which was on par with mustard followed by sorghum and sunflower sequence, which was superior over maize. The lowest values were observed in maize sub plot. This increase in blackgram crop might be due to fixation of atmospheric nitrogen by legumes in their nodules by rhizobium through symbiotic N-fixation process and lowest values were might be due to exhaustive nature of maize. Regarding to interaction effect of cropping sequence and INM, significantly highest available nutrient values were observed with M_2S_1 treatment i.e. rice-blackgram cropping system in INM treated plots during both the years.

Table 1: Initial properties of the experimental soil

Particulars	2015-16 Field	2016-17 Field	Class/Group
1. Sand (%)	42	40	Clay loam
2. Silt (%)	20	21	
3. Clay (%)	38	39	
Textural class	Clay loam	Clay loam	
Bulk density (Mg m^{-3})	1.44	1.43	Normal
Porosity (%)	43.50	43.80	Normal
Water holding capacity (%)	45.10	45.80	Normal
pH (1:2.5)	7.70	7.50	Neutral to slightly alkaline in nature
EC (dS m^{-1})	0.26	0.31	Non-saline
Cation exchange capacity (Cmol (p+) kg^{-1})	35.4	37.2	Normal
Organic carbon (%)	0.55	0.50	medium
N (kg ha^{-1})	266	250	Low
P_2O_5 (kg ha^{-1})	59	53	High
K_2O (kg ha^{-1})	630	668	Very high
Exchangeable Ca (Cmol (p+) kg^{-1})	23.39	24.07	Normal
Exchangeable Mg (Cmol (p+) kg^{-1})	5.80	5.70	Normal
SO_4^{-2}-Sulphur (mg kg^{-1})	15.00	15.50	Normal
Iron	27.50	25.00	Sufficient
Manganese	5.50	4.90	Sufficient
Zinc	2.55	2.65	Sufficient
Copper	0.59	0.65	Sufficient

Table 2: Residual effect of INM & cropping systems on soil available nitrogen (kg ha^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	298	261	268	259	283	274	270	236	233	245	232	243.2
M_2	299	290	288	298	298	295	280	245	235	265	253	255.0
Mean	298.5	275.5	278	278.5	290.5		275	240	234	255	242	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	3.35	19.39	10.55	Main plots (M)	1.26	7.50	11.96
Sub plots (S)	6.74	10.5	7.79	Sub plots (S)	6.70	13.5	8.58
Interaction (MXS)	9.53	NS		Interaction (MXS)	9.48	NS	

M_1=100% RDN M_2= 50% RDN+25% N-FYM+ 25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5=Mustard

Table 3: Residual effect of INM & cropping systems on soil available P_2O_5 (kg ha^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	69.0	68.3	59.6	70.0	70.0	67.38	55.0	52.3	49.6	51.3	50.6	51.76
M_2	76.6	73.0	64.6	73.3	73.0	72.10	56.0	52.8	55.3	59.0	59.0	56.42
Mean	72.8	70.65	62.1	71.65	71.5		55.5	52.55	52.45	55.15	54.8	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.85	1.18	8.51	Main plots (M)	0.63	3.85	10.54
Sub plots (S)	2.76	1.30	9.24	Sub plots (S)	1.80	1.00	8.18
Interaction (MXS)	3.90	NS		Interaction (MXS)	2.55	NS	

M_1=100% RDN M_2=50% RDN+25% N-FYM+25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5=Mustard

Table 4: Residual effect of INM & cropping systems on soil available K_2O (kg ha^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	697	648	639	678	645	661	708	654	638	656	658	663
M_2	709	657	654	687	680	677	774	657	639	674	667	682
Mean	703	652	646	682	662		741	655.5	638.5	665	662.5	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	1.20	7.31	6.9	Main plots (M)	2.30	14.05	13.29
Sub plots (S)	3.81	11.4	13.9	Sub plots (S)	7.83	23.49	12.85
Interaction (MXS)	5.39	NS		Interaction (MXS)	11.08	NS	

M_1=100% RDN M_2=50% RDN+25% N-FYM+25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5=Mustard

