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Effect of integrated nutrient management practices on the physical and chemical properties of soil under soybean-vegetable system in a *Vertisol*

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Abstract
The field experimental was conducted at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during *Kharif* 2018-2019. The soil sample was collected at 0-15cm and 15-30cm soil depth. The treatments consisted of organic and inorganic combination of T1[Control(N0P0K0), T2 [100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake)], T3 (75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS), T4 (50% N through Inorganic + 50% N through Organic), T5 (75% N through Organic + 25% N through Inorganic), T6 (100% N through Inorganic). The highest BD was recorded in T1 and T6 treatments (1.33Mgm-3) at 0-15 cm and at 15-30cm T4, T5, T6 (1.42Mgm-3). Lowest BD was recorded in T2 treated plot at both depth of the soil the value was 1.31 Mgm-3 (0-15 cm) and 1.40 Mg m-3 (15- 30 cm). The maximum pH was recorded in the treatment plot of T4 and T6 that was 7.74 in surface soil, while the maximum value (7.78) of sub-surface soil pH was recorded in the T1 and T4. Similarly, the minimum soil pH was recorded in the treatment of T2 at 0-15cm depth and T6 at 15-30cm depth, the value was (7.71) and (7.75) respectively. The EC observed in T4 at both depth of soil compare with other treatments the value was 0-15cm (0.245dSm-1) and 15-30cm (0.183 dSm-1). The soil organic carbon was maximum observed in T2 at both 0-15cm (6.97 g kg-1) and 15-30cm (6.71g kg-1) depth. The available N higher in T3 (258.64 kg ha-1) at 0-15 cm and T4 (247.49 kg ha-1) at 15-30 cm. The available P was maximum in treatment T2 at 0- 15cm (20.82 kg ha-1) available Phosphorous at 15-30cm treatment T3 recorded maximum which was (19.27 kg ha-1). The value of available potassium was maximum recorded in treatment T4 (378.86kg ha-1) at surface soil and T2 at subsurface soil (349.05 kg ha-1).

Keywords: Integrated nutrient management, soybean-vegetable, physical and chemical properties

Introduction
Application of ammonium nitrogen (N) fertilizer and urea continuously caused many soil problems, like it lowers the contents of soil organic carbon (SOC), acidifying soil and bringing about poor soil physical properties (Celik *et al.*, 2010) [8]. Unbalanced use of nutrients in the soils may be causing a harmful effect. When the long run used of uneven nutrient made soil unproductive. It cannot be maintained sustainable crop production by alone using chemical fertilizers and organic manures. Souse of integrated inorganic fertilizers with organic manures, improving soil fertility as well as crop productivity (Bhatt *et al.*, 2018) [4]. Organic carbon losses from the soil by incessant crop cultivation with no nutrient management Practices (Bhattacharya *et al.*, 2011) [5]. Inorganic fertilization increases crop residues that indirectly enhance soil organic carbon storage to the soil (Tian *et al.*, 2015) [18]. However, the application of manure improves SOM through the direct inputs of treated organic materials to soil (Hai *et al.*, 2010) [9].

Soybean yield was increased by combining the application of inorganic fertilizer with organic manure (NPK+FYM) as compared to the sole application of NPK fertilizer also organic manure. It is improved the physical and chemical properties of soil (Bandyopadhyay *et al.*, 2010) [3]. For the growth and development of microorganisms and maintain a favourable nutritional balance and physical properties of soil organic manures provide a good substrate.

One such strategy to maintain soil fertility for sustainable production of soybean is through the judicious use of fertilizers (Bobde *et al*., 1998) [7].

For the production of crop fertilizer required in a balanced amount, but inorganic fertilizer requirement for the crop are may reduce by application of inorganic fertilizer with manures, this saves some part of the total crop production cost of the small farmers. Environmental pollution can be reduced significantly by controlling the excessive use of chemical fertilizers and increasing the use of manures. The combination of manures added with inorganic fertilizers improve Soybean yield, soil fertility, also increase the fertilizer-use efficiency and soil microorganisms. Soil micro-organism help to maintain ecological balance and soil fertility.

Organic carbon losses from the soil by incessant crop cultivation with no nutrient management Practices (Bhattacharya *et al*., 2011) [5]. Inorganic fertilization increases crop residues that indirectly enhance soil organic carbon storage to the soil (Tian *et al*., 2015) [18],

However, the application of manure improves SOM through the direct inputs of treated organic materials to soil (Hai *et al*., 2010) [9].

Materials and Methods

Experimental Area: The field experimental was conducted at the Research cum Instructional Farm, Indira Gandhi Krishi, Raipur (Chhattisgarh) during Kharif 2018-19. Raipur comes under agro- climatic plain zone of Chhattisgarh state and lies at 21◦16 N latitude and 81◦36 E longitude with an altitude of 293 m above the mean sea level.

