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Study of mineralization of phosphorus and sulphur from various sources of green manures incorporated in entisol

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Abstract
The laboratory experiment was carried out for 120 days in ambient condition to study mineralization of nitrogen from various sources of green manures, added on the basis of carbon content. Among the various sources of greenmanures the highest amount of total N, P and Fe contents were observed in the Cow pea while the lowest amount of total N, P, K, S, Mn, Zn and Cu contents were recorded in *Subabul*. The lowest C:N ratio (11.97) was recorded in Glyricida. However, the highest C:N ratio (20.89) was noticed in Sunnhemp. The available phosphorus was increased with increase in days after incubation in all the treatments. The maximum cumulative increase of available phosphorus was observed in cowpea while the lowest cumulative available phosphorus was recorded in control treatment. The slightly increased the available phosphorus content with increase in days after incubation in control treatment. The results of sulphur mineralization showed that the soils amended with all the sources of organic manures also increased available sulphur with increase in days after incubation. However, the slightly decrease in available sulphur was noticed in control treatment. A more or less available sulphur content was recorded at 60 and 90 days after incubation. The soils properties viz., pH, EC, calcium carbonate, Ex. Ca, Ex. Mg and all the DTPA extractable micronutrients were significantly not affected due to the incorporation of all the sources of organic manures. However, the addition of all the sources of organic manures significantly improved the organic carbon, available nitrogen and potassium content as compared with control treatment.The results concluded that the addition of Glyricidia is beneficial for improving the sulphur content while cowpea is helpful for improving the available phosphorus content of soil.

Keywords: Green manures, phosphorus, sulphur, C:N ratio

Introduction

Green manuring is an ageold practice of agriculture where crops are incorporated into soil primarily as a soil amendment and as a source of plant nutrients for other crops, which lost importance as the use of mineral fertilizers became widespread. legumes are used as green manures, they fix atmospheric nitrogen and add a lot of organic matter to the soil. Organic matter when they decompose adds macro and micro-nutrients as well as improves the soil organic carbon content. The most effective means of improving natural supply of N and organic matter to the soil is the cultivation of suitable legumes and the in-situ incorporation at an appropriate stage of growth. The suitability of organic material as a sources of N depends to a great extent on its mineralization of N in relation to crop demand. The mineralization of N from crop residues varies with N content and C:N ratio of residue (Pathak and Sarkar 1994) [9].
Green manuring is an agronomic practice whereby a crop is grown and incorporated into the soil at an early stage of development. In temperate conventional and organic cropping system, it has been demonstrated that green manures can be used to improve the retention and supply of nitrogen (N) (Thorup – Kristensen *et al.* 2003; Fowler *et al*. 2004) [6]. The successful use of organic manures, green manures and crop residues as source of nitrogen (N) for crops requires an understanding of the decomposition and mineralization from them. Due to addition of organic matter in soil, the main part of plant demand for P is compensated by mineralization process. The rate of P mineralization is mainly influenced by season, climate, soil condition and C:P ratio of organic matters. Xiao *et al.* (2012) [1] indicated that the distribution and dynamic of P forms in soil can be significantly affected by different biogeochemical properties, e.g., soil moisture, organic matter and clay content.

Sulphur (S) is an essential element for plant and animals and S requirements are similar to those for phosphorus and magnesium. The quantity and pattern of mineralization of soil organic S. According to between 90% and 95% of soil S is stored in organic form linked to a carbon atoms as C-S (carbon bonded sulphate) or C-O / N-S (ester sulphates and sulfamates). The impact of plant residues on S turnover in soil was investigated early on (Barrow, 1960) to predict net mineralization as function of the C:S ratio of the crop residue. Because elements combine in soil organic matter, the C, N and S cycles are interdependent.

Material and Methods

The laboratory experiment was conducted at wire house, Soil Science and Agricultural Chemistry Section, RCSM College of Agriculture, Kolhapur during December 2018- March 2019 under ambient condition.

Soil: Soil samples from 0-15 cm depth were collected randomly before conduct of the experiment to study the physico-chemical properties of soil. Physical and chemical properties of the soil *viz*., sand, silt, clay, textural class, pH, EC, calcium carbonate, organic carbon, available nitrogen, available phosphorus, available potassium, exchangeable calcium, exchangeable magnesium, available sulphur, DTPA extractable micronutrients (Fe, Mn, Zn, Cu) were determined.

Incubation Study: The green manures collected were added on the basis of carbon content @ 1.5 g C Kg^{-1} soil. The 10 kg capacity plastic pots were field with 2 mm sieved, 5 kg entisol soil. Carbon was added through chopped green manures on oven dry weight basis by considering moisture content on fresh weight basis. Chopped green manures and MPKV's decomposing culture @ 2.5 g per 5 kg soil were mixed in soil. Incubation study was carried out for 0, 30, 60, 90 and 120 days for determination of periodical NH_4-N and NO_3-N in Entisol. The moisture was maintained at field capacity level throughout the experiment.

Phosphorus and sulphur Mineralization: The available phosphorus was analysed as per the method described by Olsen *et al.* (1965). The available sulphur analysis was carried out as per the Turbidimetry method described by Williams and Steinbergs (1969).

Results and Discussion

Characterization of Green Manures and their C:N Ratio

The green manure crop *viz.*, Dhaincha, Sunnhemp, Cowpea were collected from field which is harvested at 45 day old and Subabul, Glyricidia and Neem leaves were collected from field sources.

The N concentration in green manure crop residue ranged from 2.01% in sunnhemp to 3.16% in cowpea. Variation in P and K concentration among green manure residue was high ranging from 0.15% in subabul to 0.75% in cowpea and 0.16% in subabul to 4.60% in glyricidia, respectively. The concentration of carbon in the crop residue differed considerably ranging from 33.0% in glyricidia to 52.3% in neem leaves. Concentration of Sulphur was variable ranging from 0.26% in subabul to 0.46% in dhaincha. Concentration of different micronutrients *viz.*, Fe, Mn, Zn and Cu in various crop residues show wide variation. The iron content varied from 0.52 g kg^{-1} in subabul to 1.04 g kg^{-1} in cowpea, similarly Mn ranged from 0.098 g kg^{-1} in subabul to 0.38 g kg^{-1} in glyricidia as well as Zn ranged from 0.094 g kg^{-1} in subabul to 0.30 g kg^{-1} in cowpea and Cu ranged from 0.055 g kg^{-1} in sunnhemp to 0.10 g kg^{-1} in dhaincha.

There was wide variation in C:N ratio of green manure crop residue. The C:N ratio of green manure crop residue varied inversely to their N concentration. The C:N ratio of green manure crop residue differed considerably ranging from 11.97 in glyricidia to 20.89 in sunnhemp. Constatnides and Fowners, (1994) reported the similar results that the green manure crop residue had wider C:N ratio due to their low N concentration

From data in relation to different parameters following decreasing trend was observed :

N concentration : cowpea >dhaincha>subabul> neem leaves >glyricidia>sunnhemp.

Pconcentration : cowpea >sunhhemp>dhiancha>glyricidia> neem leaves >subabul.

S concentration :dhaincha> cowpea >sunnhemp> neem leaves >glyricidia>subabul.

C concentration : neem leaves >dhaincha> cowpea >sunnhemp>subabul>glyricidia.

C:N ratio :sunnhemp> neem leaves >dhaincha> cowpea >subabul>glyricidia

Table 1: Chemical composition of green manuring crops

Green manures	Total N (%)	Total P (%)	Total K (%)	Total S (%)	Total C (%)	C:N Ratio	Micronutrients (mg kg^{-1})			
							Fe	Mn	Zn	Cu
Subabhul	2.85	0.15	0.16	0.26	36.0	12.6	522.7	98.1	94.8	62.02
Glyricidia	2.77	0.28	4.60	0.30	33.0	11.97	902.5	387.8	220.7	99.37
Dhaincha	2.86	0.33	2.07	0.46	43.80	15.03	835.7	231.7	122.9	98.6
Sunnhemp	2.01	0.50	2.0	0.38	42.00	20.89	944.1	226.3	121.6	55.87
Neem leaves	2.83	0.28	1.3	0.32	52.3	18.72	754.3	151.1	122.9	56.02
Cowpea	3.16	0.75	2.10	0.40	42.60	13.48	1041.2	194.5	303.3	75.27

Phosphorus Mineralization

The different green manure crop residues were incorporated in soil @ 1.5 C g kg^{-1} soil. An amount of added P from various sources of green manures was different (Table 2). The change in available P content at different intervals were studied. The data presented in Table 3 and fig 1.

Table 2: Amount of P Addedin Soil through Various Green Manures

Treatments	Amount of P added through green manures (g)
T_1- Subabul	0.031
T_2-Glyricidia	0.063
T_3- Dhaincha	0.056
T_4- Sunnhemp	0.089
T_5- Neem leaves	0.040
T_6- cowpea	0.132

Variation in available P mineralization was noticed among the different treatments (Table 4.7) the soil amended with the green manure crops residues released significantly higher amount of available P throughout the incubation period than that without green manure soil. This was conformity with the observations made by Randhawa *et al*. (2005), they were reported that addition of green manure amendments contributed to an overall increase in soil P availability through enhanced organic P mineralization. Incorporation of green manure into the soil tends to released P slowly and thus prevents adsorption and precipitation as inorganic P fertilizers. Thus, the effect of green manure on phosphorus availability is depend on the C:P ratio of green manures and the soil P status.

Amongst the all treatments of different green manure crop residues highest amount of available P is recorded in T_6 i.e., Cowpea (156.55 mg kg^{-1}), this could be due to high P content and narrower C:P ratio.

Table 3: Mineralization of phosphorus content in soil with various green manures (mgkg^{-1})

Days → / Green Manures ↓	Incubation period (Days)					Cumulative Total
	0	30	60	90	120	
Subabhul	21.73	27.62	28.93	31.74	32.50	142.52
Glyricidia	21.63	29.84	31.98	31.72	33.47	148.64
Dhaincha	21.73	28.34	29.84	30.99	32.80	143.7
Sunnhemp	21.63	31.34	32.06	33.47	34.14	152.64
Neem leaves	21.73	26.91	27.99	31.36	32.18	140.17
Cowpea	21.63	32.06	33.05	34.48	35.53	156.55
Control	21.73	25.02	25.41	26.88	27.62	126.66
SE ±	0.63	0.81	0.68	0.86	0.76	-
CD at 5%	NS	2.5	2.09	2.65	2.34	-