Table 5: Residual effect of INM & cropping systems on exchangeable calcium (cmol(p^+) kg^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	26.60	21.00	21.10	22.50	22.30	22.72	29.00	20.83	21.16	23.20	25.50	23.93
M_2	28.80	21.16	21.55	24.10	27.60	24.64	29.55	21.30	22.16	25.50	28.50	25.40
Mean	27.7	21.08	21.32	23.3	24.95		29.27	21.06	21.66	24.35	27.00	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.25	1.56	10.20	Main plots (M)	0.21	1.32	11.40
Sub plots (S)	0.76	NS	7.91	Sub plots (S)	0.76	NS	7.58
Interaction (MXS)	1.08	NS		Interaction (MXS)	1.08	NS	

M_1=100% RDN M_2=50% RDN+25% N-FYM+25% N-neem cake + bacterial consortium
S_1= Blackgram S_2=Maize S_3= Sorghum S_4=Sunflower S_5= Mustard

Table 6: Residual effect of INM & cropping systems on exchangeable magnesium (cmol(p^+) kg^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	6.14	5.13	5.21	5.53	5.47	5.49	5.98	5.55	5.58	5.76	5.62	5.69
M_2	6.51	6.10	6.08	6.40	6.00	6.21	6.11	5.66	6.01	5.90	6.08	5.95
Mean	6.32	5.61	5.64	5.96	5.73		6.04	5.60	5.79	5.83	5.85	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.03	0.19	10.07	Main plots (M)	0.03	0.22	12.41
Sub plots (S)	0.39	NS	6.60	Sub plots (S)	0.16	NS	9.95
Interaction (MXS)	0.56	NS		Interaction (MXS)	0.23	NS	

M_1=100% RDN M_2=50% RDN+25% N-FYM + 25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5=Mustard

Table 7: Residual effect of INM& cropping systems on soil SO_4^{-2}-S (mg kg^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	16.36	14.90	15.16	15.25	14.65	15.26	15.66	14.18	13.70	14.50	14.53	14.51
M_2	17.18	15.71	15.41	16.35	16.21	16.17	16.80	15.58	16.00	16.05	15.30	15.94
Mean	16.77	15.30	15.28	15.80	15.43		16.23	14.88	14.85	15.27	14.91	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.13	0.80	8.24	Main plots (M)	0.21	1.29	9.42
Sub plots (S)	0.41	NS	10.48	Sub plots (S)	0.50	NS	8.15
Interaction (MXS)	0.58	NS		Interaction (MXS)	0.71	NS	

M_1=100% RDN M_2=50% RDN+25% N-FYM+25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5=Mustard

Table 8: Residual effect of INM & cropping systems on soil available iron (mg kg^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	32.00	28.00	26.16	28.50	29.50	28.88	30.40	26.00	27.60	29.50	29.40	28.58
M_2	33.30	30.10	30.16	30.90	30.50	30.99	31.25	28.90	28.30	30.80	30.80	30.01
Mean	32.65	29.05	28.16	29.70	30.00		30.80	27.45	27.90	30.10	30.10	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.31	1.88	10.01	Main plots (M)	0.177	1.08	7.35
Sub plots (S)	0.95	NS	7.83	Sub plots (S)	0.755	NS	10.32
Interaction (MXS)	1.35	NS		Interaction (MXS)	1.06	NS	

M_1=100% RDN M_2 = 50% RDN+25% N-FYM+ 25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5 = Mustard

Table 9: Residual effect of INM & cropping systems on soil available manganese (mg kg^{-1}) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	5.83	5.40	5.36	5.53	5.68	5.56	5.57	5.46	5.36	5.44	5.50	5.46
M_2	6.21	5.65	5.64	6.05	5.69	5.84	5.83	5.50	5.56	5.60	5.57	5.61
Mean	6.02	5.52	5.50	5.79	5.68		5.70	5.48	5.46	5.52	5.53	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.02	0.16	10.79	Main plots (M)	0.019	0.11	13.30
Sub plots (S)	0.133	NS	15.73	Sub plots (S)	0.045	NS	12.02
Interaction (MXS)	0.18	NS		Interaction (MXS)	0.064	NS	

M_1=100% RDN M_2=50% RDN+25% N-FYM+25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5= Mustard

Table 10: Residual effect of INM & cropping systems on soil available zinc (mg kg-1) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	2.90	2.80	2.71	2.75	2.80	2.79	2.90	2.35	2.48	2.50	2.68	2.58
M_2	3.50	2.93	2.88	2.95	3.26	3.10	2.98	2.73	2.83	2.85	2.78	2.83
Mean	3.20	2.86	2.79	2.85	3.03		2.94	2.54	2.65	2.67	2.73	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.04	0.25	10.48	Main plots (M)	0.05	0.33	8.06
Sub plots (S)	0.07	NS	8.58	Sub plots (S)	0.07	NS	9.93
Interaction (MXS)	0.11	NS		Interaction (MXS)	0.10	NS	

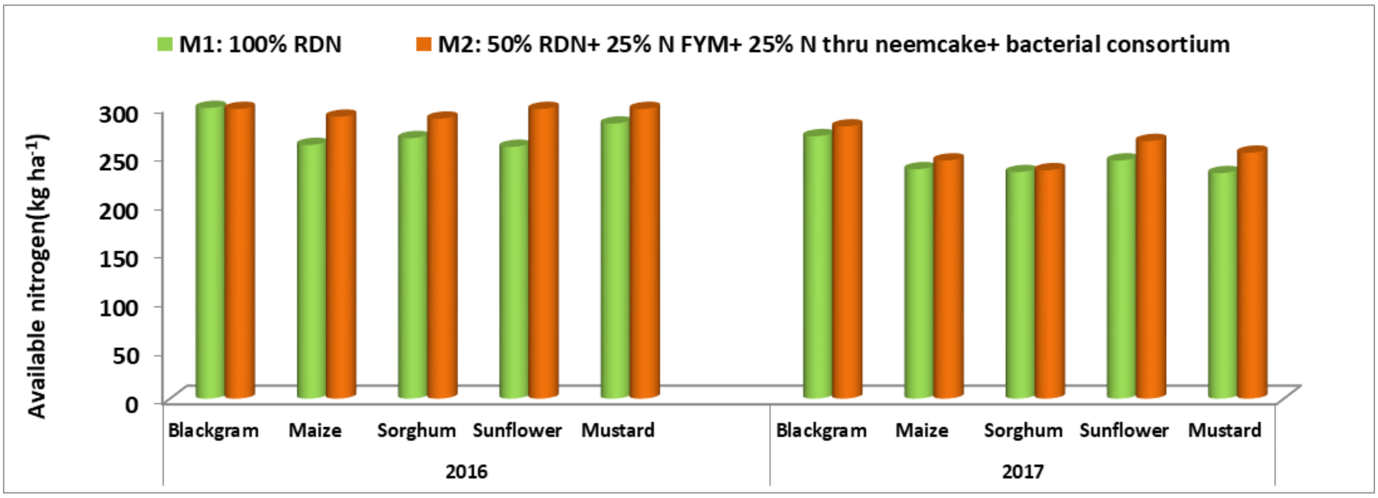
M_1=100 % RDN M_2= 50% RDN+25% N-FYM+ 25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3=Sorghum S_4=Sunflower S_5= Mustard

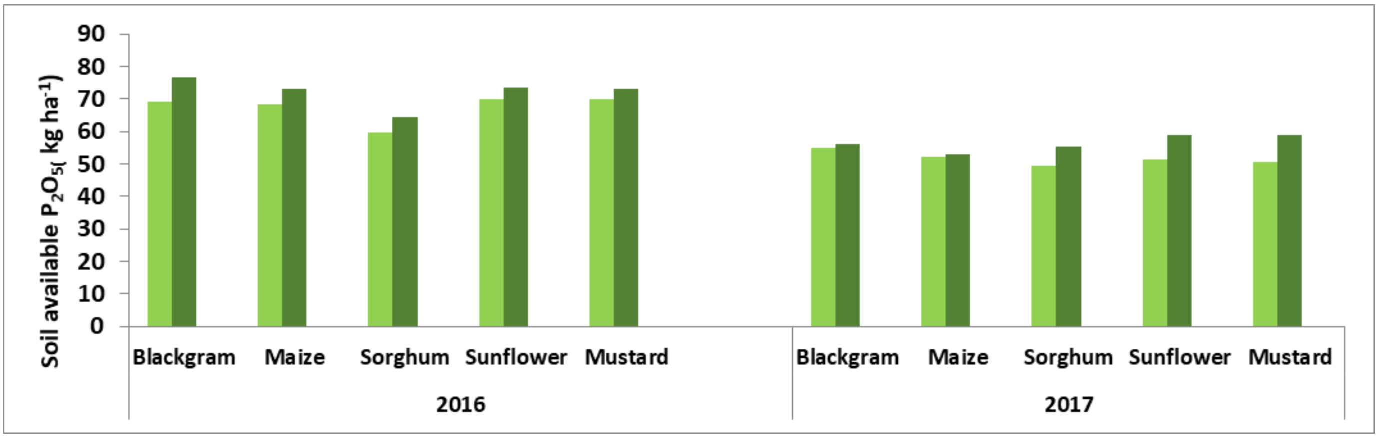
Table 11: Residual effect of INM & cropping systems on soil available copper (mg kg-1) at harvest of *rabi* crops

Treatment	2015-16					Mean	2016-17					Mean
	S_1	S_2	S_3	S_4	S_5		S_1	S_2	S_3	S_4	S_5	
M_1	0.99	0.37	0.39	0.48	0.24	0.49	0.80	0.40	0.58	0.73	0.63	0.62
M_2	1.01	0.58	0.43	0.50	0.79	0.66	0.95	0.63	0.80	0.78	0.77	0.78
Mean	1.00	0.47	0.41	0.49	0.51		0.87	0.51	0.69	0.75	0.70	

	SEm±	CD (p=0.05)	CV (%)		SEm±	CD (p=0.05)	CV (%)
Main plots (M)	0.02	0.13	14.6	Main plots (M)	0.013	0.08	7.5
Sub plots (S)	0.15	NS	6.35	Sub plots (S)	0.037	NS	13.11
Interaction (MXS)	0.21	NS		Interaction (MXS)	0.053	NS	

M_1=100% RDN M_2=50% RDN+25% N-FYM+ 25% N-neem cake + bacterial consortium
S_1=Blackgram S_2=Maize S_3 = Sorghum S_4=Sunflower S_5=Mustard





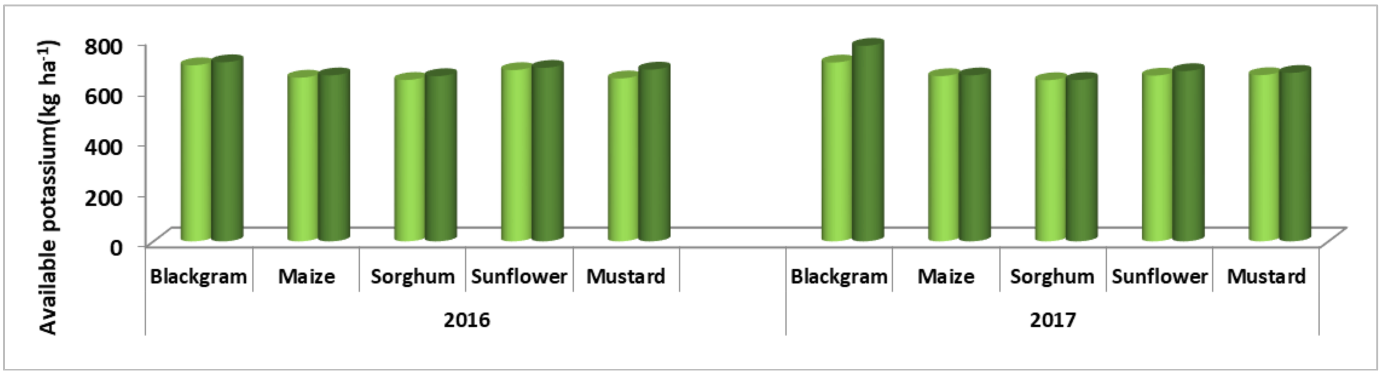


Fig 1: Residual effect of INM & cropping systems on soil available nutrients in soil

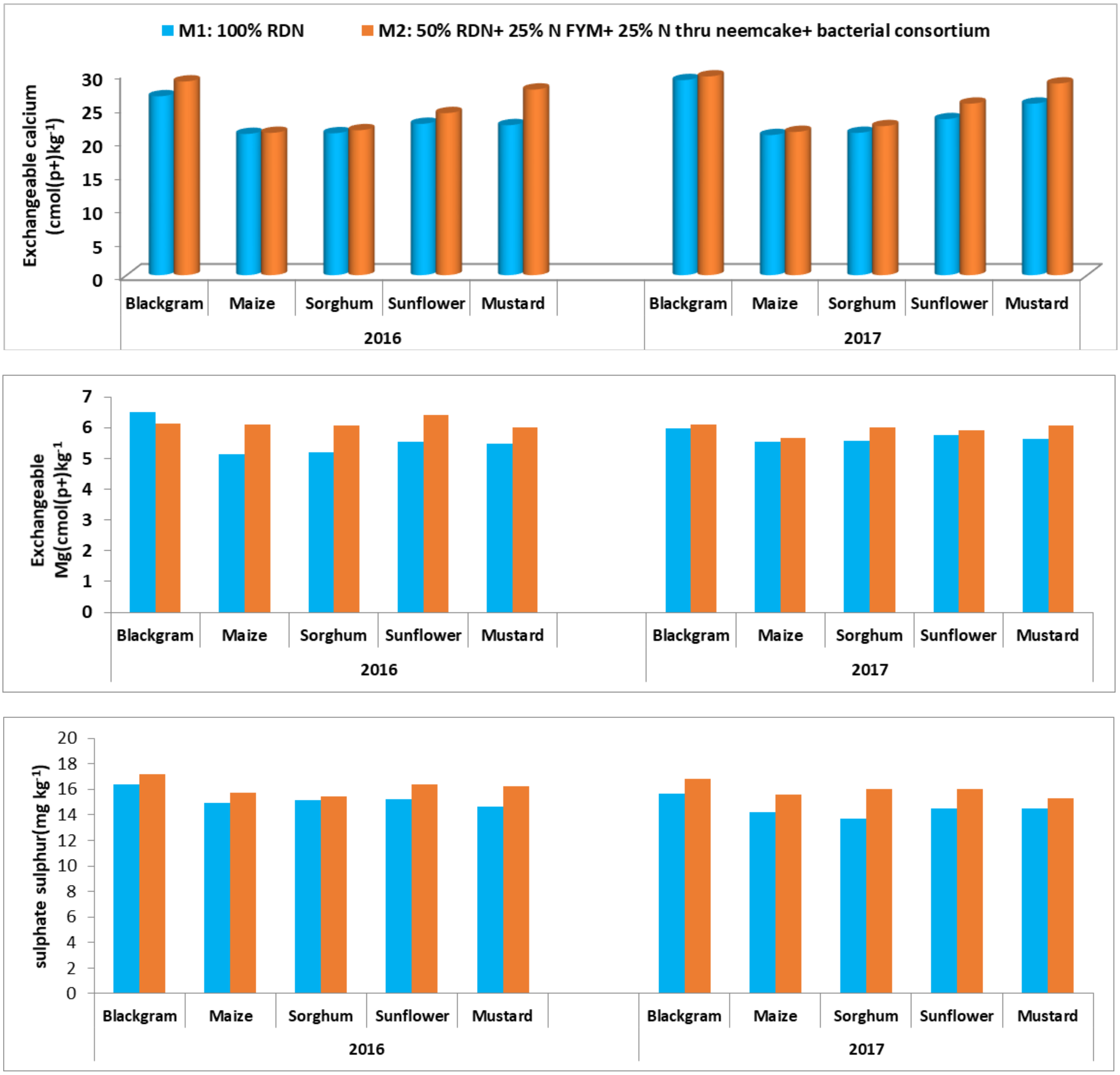


Fig 2: Residual effect of INM & cropping systems on secondary nutrient content in soil

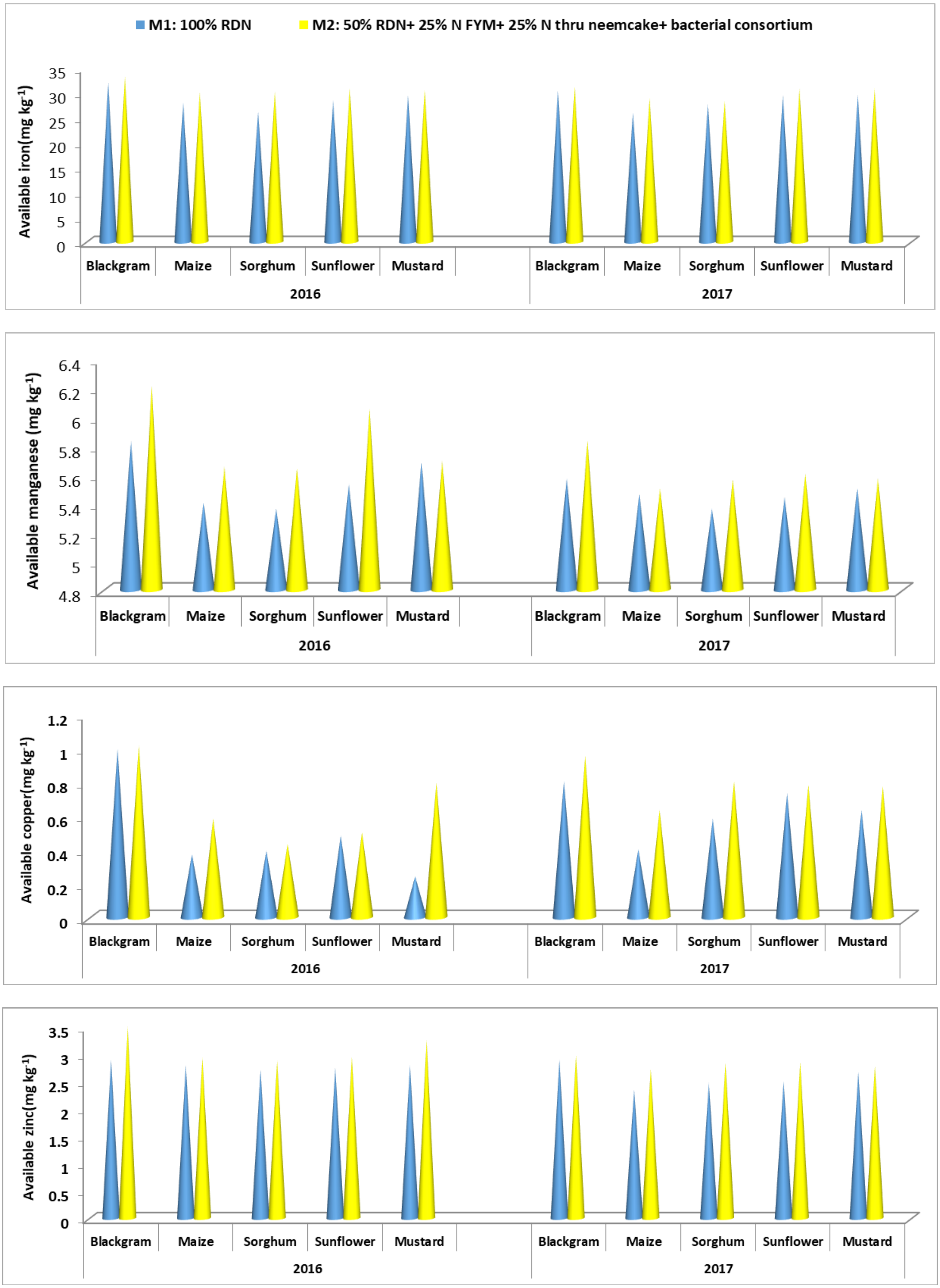


Fig 3: Residual effect of INM & cropping systems on micro- nutrient in soil

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