Climate condition

The climate of Raipur is falling under sub-humid with average annual precipitation of 1317.77 mm. Greatest quantity of precipitation happens between the month of June to September (about 3 to 4 months) which is the main Soybean growing season. The month with the average high temperature is May 42.80C and average low temperature month is December (13.80C).

Soil characteristics

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.

Collection and Preparation of soil sample

Soil samples were collected from each plot after harvesting of soybean at soil depths (0-15 cm and 15- 30 cm) from the experimental field. Soil samples were air dried in shade and stored in polythene bags for further analysis. The air dried samples were carefully and gently grind with the wooden pestle to break soil lumps (clods) and were passed through sieve of 2 mm diameter. The sieved samples were mixed thoroughly and stored in polythene bags, properly labelled and preserved for subsequent analysis.

Methodology for soil sample analysis

Bulk density: Bulk Density was measured as per method given by Black (1965) [6]. To determine bulk density, soil was collected with manually operated core sampler from 0-15 and 15-30 cm depth. The samples were oven dried at 105 0C to a constant weight. Bulk density was calculated by the following formula.

$$\text{B.D. (Mgm}^{-3}\text{)} = \frac{\text{Weight of oven dried soil}}{\text{Volume of soil core}}$$

Soil pH: Hydrogen ion activity expressed as pH at 0-15 cm and 15-30 cm soil depth at harvest was determined by potentiometry using 1:2.5 soil water suspensions as described by (Piper, 1967).

Electrical conductivity

The clear water supernatant obtained from the suspension used for pH at 0-15 cm and 15-30 cm soil depth at harvest was utilized for the EC measurement using Conductivity Bridge as described by Black (1965) [6].

Available Nitrogen

The available nitrogen in 0-15 cm and 15-30 cm soil depth at harvest was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1965).

Available Phosphorous

The available phosphorus in 0-15 cm and 15-30 cm soil depth at harvest was determined using 0.5M NaHCO3 (pH 8.5) solution (Olsen extractant). Darco-G-60 used to make filtrate colourless for colorimetric analysis (Watanabe and Olsen, 1965) [20].

Available Potassium

Soil available potassium at 0-15 cm and 15-30 cm soil depth at harvest was extracted by shaking with neutral normal ammonium acetate for 5 minute (Hanway and Heidel, 1952) [10] and potassium extract was estimated by flame photometer.

Organic carbon

Organic carbon at 0-15 cm and 15-30 cm soil depth at harvest was determined by Walkley and Black's rapid titration method (1934) [19].

Results and Discussion

Physical and chemical properties of soil after harvest of soybean

Soil pH: The effect of different organic and inorganic treatments on soil pH after harvest of soybean crop presented in table 1 and figure 1. The pH of the soil was not significantly difference in the entire treatments. The pH value was increased with increasing soil depth in 0-15cm to 15-30cm. The soil pH increase depth wise may possibly due to incessant utilized of organic and inorganic fertilizers. The maximum pH observed in the treatment T4 (50% N through Inorganic + 50% N through Organic) (7.74) and T6 (100% N through Inorganic) (7.74) at depth 0-15cm. while, the maximum value of sub-surface soil pH was recorded in the T1 [control (N0P0K0)] (7.78) and T4 (50% N through Inorganic + 50% N through Organic) (7.78). While, minimum soil pH was recorded in the treatment T2 [100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)] at 0-15cm depth and T6 (100% N through Inorganic) at 15-30cm depth, the value was (7.71) and (7.75) respectively. However, the initial value of soil pH were 7.74 (0-15cm) and 7.78(15-30cm). The rise in soil pH is attributed to decrease in organic carbon content of the soil due to incessant cropping. Organic matter produces different acids, which slightly decreased the soil pH. The Soil pH was slight high in treatments where integrated use of fertilizers and manures was made. This marginal increase in soil pH in integrated treatments might be due to the moderating effect of organics over the years as it decreases the activity of exchangeable Al3+ ions in soil solution due to chelating effect of organic molecules (Prasad *et al*., 2010) [15].

Electrical Conductivity (dSm-1)

The effect of different organic and inorganic treatments on electrical conductivity after harvest of soybean crop shown in table 1 and figure 2. The EC was not shown significant effect by all the treatments. The electrical conductivity decreased with increase soil depth. The maximum EC recorded in the T4 (50% N through Inorganic + 50% N through Organic) treated plot at both depth *i.e.* 0-15cm (0.245dSm-1) and 15-30cm (0.183 dSm-1) respectively. The lowest amount of EC was observed in T3(75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS) (0.173 dSm-1) at 0-15cm depth then T2 (100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake) (0.178dSm-1) T6 (100% N through Inorganic) (0.194 dSm-1) in the 0- 15cm (surface) depth of the soil. