

Original Research Article

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Fertility Status of Major Cropping Systems Existing in Black Soils of Mudhol Taluka of Northern Karnataka, India

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ABSTRACT

Keywords

Soil fertility, Free CaCO₃, Vertisols, Cropping systems, Soil organic-C

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Soil properties are sensitive to changes in the soil environment as influenced by vegetation, climate and inputs and losses of biomass and nutrients. Thus, the cropping systems with different management practices are likely to influence soil properties. Grid based soil survey was conducted in Mudhol to compare the soil fertility status of three major cropping systems namely, sugarcane, groundnut-maize/onion and cereal-pulse systems. Surface composite soil samples representing 143 grids of 4.86 sq km each were analyzed for available major and secondary nutrients and the factors influencing their availability namely, pH, free CaCO₃ and soil organic-C. Among nutrients, available-N, K and S varied significantly among three cropping systems while, available-P, Ca and Mg did not vary significantly. Variations in soil pH as influenced by free CaCO₃ might have reduced phosphorus availability. The soil organic-C was found positively correlated with N-availability in soils. Higher amounts of nutrient (except K) in irrigated cropping systems especially, sugarcane system may be attributed to nutrient and water management practices and high biomass turnovers. Less utilization of soil-K may be the reason for higher K-availability in cereal-pulse cropping systems.

Introduction

Nutrient availability plays an important role in crop production. Availability of nutrients depends on soil, climate, cropping system, management practices etc (Raysschaert *et al.*, 2004). Evaluation of soil fertility thus, serves as one of the most important tool to achieve higher crop yields. Soil tests provide information about nutrient availability upon which the fertilizer recommendations could be made for maximizing crop yields. Maintenance of optimum concentration of

plant nutrient in soil has significant agronomic importance, as they are vital to maintain physiological plant functions. The availability of nutrients is very sensitive to changes in soil environment and they are largely influenced by soil organic matter and soil reaction (Lindsay, 1972). These soil properties are directly influenced by native soil properties and crop management practices. This study was conducted systematically for a Taluka (Block) to assess macronutrients availability in black soil and the factors influencing it.

Materials and Methods

Study area and the cropping systems

Field based soil fertility survey was carried out in Mudhol Taluka (Bagalkot District) of Northern Karnataka. The mean annual temperature (last 10 year) of Mudhol Taluka varied from 30.2 to 32.6 °C. The average annual precipitation was about 447.3 mm and nearly 90 per cent of it was received during monsoon season. The study area was mostly under black soils (> 90 %) and sugarcane, maize/ groundnut - onion and cereal-pulse crops were the predominant cropping systems. The entire study area of Mudhol was divided into smaller grids of 2.25×2.25 km² (sq. km) and each grid was used as a study unit. The dominant cropping system of each grid was identified and a representative location was identified for soil study.

Soil sampling and analyses

The soil samples were collected from the above predetermined representative points. Soil samples were collected from 3 different points at 0-15 cm depth and made into one composite sample. Representative soil samples were air dried, sieved (2 mm) and stored for fertility analysis.

Processed soil samples were analysed for soil pH (1:2.5 soil:water ratio) by pH meter (Model Systronics 361); soil organic matter by wet oxidation method (Walkley and Black, 1934); and free CaCO₃ content by acid titration (Richards, 1954). Among major soil nutrients, alkaline potassium permanganate method for available-N (Subbiah and Asija, 1956); ammonium molybdate complex colorometric method for available - P₂O₅ (Jackson, 1973) and ammonium acetate extractant - flame photometric method for available K₂O (Jackson, 1973) were adopted. The secondary nutrients namely, available-Ca

and Mg (exchangeable) and available-S were determined by versenate titration and turbidometric method respectively (Black, 1965).

Statistical analysis

Finally, these observations were subjected to ANOVA tests for comparison of cropping systems. Correlation tests were also made to assess the influence of pH, free CaCO₃ and Soil organic-C contents on nutrient availability.

Results and Discussion

Availability of major nutrients

The extent of nitrogen, phosphorus and potassium availability among three different cropping systems are given in Table 1 and their mean values are depicted in Figure 1. Among 143 soil samples analysed, more than 2/3rd of the samples (n=101) recorded medium levels of available-N (280-560 kg N ha⁻¹) while, the remaining samples had < 280 kg N ha⁻¹. None of the soil samples were observed in higher availability ranges (> 560 kg N ha⁻¹). Among different cropping systems, the available- N in sugarcane systems (340.74 ± 76.68 kg N ha⁻¹) and maize /groundnut – onion systems (321.96 ± 57.27 kg N ha⁻¹) were found on par with each other and the mean values were found significantly higher than cereal- pulse system (286.4 ± 46.46 kg N ha⁻¹). Higher amounts of available-N in sugarcane and maize/ groundnut-onion based cropping systems may be attributed to application of large amounts of N-fertilizers (Kumar *et al.*, 2014). It may also be higher soil organic-C in these soils at it exhibits strong positive relationship with available-N (Pulakeshi *et al.*, 2012).

In terms of available-P, nearly 1/3rd of soil samples (n=46) recorded lower availability (<

22.9 kg P₂O₅ ha⁻¹) while, half of the soil samples (n = 80) were observed with medium range values (22.9-56.3 kg P₂O₅ ha⁻¹). Only 1/10th of the samples were found in higher availability range (56.3 kg P₂O₅ ha⁻¹). However, the mean available-P₂O₅ contents among different cropping systems did not vary significantly. Minor variations in its availability among different systems may be attributed to phosphorus applications (Freney *et al.*, 1983). Low availability of phosphorus in some soils may be attributed to higher pH. Presence of free CaCO₃ is known to have higher activity of calcium in soil solution and induce precipitation of added-P into di-calcium phosphates and Octa-calcium phosphates (Mortvedt *et al.*, 2000).

Nearly 2/3rd of the samples (n=93) were recorded in higher potassium ranges (>336 kg K₂O ha⁻¹) while, 1/3rd of the samples showed medium availability range (144-336 kg K₂O ha⁻¹). None of the soil samples were observed in lower ranges (<144 kg K₂O ha⁻¹). Among different cropping systems, the available potassium contents varied significantly in the order: cereal-pulse system (407.01 ± 44.80 kg K₂O ha⁻¹) > sugarcane (357.01 ± 84.48 kg K₂O ha⁻¹) > maize / groundnut - onion cropping systems (321.86 ± 90.09 kg K₂O ha⁻¹). Inherent abilities of black soils for high K contents associated with low crop uptake in dry land areas might be the reasons for their higher availability compared to higher uptake in other cropping systems with irrigations (Raysschaert *et al.*, 2004).

Availability of secondary nutrients

The extent of available secondary nutrient status among different cropping systems is presented in Table 1 and their respective mean values are depicted in Figure 2. Nearly 3/4th of soils of Mudhol taluka were observed with higher available-Ca (> 32.0 meq 100g⁻¹) and available-Mg (> 8.0 meq 100g⁻¹) contents.

However, these nutrient mean values did not differ significantly among three cropping systems studied. The arid conditions prevailing in Mudhol and occurrence of free CaCO₃ might have caused higher availability in all the systems. Similar observations on higher Ca and Mg contents in Rajasthan are reported (Dhir *et al.*, 1979).

The amount of available sulphur in soils ranged from 5.84 to 55.75 ppm. In terms of its availability, nearly 50% of the soil samples were observed in lower range (<10ppm-S). Interestingly, 1/3rd of the soil samples from sugarcane cropping system were recorded in higher range (>20 ppm-S). Among different cropping systems, sugarcane (20.84 ± 14.76 ppm-S) and maize / groundnut – onion system (18.01 ± 14.58 ppm-S) recorded higher sulphur contents compared to cereal – pulse cropping systems (12.05 ± 6.81 ppm-S). Application of sulphur containing fertilizer nutrients such as MgSO₄ and (NH₄)₂SO₄ in sugarcane and use of CaSO₄, MgSO₄ and elemental-S in maize- ground nut/ onion systems might have caused higher sulphur availability (Balanagoudar and Satyanarayana, 1990).

Factors influencing soil fertility

The presence of free CaCO₃ and Soil organic-C are likely to influence nutrient availability (Rahmatullah *et al.*, 1994). The experimental data indicated a strong positive relationship between soil organic-C and available-N (Figure 3; R² = 0.294*). The soil organic-C is considered as nutrient store house and it also has complimentary effects by chelation of metal ions (Pulakeshi *et al.*, 2012). Similar reports of higher available-N among different land use systems with increase in soil organic-C are reported in irrigated cropping systems (Punith Raj *et al.*, 2012). The presence of free CaCO₃ showed significant negative effects on available phosphorus (R² = 0.229*).

Table.1 Extent of major and secondary nutrient availability among different cropping systems

Cropping System	Number of samples with different availability ranges <i>w.r.t.</i>								
	Nitrogen (kg N ha ⁻¹)			Phosphorus (kg P ₂ O ₅ ha ⁻¹)			Potassium (kg K ₂ O ha ⁻¹)		
	Low < 280	Medium 280 – 560	High > 560	Low < 22.9	Medium 22.9 - 56.3	High > 56.3	Low < 144	Medium 144 - 336	High > 336
Cereal-Pulse (n = 16)	7 (4.89)	9 (6.10)	0 (0.00)	6 (4.19)	10 (6.99)	0 (0.00)	0 (0.00)	1 (0.69)	15 (10.48)
Maize /G nut - Onion (n = 5)	1 (0.69)	4 (2.71)	0 (0.00)	2 (1.39)	3 (2.09)	0 (0.00)	0 (0.00)	3 (2.09)	2 (1.39)
Sugarcane (n = 122)	28 (19.58)	94 (65.72)	0 (0.00)	38 (26.56)	67 (46.84)	17 (11.80)	0 (0.00)	46 (30.92)	76 (54.31)
Total (n=143)	42 (29.37)	101 (70.62)	0 (0.00)	46 (32.16)	80 (55.94)	17 (11.88)	0 (0.00)	52 (34.96)	93 (65.03)
	Number of samples with different availability ranges <i>w.r.t.</i>								
Cropping System	Calcium (meq 100g ⁻¹)			Magnesium (meq 100g ⁻¹)			Sulphur (mg kg ⁻¹)		
	Low < 24.0	Medium 24.0 - 32.0	High > 32.0	Low < 6.0	Medium 6.0 - 8.0	High > 8.0	Low < 10	Medium 10 - 20	High > 20
Cereal-Pulse (n = 16)	0 (0.00)	1 (0.69)	15 (10.48)	0 (0.00)	0 (0.00)	16 (11.18)	9 (6.29)	5 (3.49)	2 (1.39)
Maize /G nut - Onion (n = 5)	0 (0.00)	3 (2.09)	3 (2.09)	0 (0.00)	1 (0.69)	4 (2.79)	3 (2.09)	0 (0.00)	2 (1.69)
Sugarcane (n = 122)	0 (0.00)	33 (23.07)	88 (61.53)	4 (2.79)	20 (13.98)	98 (68.52)	54 (37.75)	22 (15.38)	46 (32.16)
Total (n=143)	0 (0.00)	37 (25.87)	106 (74.12)	4 (2.79)	21 (14.68)	118 (82.51)	66 (46.15)	27 (18.88)	50 (34.96)

Fig.1 Available major nutrient status among different cropping systems

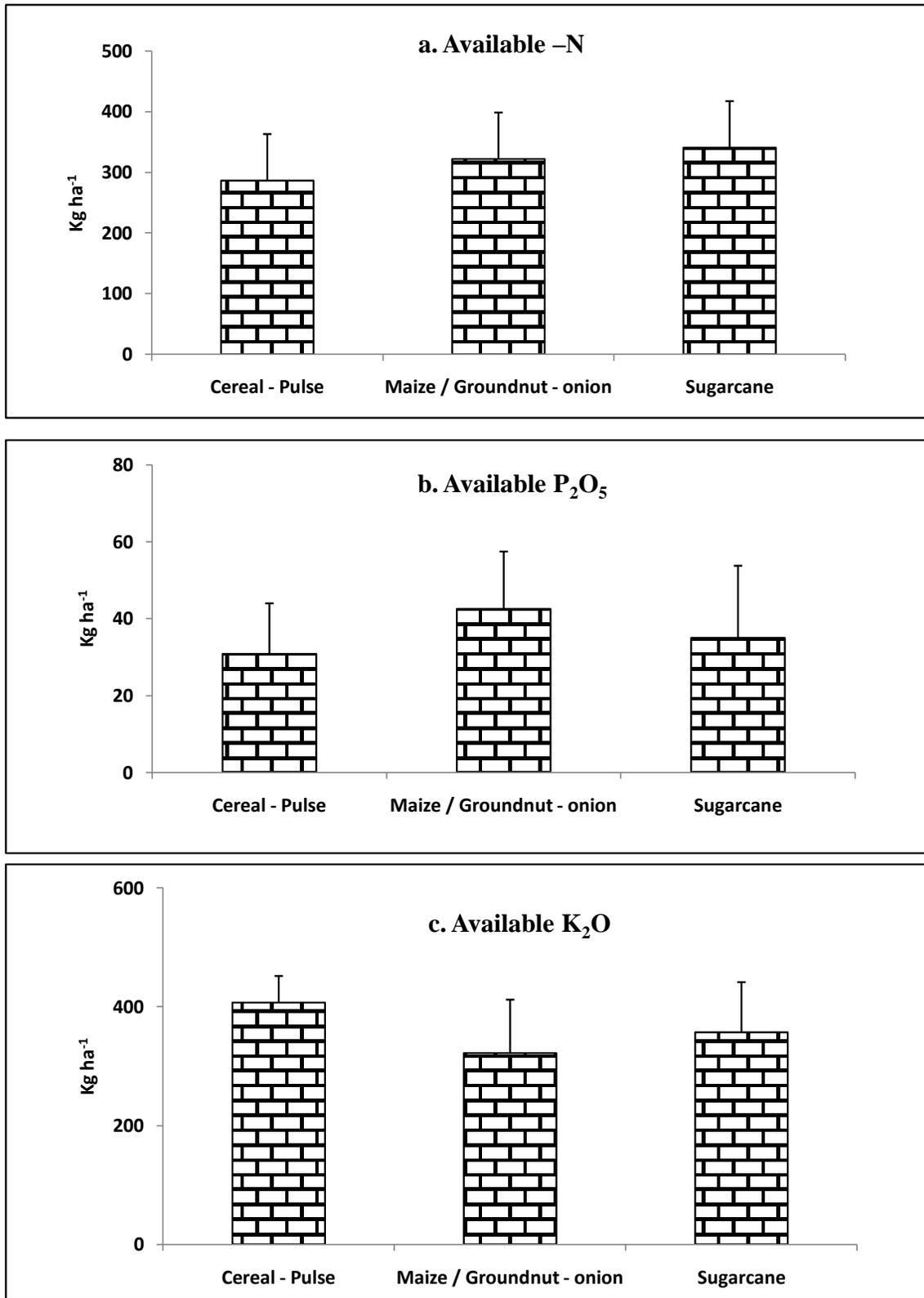


Fig.2 Available secondary nutrient status among different cropping systems

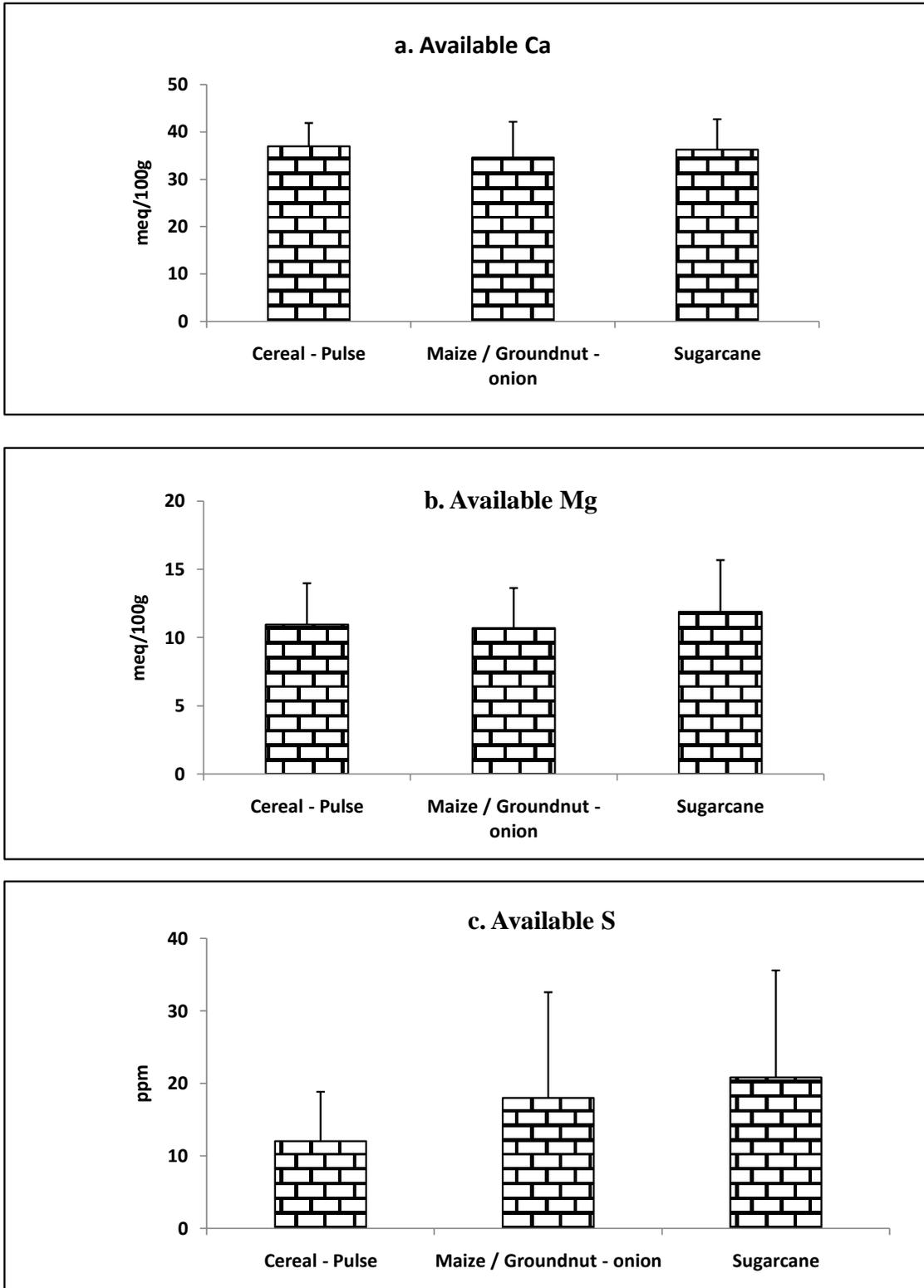
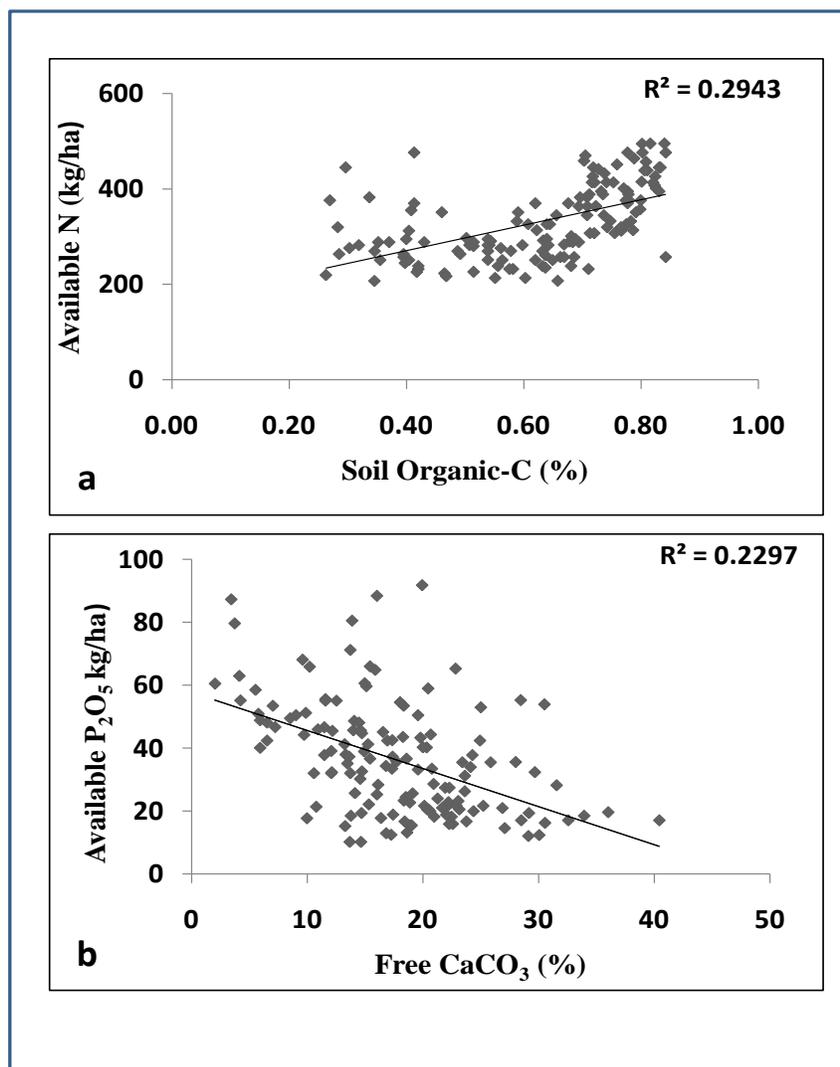


Fig.3 Relationship between a. Soil Organic-C (%) and available-N (kg/ha) and b. Free CaCO₃ (in %) and available-P₂O₅ (kg ha⁻¹)



Higher amounts of free CaCO₃ are known to increase soil pH and induce higher Ca-activity and hence, fixation of added phosphorus into insoluble forms (Mortvedt *et al.*, 2000). The study indicated that intensive cropping systems with high biomass turnovers are likely to exhibit higher nutrient availability.

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