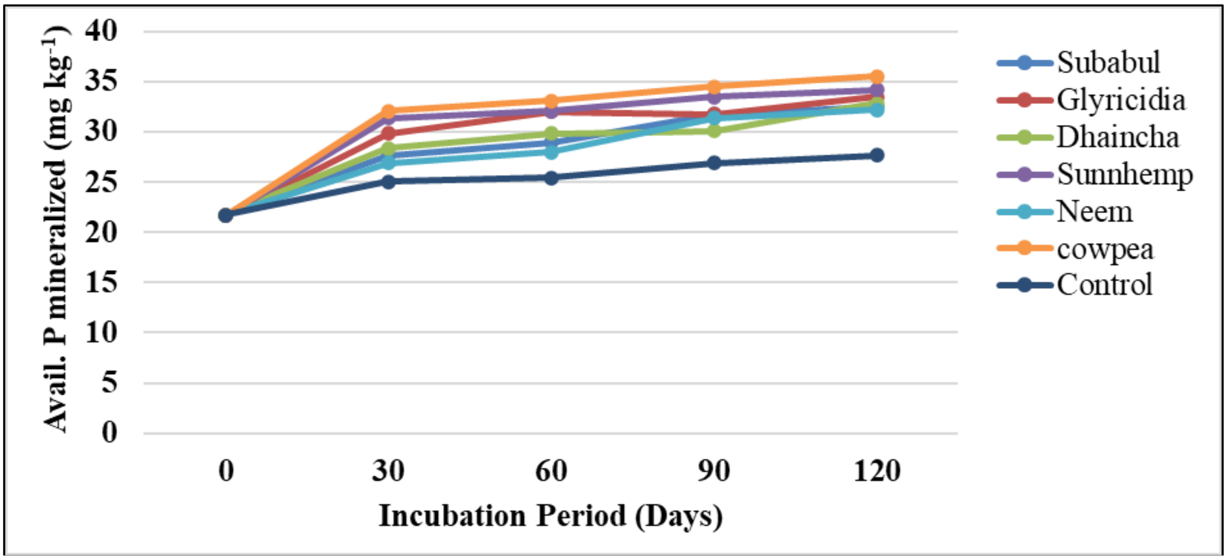

Fig 1: Mineralization of Avail. P in soil from various sources of green manures at different intervals during incubation period.

The next best treatment, regarding highest available P was T_5 (sunnhemp) 152.64 mg kg^{-1}. While was lowest in T_7 (control) 126.66 mg kg^{-1}. The result indicated that the application of green manure residues released higher amount of available P than unamended soil. The mineralization of P from green manures is regulated by the P content of residues. The critical C:P ratio to facilitates mineralization ranges from 55 to 300 (Barrow, 1960).

The release pattern of available P from green manure crop residues amended soil also revealed identical trend but the magnitude of rate of mineralization followed the order: cowpea >sunnhemp>glyricidia>dhaincha>subabul> neem leaves > control. The lowest released available P is noticed in neem leaves amended treatment. The release of P during mineralization of green manure in addition to accumulation to intermediate organic acid complexed metal cations induce the solubilization of native P in soil (Hundal *et al*. 1998). Similarly, Pal and Chand (1993), reported that, increased availability of P with addition of green manure may be due to both carbon dioxide liberation and organic acid produced.

Sulphur Mineralization

The different green manure crop residues were incorporated in soil @ 1.5 C g kg^{-1} soil. An amount of added S from various sources of green manures was different, amount S added through different green manures varied largely according to source of green manuring, the data pertaining to total amount of S being added through green manure is presented in Table 4. The change in available S content at different intervals were studied, the data is presented in Table 5 and depicted in fig 2.

Table 4: Amount of S added in soil through various green manures

Treatments	Amount of S added through green manures (g)
T_1- Subabul	0.054
T_2- Glyricidia	0.090
T_3- Dhaincha	0.034
T_4- Sunnhemp	0.049
T_5- Neem leaves	0.045
T_6- cowpea	0.052

The results revealed that considerable difference in the avail. S mineralization from different green manure crop residues (Table 4.9 and fig 4.5) which might be attributed to difference in chemical composition of green manure crop residue, and their C:S ratio. Organic material having a C:S ratio below 200 are prone to result in mineralization of S (Barrow, 1960).

The soil amended with the various green manures released significantly higher amount of avail. S than that of unamended soil. Treatment T_2 (glyricidia) resulted in significantly superior results in terms of Sulphur mineralization at all the intervals followed by T_1 (subabul). Cumulative S mineralization was found higher due to application of glyricidia, subabul, cowpea (75.98, 67.87 and 63.68 mg kg^{-1}, respectively). This could be due to high amount of added S through green manures and narrower C:S ratio and it also may be due to biological activity. Mineralization of S in soil is largely mediated by biological activity and the work carried out on aerobic and anaerobic soil indicates that S mineralization is control by soil chemical and physical properties and type of organic residue added (Pirela and Tabatabai, 1988).

the S release pattern from green manure residues amended soil also recorded identical trend and rate of mineralization followed the order: glyricidia>subabul> cowpea >sunnhemp>dhaincha> neem leaves > control. Similarly, Reddy *et al*. (2002) reported the total S mineralized in amended soil varied considerably depending on type of organic materials incorporated and soil used. Study clearly indicated the dependence of S mineralization on the C:S ratio and amount of S added through the green manure sources.

Table 5: Mineralization of Sulphur content in soil with various green manures (mg kg^{-1})

Days → / Green Manures ↓	Incubation period (Days)					Cumulative Total
	0	30	60	90	120	
Subabhul	9.06	12.59	14.42	15.22	16.58	67.87
Glyricidia	9.03	14.60	16.64	17.50	18.21	75.98
Dhaincha	9.06	10.38	11.69	12.13	13.13	56.39
Sunnhemp	9.03	11.13	12.31	13.03	14.08	59.58
Neem leaves	9.06	10.05	11.1	11.23	12.1	53.54
Cowpea	9.03	11.61	13.27	14.35	15.42	63.68
Control	9.06	9.67	9.83	9.75	9.52	47.83
SE ±	0.09	0.36	0.41	0.43	0.30	-
CD at 5%	NS	1.09	1.26	1.33	0.93	-

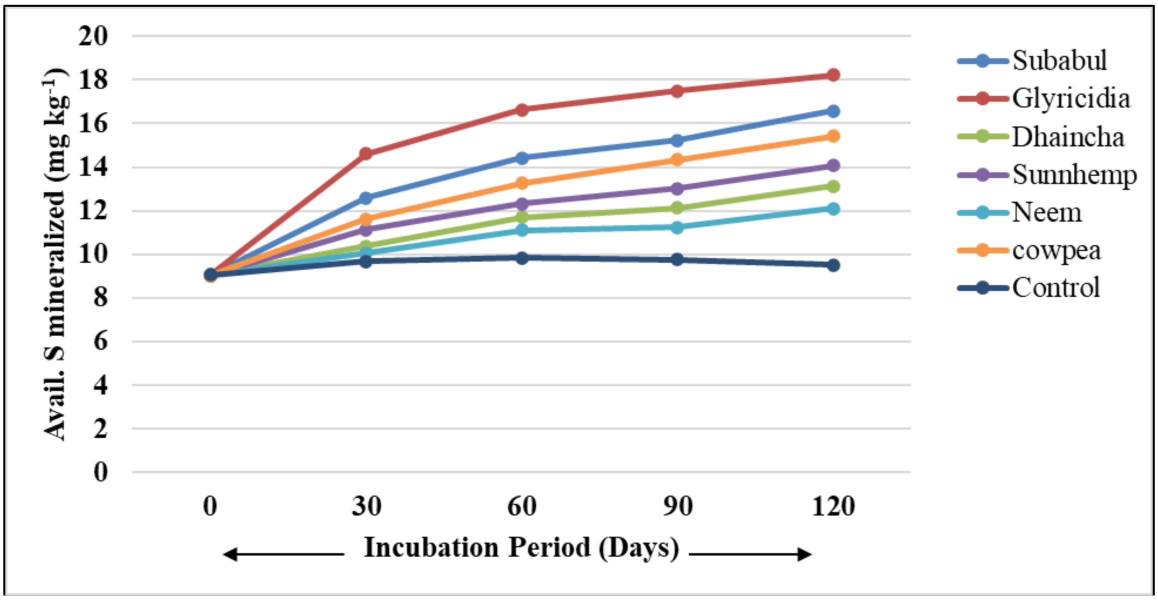

Fig 2: Mineralization of Avail. S in soil from various sources of green manures at different intervals during incubation period.

Conclusion

Among the different sources of green manures cowpea recorded the highest amount of total nitrogen, phosphorus and potassium content. Neem leaves recorded the highest amount of total carbon and glyricidia recorded the narrow C:N ratio. Among the green manures, amended with glyricidia recorded more values for NH_4-N, NO_3-N and (NH_4-N+NO_3-N) throughout the incubation study period over rest of treatments. The rate of NH_4-N, was found fastly increase upto 30 DOI followed by declined upto 60 DOI, then gradual decrease upto 120 DOI. The release pattern of NO_3-N was found maximum upto 30 DOI and constantly decreased upto 60 DOI and then fastly slow down upto 120 DOI.

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