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Effect of long term integrated nutrient management on carbon pools and their relationship with yield of cotton + greengram (1:1) intercropping system in Vertisols

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Abstract
A field study was conducted during *kharif* 2018 at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra to assess the long term effect of integrated nutrient management on carbon pools and yield of cotton+greengram(1:1) intercropping system in Vertisols. The eight treatments replicated three times in randomized block design comprised of control, 50% and 100% RDF, 50% N ha^{-1} through gliricidia/FYM, 50% N fertilizers + 50% N ha^{-1} gliricidia/FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers and 100% N ha^{-1} gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers.The results after 32nd cycle indicated that application of 50% RDN through FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics recorded higher cotton+greengram yield and was on par with the application of 50% N through gliricidia + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers.However, the significant improvement in carbon pools was recorded with application of 50% N through gliricidia + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers and was on par with 50% RDN through FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics. Among the various carbon pools, the labile and less labile carbon pool was highly correlated with yield of crops. Hence, it is concluded that conjunctive application of 50% N through FYM/gliricidia in combination with + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers resulted in improvement in carbon pools and yield of cotton+greengram grown in Vertisols under rainfed conditions.

Keywords: Carbon pools, integrated nutrient management, Vertisols

Introduction

Cotton (*Gossypium spp.*) is an important cash crop globally known as “king of fiber” and play vital role in the economy of farmers as well as the country and is popularly known as “white gold”. It is a fiber crop originated in India and belongs to *Malvaceae* family. Among different species of cotton *Gossypium hirsutum* and *Gossypium arboreum* are commonly grown in Maharashtra and used in textile industries for manufacture of cloth.

Greengram (*Vigna radiata*) is an important pulse crop believed to be originated from India. Greengram commonly known as mung, is also known as “golden gram” and it contains 20-25% protein, 1.3% fat, 3.5% minerals, 4.1% fiber and 56.7% carbohydrate. It is cultivated in variety of soils from red lateritic to black cotton soil. More than 70% of world’s greengram production comes from India.

The organic carbon is present in different fractions or pools in soil such as active pool, passive pool and slow pool etc. The active pool of C consists of labile or easily decomposed material and half-life of this pool is only a few days to one year. Organic matter in this pool has relatively high average C/N ratio (about 15-30) and included such organic matter fractions as living biomass, tiny pieces of detritus (POM), most of the polysaccharides and other non-humic substances. Active pool provides most of the readily accessible food for microbes and most of the readily mineralizable nitrogen. It can be readily increased by addition of fresh plant and animal residues into the soil and readily loss occurs if such additions are reduced or tillage is intensified. This pool rarely comprises > 10-20% of total soil organic matter. The slow pool of soil organic carbon has intermediate properties between the active and passive pools. Probably includes the finest fraction of particulate organic matter that are high in lignin and other slowly decomposable and chemically resistant components, half-life is typically measured in decades. This pool is an important source of mineralizable N and other plant nutrients as well as also responsible for structure stability, lead to enhance infiltration, resistance to erosion and ease of tillage practices. It also probably makes some contribution to the effects associated primarily with active and passive pools.

Integrated plant nutrient management enhances the crop productivity and improves the soil physical, chemical as well as biological properties. The chemical properties namely organic carbon content and available nutrients enhances with the application of crop residues supplemented with chemical fertilizers. Long term fertilizer experiments have shown that the integrated use of organic manures and chemical fertilizers can maintain high productivity and sustainable crop production. The application of FYM, compost and crop residues effectively maintain the soil organic matter.

The present study was carried out to study the long term effect of FYM/gliricidia green leaf manuring and inorganic fertilizer application on organic carbon pools and productivity of cotton+greengram intercropping system in Vertisols.

Materials and Methods

A field experiment conducted on Vertisols was initiated on the research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola since 1987-1988. The present study was undertaken during 2018-19 with the cotton + greengam (1:1) intercropping system. The eight treatments replicated three times in randomized block design comprised of control, 50% and 100% RDF, 50% N ha^{-1} through gliricidia/FYM, 50% N fertilizers + 50% N ha^{-1} gliricidia/FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers and 100% N ha^{-1} gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers.

Soil organic carbon (SOC) was determined by modified Walkley and Black (1934) using 36 N H_2SO_4 implying the recovery factor of 1.298 represents the total SOC pool. This fraction was sub-fractionated into four different pools namely very labile (pool I: C_{VL}), labile (pool II: C_L), less labile (pool III: C_{LL}) and non labile (pool IV: C_{NL}) using 5, 10 and 20 ml of concentrated (36.0 *N*) H_2SO_4 that resulted in three acid-aqueous solution ratios of 0.5:1, 1:1 and 2:1 (corresponding to 12.0, 18.0 and 24.0 *N* of H_2SO_4, respectively). The amount of C, thus determined allowed the differentiation of total soil organic carbon into the following four different pools, according to their decreasing order of oxidizability.

Pool I (CVL very labile): Organic C oxidizable by 12.0 N H2SO4

Pool II (CL labile): The difference in C oxidizable by 18.0 N and that by 12.0 N H2SO4

Pool III (CLL less labile): The difference in Ctot oxidizable by 24.0 N and that by 18.0 N H2SO4

Pool IV (CNL non labile): The difference between C and oxidizable by 24.0 N H2SO4.

The pool I and II together represent the active pool [active pool = Σ (pool I + pool II)] while pool III and pool IV together constitute the passive pool [Passive pool = Σ (pool III + pool IV)] of organic C in soils (Chan *et al*. 2001) [1].

Results and Discussion

Yield of cotton

The yield of cotton in cotton+greengram(1:1) intercropping system is presented in (Table 1). The mean seed cotton yield ranged between 601.2 to 968.9 kg ha^{-1}. Long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) recorded higher seed cotton yield (968.9 kg ha^{-1}) and was on par with the application of 50% N through gliricidia + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers (T_6) and application of 100% RDF (T_2).The increase in seed cotton yield with long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) was 61% and 15% higher as compared to control (T_1) and 100% RDF (T_2) treatments respectively. The lowest seed cotton yield (601 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

Table 1: Effect of long term INM treatments on cotton and greengram yield

Treatments		Cotton yield (kg ha^{-1})		Greengram yield (kg ha^{-1})		SCEY (kg ha^{-1})
		Seed cotton	Stalk	Grain	Straw	
T_1	Control	601.2	1301.0	361.0	176.4	882.0
T_2	100% RDF	841.7	1794.0	465.8	213.0	1204.0
T_3	50% RDF	691.7	1553.5	392.8	192.6	997.2
T_4	50% N ha^{-1}gliricidia	634.8	1413.3	369.6	182.7	922.3
T_5	50% N ha^{-1} FYM	686.5	1441.6	357.3	186.5	964.4
T_6	50% N fertilizers + 50% N ha^{-1} gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	904.2	1902.4	503.2	211.3	1295.6
T_7	50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	968.9	2034.7	536.8	217.7	1386.5
T_8	100% N ha^{-1}gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	770.6	1641.7	402.2	194.0	1083.4
SE (m) ±		48.8	91.3	36.2	7.6	53.9
CD at 5%		145.1	271.2	107.5	22.7	160.3

The mean cotton stalk yield ranged from 1301.0 to 2034.7 kg ha^{-1} and significantly higher cotton stalk yield (2034.7 kg ha^{-1}) was recorded with long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) and was on par with the application of 50% N through gliricidia + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers (T_6) and application of 100% RDF (T_2).The increase in cotton stalk yield with long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) was 56% and 13% higher as compared to control (T_1) and 100% RDF (T_2) treatments respectively. The lowest cotton stalk yield (1301.0 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

Higher cotton yield with conjunctive application of FYM and gliricidia green leaf manure along with chemical fertilizers may be due to balanced supply of nutrients to the crop throughout the crop growth period. Green leaf manure undergo decomposition during which series of nutrient transformation takes place which helps in their higher availability to the crops and higher uptake of nutrients by the crops will result in higher yield.

Yield of greengram

The yield of greengram in cotton+greengram intercropping system is presented in (Table 1). The greengram grain yield ranged between 361.0 to 536.8 kg ha^{-1}. Long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) recorded higher greengram grain yield (536.8 kg ha^{-1}) and was on par with the application of 50% N through gliricidia + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers (T_6) and application of 100% RDF (T_2).The increase in greengram grain yield with long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) was 48% and 15% higher as compared to control (T_1) and 100% RDF (T_2) treatments respectively. The lowest greengram grain yield (361kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

The greengram straw yield ranged between 176.4 to 217.7 kg ha^{-1}. Long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) recorded higher greengram straw yield (217.7 kg ha^{-1}) and was on par with the application of 50% N through gliricidia + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers (T_6) and application of 100% RDF (T_2).The increase in greengram straw yield with long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) was 23% and 2% higher as compared to control (T_1) and 100% RDF (T_2) treatments respectively. The lowest greengram grain yield (176.4kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

Higher greengram yield with conjunctive application of FYM and gliricidia green leaf manure along with chemical fertilizers may be due to balanced supply of nutrients to the crop throughout the crop growth period. Green leaf manure undergo decomposition during which series of nutrient transformation takes place which helps in their higher availability to the crops and higher uptake of nutrients by the crops will result in higher yield.

Seed cotton equivalent yield

The seed cotton equivalent yield in cotton+greengram intercropping system is presented in Table 1. The seed cotton equivalent yield (SCEY) ranged between 882.0 to 1386.5 kg ha^{-1}. Long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) recorded higher seed cotton equivalent yield (1386.5 kg ha^{-1}) and was on par with the application of 50% N through gliricidia + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers (T_6).The increase in seed cotton equivalent yield with long term application of 50% RDN through organic source *i.e.* FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O ha^{-1} through inorganics (T_7) was 57% and 15% higher as compared to control (T_1) and 100% RDF (T_2) treatments respectively. The lowest seed cotton equivalent yield (882 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

Higher seed cotton equivalent yield with conjunctive application of FYM and gliricidia green leaf manure along with chemical fertilizers may be due to balanced supply of nutrients to the crop throughout the crop growth period. Green leaf manure undergo decomposition during which series of nutrient transformation takes place which helps in their higher availability to the crops and higher uptake of nutrients by the crops will result in higher yield.

In general, the increase in yield of cotton and greengram was recorded with conjunctive application of FYM and gliricidia green leaf manure along with chemical fertilizers. Similar observations were recorded by Deshpande and Patil (2007) [3]., Rao and Janawade (2009) [8] and Simon *et al.* (2016). [9]

Organic carbon pools in soil

Very labile carbon

The very labile carbon content of soil as influenced by different treatments was statistically significant and it ranged from 0.99 to 2.50 g kg^{-1} indicating that the highest very labile carbon (2.50 g kg^{-1}) was recorded with the application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_6) and it was found to be on par with the application of 50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_7) under the long term fertilizer experiment where the integrated nutrient management was followed (Table 2). It was observed that 1.51 g kg^{-1} and 1.15 g kg^{-1} increase in very labile carbon content was recorded with application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_6) as compared to control (T_1) and 100% RDF (T_2).This may be due to long term application of FYM and green leaf manure since last 32 years, which has resulted into significant increase in the very labile carbon pool. Similarly, it was reported by Das *et al*. (2016) [2] that NPK+FYM or NPK+ greengram residue + FYM treatment encouraged the accumulation of very labile carbon pool.

The lower value (0.99 g kg^{-1}) of very labile carbon was found in treatment T_1 *i.e.* control due to comparatively lower addition of biomass. However, the intercropping of greengram has been observed to contribute to pools of organic carbon.

Labile carbon

The labile carbon content of soil as influenced by different treatments was statistically significant (Table 2) and it ranged from 0.42 to 0.94 g kg^{-1} indicating that the highest labile carbon (0.94 g kg^{-1}) was recorded with the application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_6) and it was found to be on par with the application of 50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_7) under the long term fertilizer experiment where the integrated nutrient management was followed. The increase in labile carbon content was 0.52 g kg^{-1} and 0.42 g kg^{-1} higher with application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_6) as compared to control (T_1) and 100% RDF (T_2).This may be due to long term application of FYM and green leaf manure since last 32 years, which has resulted into significant increase in the labile carbon pool. Labile soil organic carbon is considered as the readily accessible source of microorganisms which turns over rapidly and has direct impact on nutrient supply. Labile soil organic carbon pool generally includes light fraction of organic matter and microbial biomass. The significant increase in labile carbon under integrated nutrient management system indicated its superiority over the management by organic and chemical fertilizer alone in sustaining crop productivity. Similar observations were also reported by Das *et al*. (2016) [2] and Kumar *et al*. (2018) [4]

that NPK+FYM or NPK+ greengram residue +FYM treatment encouraged the accumulation of labile carbon pool. The lower value (0.42 kg^{-1}) of labile carbon was found in treatment T_1 *i.e.* control due to comparatively lower addition of biomass. However, the intercropping of greengram has been observed to contribute to pools of organic carbon.

Table 2: Long term effect of INM on soil organic carbon pools

Treatments		Very labile (g kg^{-1})	Labile (g kg^{-1})	Less Labile (g kg^{-1})	Non Labile (g kg^{-1})	Total SOC (g kg^{-1})
T_1	Control	0.99	0.42	0.31	2.67	4.39
T_2	100% RDF	1.35	0.52	0.47	3.04	5.38
T_3	50% RDF	1.04	0.47	0.36	2.91	4.79
T_4	50% N ha^{-1} gliricidia	1.09	0.52	0.47	3.46	5.54
T_5	50% N ha^{-1} FYM	2.19	0.57	0.52	3.66	6.93
T_6	50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	2.50	0.94	0.78	4.38	8.60
T_7	50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	2.45	0.89	0.68	4.10	8.13
T_8	100% N ha^{-1} gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	2.03	0.78	0.68	4.01	7.44
SE(m)±		0.05	0.04	0.03	0.08	1.29
CD at 5%		0.14	0.11	0.10	0.23	NS

Less labile carbon

The less labile carbon content of soil (Table 2) as influenced by different treatments was statistically significant and it ranged from 0.31 to 0.78 g kg^{-1} indicating that the highest less labile carbon (0.78 g kg^{-1}) was recorded with the application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_6) and it was found to be on par with the application of 50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_7) under the long term fertilizer experiment where the integrated nutrient management was followed. The increase in less labile carbon content was 0.47 g kg^{-1} and 0.31 g kg^{-1} higher with application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_6) as compared to control (T_1) and 100% RDF (T_2).This may be due to long term application of FYM and green leaf manure, which has resulted into significant increase in the less labile carbon pool. Similar observations were also reported by Nath *et al*. (2015) [7], Das *et al*. (2016) [2] and Mundhe *et.al* (2018) [6].

The lower value (0.31 g kg^{-1}) of less labile carbon was found in treatment T_1 *i.e.* control due to comparatively lower addition of biomass. However, the intercropping of greengram has been observed to contribute to pools of organic carbon.

Non labile carbon

The non labile carbon content of soil as influenced by different treatments was statistically significant (Table 2) and it ranged from 2.67 to 4.38 g kg^{-1} indicating that the highest non labile carbon (4.38 g kg^{-1}) was recorded with the application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_6) and it was found to be on par with the application of 50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_7) and 100% N ha^{-1} gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers (T_8) under long term integrated nutrient management. It was noted that 1.71 g kg^{-1} and 1.34 g kg^{-1} increase in non labile carbon content was recorded with application of 50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers(T_6) as compared to control (T_1) and 100% RDF (T_2). This may be due to the largest effect of NPK+FYM treatment on less labile and non labile fraction, may be attributed to the higher lignin and poly-phenol content of FYM that could lead to formation of more stable complex with protein of plant origin and thus made FYM-C more resistant to decomposition resulting higher proportion of the total carbon and passive pools. Similar findings were reported by Nath *et al*. (2015) [7], Das *et al*. (2016) [2] and Mundhe *et al.* (2018) [6].

The lower value of non labile carbon (2.67 g kg^{-1}) was found in treatment T_1 *i.e.* control due to comparatively lower addition of biomass. However, the intercropping of greengram has been observed to contribute to pools of organic carbon.

The total soil organic carbon content of soil as influenced by different treatments was found to be non significant (Table 2) and it ranged from 4.39 to 8.60 g kg^{-1} indicating that the numerically higher total soil organic carbon content (8.60 g kg^{-1}) was recorded with the application of 50% N fertilizers + 50% N gliricidia + 100% P_2O_5 + 100% K_2O ha^{-1} fertilizers (T_6) followed by with the application of 50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5 + 100% K_2O ha^{-1} fertilizers (T_7).

Contribution of different soil organic carbon fractions to TOC

The contribution of non-labile carbon pool to the total soil organic carbon was higher and total soil organic carbon varied from 50.49 to 62.42% under various treatments(Table 3). Among all the pools, less labile carbon pool contributed less. The contribution made by very labile and labile pools was more or less similar.

The abundance of four soil organic carbon fractions was in the order non labile carbon (56.09%) >very labile carbon (25.88%) > labile carbon (9.86%) > less labile carbon (8.16%).

Table 3: Contribution of different soil organic carbon fractions to TOC

Treatments		Very labile pool (%)	Labile pool (%)	Less Labile pool (%)	Non Labile pool (%)
T_1	Control	22.57	9.50	7.07	60.87
T_2	100% RDF	25.05	9.67	8.74	56.54
T_3	50% RDF	21.80	9.82	7.52	60.86
T_4	50% N ha^{-1} gliricidia	19.66	9.44	8.84	62.42

T_5	50% N ha^{-1} FYM	31.55	8.18	7.50	52.77
T_6	50% N fertilizers + 50% N gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	29.06	10.93	9.10	50.91
T_7	50% N fertilizers + 50% N ha^{-1} FYM + 100% P_2O_5+ 100% K_2O ha^{-1} fertilizers	30.15	10.95	8.41	50.49
T_8	100% N ha^{-1} gliricidia + 100% P_2O_5 + 100% K_2O ha^{-1} fertilizers	27.23	10.43	8.46	53.87
Average		25.88	9.86	8.16	56.09
		Active pool = 35.74		Passive pool = 64.25	

Correlation among crop yield and various carbon pools

The data on correlation among crop yield and various carbon pools are presented in Table 4.The greengram grain yield was positively correlated with all the carbon pools. The coefficient of correlation ranged between 0.281 to 0.617**. The less labile pool(r=0.617**) was highly correlated with greengram grain yield indicating influence of this pool on greengram grain yield.

The seed cotton yield was significantly and positively correlated with all the carbon pools. The coefficient of correlation ranged between 0.581 to 0.688**. The labile carbon pool (r=0.688**) was highly correlated with seed cotton yield indicating influence of this pool on seed cotton yield.

Table 4: Correlation among crop yield and various carbon pools

	Green gram yield	Seed cotton yield	Seed cotton equivalent yield
Yield	1.000	1.000	1.000
VL	0.483*	0.648**	0.653**
L	0.573*	0.688**	0.715**
LL	0.617**	0.668**	0.715**
NL	0.464*	0.581*	0.596*
TOC	0.281	0.676**	0.605**

* Significant at 5% level of significance

** Significant at 1% level of significance

The seed cotton equivalent yield was significantly and positively correlated with all the carbon pools. The coefficient of correlation ranged between 0.596 to 0.715**.The labile and less labile carbon pool (r=0.715**) was highly correlated with seed cotton equivalent yield indicating influence of this pool on seed cotton equivalent yield.

Correlation among various carbon pools

The correlation among various carbon pools (Table 5) indicated that, all the carbon pools showed significant and positive correlation with very labile pool indicating rapid establishment of equilibrium between these forms. Comparatively high degree of correlation of less labile pool with non labile pool (r=0.936**) followed by labile carbon pool with non labile carbon pool (r=0.904**) showed the rapid establishment of equilibrium between these forms.Similar type of correlation was reported by Liang *et al.* (2012) [5], Venkatesh *et al.* (2013) [10] and Nath *et al.* (2015) [7].

Table 5: Correlation among various carbon pools

	VL	L	LL	NL	TOC
Yield					
VL	1.000				
L	0.852**	1.000			
LL	0.870**	0.881**	1.000		
NL	0.896**	0.904**	0.936**	1.000	
TOC	0.618**	0.565*	0.585*	0.567*	1.000

* Significant at 5% level of significance

** Significant at 1% level of significance

Conclusion

In view of the above, it is concluded that conjunctive application of 50% N through FYM/gliricidia in combination with + 50% N +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers resulted in improvement in soil fertility, carbon pools and yield of cotton + greengram grown in Vertisols under rainfed conditions.

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