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Effect of organic and inorganic fertilizer application on different carbon fractions under soybean-vegetable system in a vertisol

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Abstract
Soil Organic Carbon (SOC) is a very crucial element in soil fertility and productivity. It is found in the soil in the forms of labile and non-labile. The labile form contains three fractions that are $frac_1$ (very labile carbon), $frac_2$ (labile carbon) and $frac_3$ (less labile carbon), and $frac_4$ of the carbon is non-labile. The experiment was conducted at the Research cum Instructional Farm, IGKV, Raipur, (C.G.) during *Kharif* season 2018-19. The soil sample was collected at 0-15 cm and 15-30 cm soil depth. The four carbon fractions *i.e.* very labile carbon (VLC), labile carbon (LC), less labile carbon (LLC), non-labile carbon (NLC) were compared in randomized block design (RBD) with three replications. The treatments consisted of organic and inorganic combination of T_1[Control($N_0P_0K_0$), T_2 [100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake)], T_3 (75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25-30 DAS and 50-60 DAS), T_4 (50% N through Inorganic + 50% N through Organic), T_5 (75% N through Organic + 25% N through Inorganic), T_6 (100% N through Inorganic). The carbon fractions were not significantly affected by all the treatments. The higher carbon fractions recorded in 100% N through organic source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake) at surface (0-15 cm) and sub-surface (15-30 cm) soil as compared to control ($N_0P_0K_0$). The yield of soybean significantly different in all the treatments. The maximum seed yield in treatment T_3 (75% N RDF through organic source) and stover yield of soybean in T_2 (100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake).

Keywords: Soybean-vegetable system, very labile carbon (VLC), labile carbon (LC), less labile carbon (LLC), non-labile carbon (NLC), yield

Introduction
Soil Organic Carbon (SOC) is a very crucial element in soil fertility and productivity. It is found in the soil in the forms of labile and non-labile. The labile form contains three fractions that are $frac_1$ (very labile carbon), $frac_2$ (labile carbon) and $frac_3$ (less labile carbon), and $frac_4$ of the carbon is non-labile. These forms of carbon help in maintaining soil health (Naik *et al.*, 2016) [9]. The CVL and CL fractions are the most readily Oxidizable fractions and mainly composed of polysaccharides, decaying young organic matter, fungal hyphae, and other microbial products, which contribute to the formation of macro aggregates and availability of nutrients (Maia *et al.*, 2007) [6]. The CLL and CNL fractions are related to compounds of high chemical stability and are slowly decomposed by soil microbe (Sherrod *et al.*, 2005a) [13]. The pool being readily accessible to microorganisms directly impact plant nutrient supply. This pool is also sensitive to land management changes. The highly recalcitrant or passive pool is on the other hand, changed only very slowly by microbial activities and hence hardly serves as a good indicator for assessing soil quality and productivity (Majumdar *et al.*, 2007) [7]. Some of the important labile pools of SOC currently used as indicators of soil quality are microbial biomass C, mineralizable C oxidizable organic C fractions and light-fraction.

Organic carbon losses from the soil by incessant crop cultivation with no nutrient management Practices (Bhattacharya *et al.*, 2011) [1]. Inorganic fertilization increases crop residues that indirectly enhance soil organic carbon storage to the soil (Tian et *al*., 2015) [15], however, the application of manure improves SOM through the direct inputs of treated organic materials to soil (Hai *et al.*, 2010) [5].

A soil's capacity to oppose erosion and keep up elevated amounts of carbon (C) and nitrogen (N), rests in the appropriation of soil parts. Human soil the executives rehearses, for example, culturing rehearses, change the portion dissemination and in this way the capacity to sequester soil C and oppose erosion. From several experiments, it is suggested that long term manure fertilization promotes the accumulation of soil organic carbon mainly through increasing the amounts of labile oxidizable organic carbon due to the high labile carbon inputs by the manure (Ghosh *et al*., 2010) [4]. The continuous application of manure simultaneously increases both labile and non-labile carbon fractions (Majumder *et al*., 2008) [8] suggested that long-term manure fertilization mainly increases the content of recalcitrant oxidizable carbon fractions. Additionally, the cultivation time largely affects fertilization effect on SOC and soil oxidizable organic carbon fractions, because short-term manure fertilization mainly increased labile oxidizable C but long-term manure fertilization tended to promote the accumulation of recalcitrantoxidizable carbon (Ghosh *et al*., 2010) [4]. SOC content increased follow equilibrium dynamics after manure fertilization (Shang *et al*., 2011; Triberti *et al*., 2016) [12, 16], and labile carbon contained by manure directly contributes to the rapid increase of soil organic carbon, and non-labile carbon might be accumulated when soil organic carbon content reaches equilibrium because large amounts of labile carbon were decomposed into non-labile carbon.

Materials and methods

The field experimental was conducted at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, College of Agriculture, Raipur (Chhattisgarh) during *Kharif* 2018-19. The experimental soil is a black soil rich in montmorillonitic clay mineral. It comes under the order of *Vertisols.* It is also called as Kanhar and Regur soil. This soil have high coefficient of expansion and contraction involving churning. Black soil characterised by dark grey to black in colour due to compound of iron and aluminium (also because of titaniferous magnetite), high clay content (50%), neutral to slightly alkaline in reaction. It has poor to high fertility status. However poor in organic carbon, low N, S, and P contents. The treatments consisted of organic and inorganic combination of T_1[Control(N0P0K0), T_2 [100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake)], T_3 (75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25-30 DAS and 50-60 DAS), T_4 (50% N through Inorganic + 50% N through Organic), T_5 (75% N through Organic + 25% N through Inorganic), T_6 (100% N through Inorganic) in Randomized Block Design (RBD) with three replications.

A. Methodology for Carbon fractions analysis

Carbon fraction was estimated by modified Walkley and Black method (1934). 12 N, 18N and 24N sulphuric acid was used to the oxidization of organic carbon fractions (very labile, labile, less labile and non-labile) that is present in the soil sample. 12 N, 18N and 24N sulphuric acid is equal to 5 ml, 10 ml, and 20 ml concentrated sulphuric acid. The amount of oxidizible organic carbon determined using 5, 10, and 20 ml of concentrated sulphuric acid when compared with total carbon concentration allowed separation of total organic carbon into four fractions of decreasing oxidizability (Chan et *al*., 2001) [2].

Very labile carbon (Fraction 1): Organic carbon oxidizable under 12 N H_2SO_4.

Labile carbon (Fraction 2): Subtractions between 18N and 12 N H_2SO_4 oxidized organic carbon.

Less labile carbon (Fraction 3): Subtractions between 24N and 18 N H_2SO_4 oxidized organic carbon.

Non-labile carbon (Fraction 4): Subtractions between TOC and 24N H_2SO_4 oxidized organic carbon.

B. Yield attributes of soybean

1. Seed yield (q ha^{-1})

The weighed bundles were threshed, winnowed and clean separately. The seed weight of each plot was recorded in kg and then subsequently converted into q ha^{-1}.

2. Stover yield (q ha^{-1})

The yield of stover was calculated by subtracting seed yield of net plot from bundle weight and then converted into q ha^{-1}.

Results and Discussion

A. Carbon fractions analysis

1. Carbon fractions after harvest of Soybean

The organic and inorganic fertilizer effects on very labile carbon (VLC) and labile carbon (LC) presented in Table 1 and Fig. 1 & 2.

a) Very labile carbon (V LC) (%)

The very labile carbon was not found significant effect by all the treatments. The very labile carbon decreased with increase in depth. The very labile carbon was ranged between 0.305-0.326% at 0-15 cm depth and 0.252-0.267% at 15-30 cm depth. The highest very labile carbon was recorded in the T_2 [100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)] at both depth 0-15 cm and 15-30 cm, which was 0.326% at 0-15 cm depth and 0.267% at 15-30 cm depth. The lowest very labile carbon was observed in T_1 [Control ($N_0P_0K_0$)] at both depth 0-15 cm (0.305%) and 15-30 cm (0.252%). The initial value of very labile carbon was 0.301% (0-15 cm) and 0.255% (15-30 cm) respectively.

b) Labile carbon (LC) (%)

The different treatments were not differed significantly on labile carbon in surface and subsurface soil. The labile carbon concentration in the different treatments ranged 0.077 to 0.096% and 0.070 to 0.083% at the 0-15 cm and 15-30 cm soil depth respectively. The maximum concentration of labile carbon at surface and sub-surface soil in the T_2 [100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)], (0.096%) (0.083%) at 0-15 cm and 15-30 cm respectively. However, the minimum labile concentration recorded in T_1 [Control ($N_0P_0K_0$)], 0.077% at 0-15 cm and 0.070% at 15-30 cm soil depth. The initial value of labile carbon was at 0-15 cm (0.076%) and 15-30 cm (0.069%) respectively.

Table 1: Effect of different organic and inorganic treatment on soil very labile carbon (VLC) and labile carbon (LC) in soybean at post-harvest

Treatment	VL C%		L C %	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1- Control ($N_0P_0K_0$)	0.305	0.252	0.077	0.070
T_2- 100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)	0.326	0.267	0.096	0.083
T_3- 75% N through Organic Source + 10% foliar spray of Vermi wash and Cow Urine at 25-30 DAS and 50-60 DAS	0.321	0.264	0.090	0.078
T_4- 50% N through Inorganic + 50% N through Organic	0.316	0.258	0.083	0.074
T_5- 75% N through Organic + 25% N through Inorganic	0.318	0.263	0.086	0.076
T_6- 100% N through Inorganic	0.312	0.255	0.080	0.073
SE m±	0.005	0.003	0.004	0.002
CD (P = 0.05)	NS	NS	NS	NS
Initial	0.301	0.255	0.076	0.069

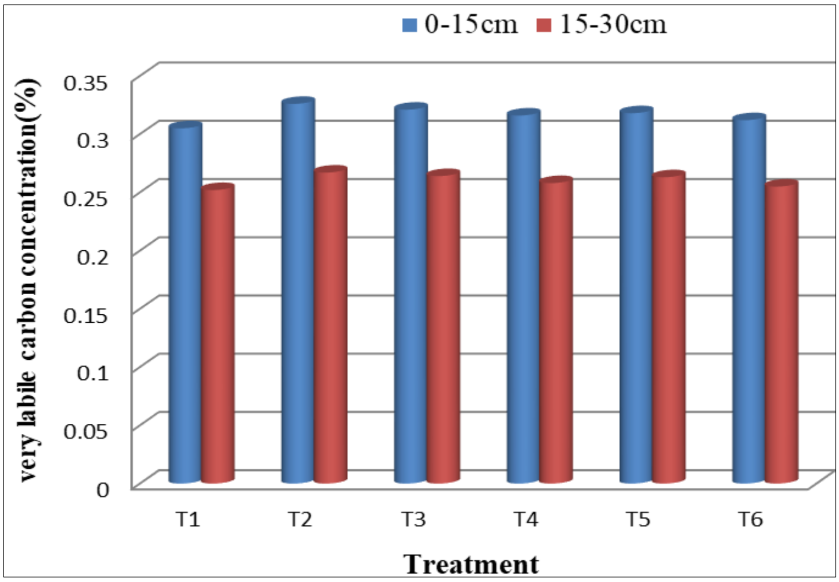

Fig 1: Effect of different organic and inorganic treatment on very labile carbon in soybean at post-harvest

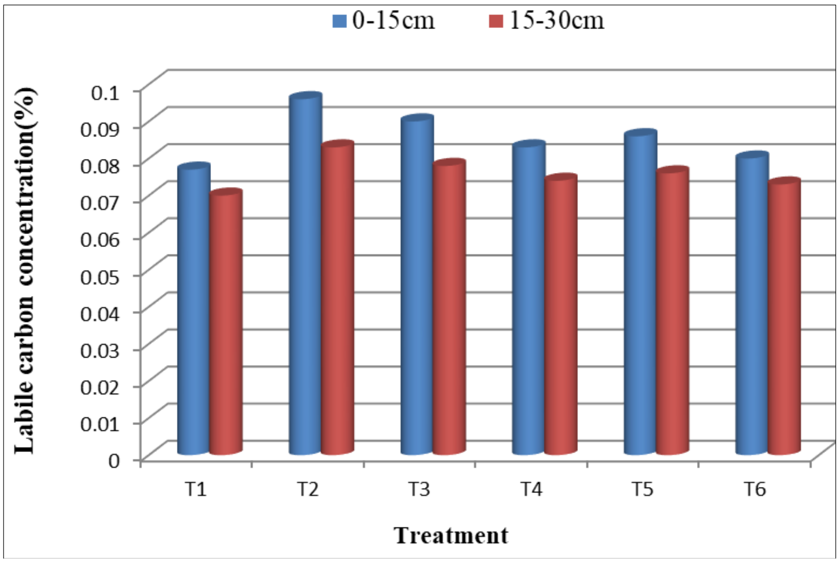

Fig 2: Effect of different organic and inorganic treatment on labile carbon in soybean at post-harvest

The organic and inorganic fertilizer effects on less labile (LLC) and non-labile carbon (NLC) in the Table 2 and Fig. 3 & 4.

Less labile carbon

The Fig 4 showed that the effects of organic and inorganic fertilizer on less labile carbon (LLC). The less labile concentration in different treatments were not differed significantly in soybean crop and the ranged from 0.237-0.250% at surface soil (0-15 cm) and 0.210-0.227% at subsurface soil (15-30 cm) respectively. The plots was receiving 100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake) (T_2) was recorded highest concentration of less labile carbon in 0-15 cm (0.250%) and at 15-30 cm (0.227%). While, minimum concentration of less labile carbon in 0-15 cm depth was 0.237% and 0.210% at 15-30 cm soil depth found in T_1[control($N_0P_0K_0$)] plots. The initial concentration value was recorded 0.235% at 0-15 cm and 0.199% at 15-30 cm depth of soil.

Non-labile carbon: The non-labile carbon was not significantly differed in all the treatments. The range of non-labile carbon was 0.159-0.172% (0-15 cm) and 0.150-0.163% (15-30 cm). The maximum concentration of non-labile in the surface (0-15 cm) soil was observed 0.172% and sub-surface (15-30 cm) soil 0.163% in T_2 plots, that plots receiving soil nutrients through 100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake). The minimum concentration of non-labile carbon in the T_1 [Control ($N_0P_0K_0$)] 0-15 cm (0.159 %) and 15-30 cm (0.150%) The initial vale of non-labile carbon was recorded 0.158%, 0.149% at (0-15 cm), (15-30 cm) respectively. Das *et al.* (2016) [3] reported that the oxidisable organic C fractions revealed that very labile C and labile C fractions were much larger in the NPK+FYM or NPK + GR + FYM treatments, whereas the less-labile C and non-labile C fractions were larger under control and NPK+CR treatments. The lowest CVL was seen in the unfertilized control treatment and CVL increased significantly under integrated plant nutrient supplied (IPNS) treatments. Seneviratne. (2000) [11] also observed that CVL and CNL decreased with soil depth. In surface soil CVL and CL dominate in organic and organic + inorganic plot while CNL is higher in control plots. Application of balanced fertilizer with manure increases polysaccharides (cellulose and hemi-cellulose) in soil that lead to production of higher amounts of CVL.

Table 2: Effect of different organic and inorganic treatment on soil less labile carbon (LLC) and Non-labile carbon (NLC) in soybean at post-harvest

Treatment	LL C %		NL C %	
	0-15	**15-30**	**0-15**	**15-30**
T_1- Control ($N_0P_0K_0$)	0.237	0.210	0.159	0.150
T_2- 100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)	0.250	0.227	0.172	0.163
T_3- 75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS	0.247	0.223	0.169	0.158
T_4- 50% N through Inorganic + 50% N through Organic	0.242	0.220	0.163	0.152
T_5- 75% N through Organic + 25% N through Inorganic	0.245	0.222	0.165	0.156
T_6- 100% N through Inorganic	0.24	0.215	0.162	0.151
S Em ±	0.009	0.009	0.004	0.002
CD (P = 0.05)	NS	NS	NS	NS
Initial	0.235	0.199	0.158	0.149

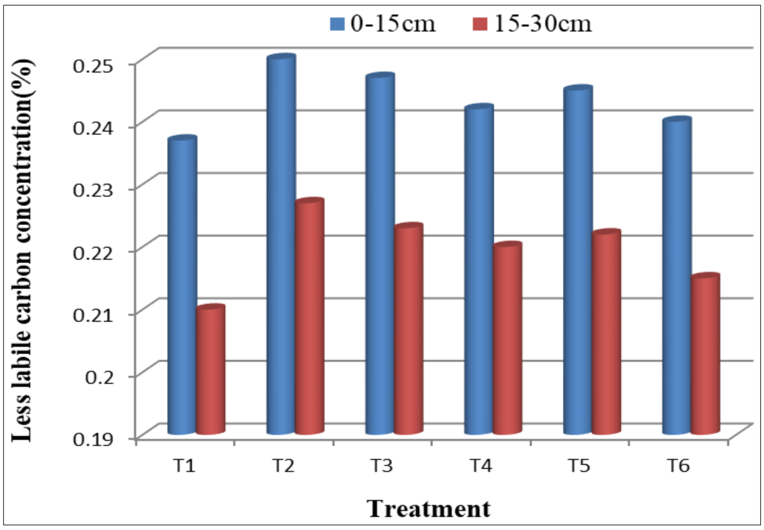

Fig 3: Effect of different organic and inorganic treatment on less labile carbon in soybean at post-harvest

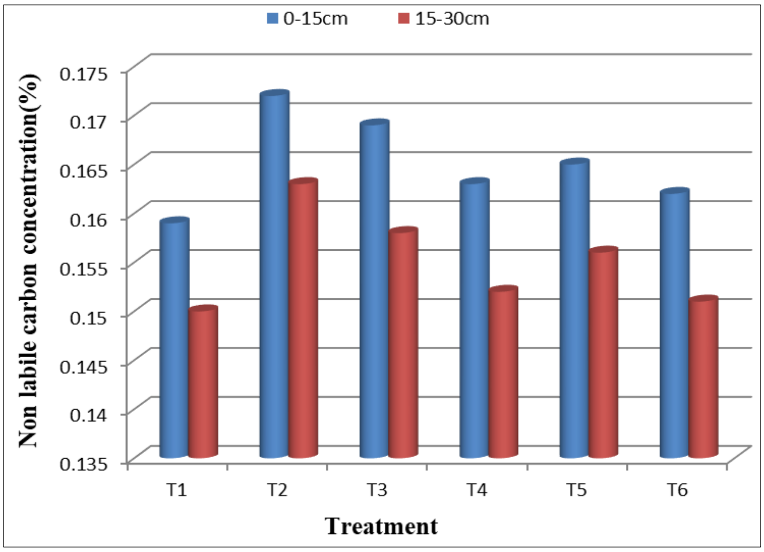

Fig 4: Effect of different organic and inorganic treatment on non-labile carbon in soybean at post-harvest

2. Effect of organic and inorganic treatment on seed and stover yield of soybean

The effect of organic and inorganic treatment on seed and stover yield of soybean depicted in Table 3 and Fig. 4.

The average seed and stover yield of soybean was significantly affected by the different treatments. The seed yield range from 10.50-21.13q ha^{-1} and stover yield from 18.32 to 29.73 q ha^{-1} in soybean. The significantly maximum seed (21.13 q ha^{-1}) and stover yield (29.73 q ha^{-1}) was recorded under treatment T_3 (75% N RDF through organic source), seed and Stover yield was found in T_2. However, the significantly lower seed (10.50 q ha^{-1}) and stover yield (18.32 q ha^{-1}) was recorded under T_1 [control ($N_0P_0K_0$)] as compared to other treatments. Son and Ramaswami (1997) [14] revealed that application of organic and bio-fertilizer could be substantiated for the N inorganic fertilizer to an extent of 40 kg N ha^{-1} for agronomic characteristic and seed yield were comparable to the control in soybean. Similar result also reported by Vyas and Khandwe (2012) [17] under soybean-wheat system on Typic Chromosterts. These findings were in agreement with Pattanashetti *et al.* (2002) [10].

Table 3: Effect of organic and inorganic treatment on seed and stover yield of soybean

Treatment	Yield	
	Seed Yield(q ha^{-1})	Stover Yield(q ha^{-1})
T_1- Control (N_0 P_0 K_0)	10.50	18.32
T_2- 100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake)	20.08	29.73
T_3- 75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 -30 DAS and 50-60 DAS	21.13	28.36
T_4- 50% N through Inorganic + 50% + N through Organic	16.96	25.75
T_5- 75% N through Organic + 25% N through Inorganic	17.15	25.96
T_6- 100% N through Inorganic	17.92	26.85
SE m ±	0.33	0.56
CD (P = 0.05)	0.86	1.36

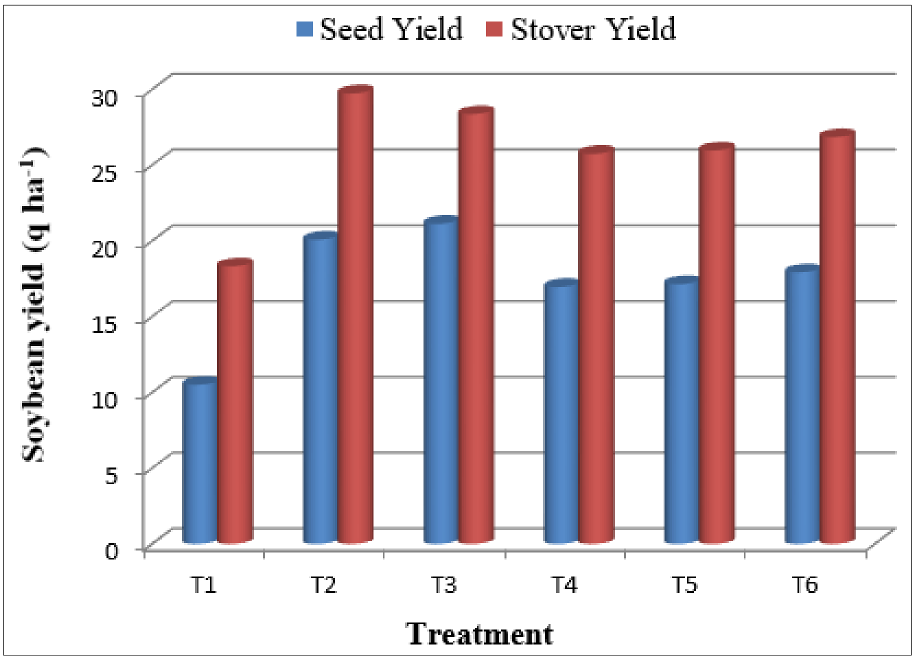

Fig 5: Effect of organic and inorganic treatment on seed and stover yield of soybean

Summary and Conclusions

The very labile, labile, less labile, non-labile carbon was not significant effect in all the treatment. The decrease concentration of those carbons with increasing soil depth. The highest concentration of very labile, labile, less labile, non-labile and were recorded in T_2 [100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)] at the both surface (0-15 cm) and sub-surface (15-30 cm) of soil. The lowest concentration was founded in T_1 [control ($N_0P_0K_0$)]. The yield of soybean (seed and stover) were significantly different in all the treatments. The maximum seed and store yield of soybean in treatment T_3 (75% N RDF through organic source) and T_2 (100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake) respectively. However, the minimum seed and stover yield was recorded in T_1 [control ($N_0P_0K_0$)] as compared to other treatments.

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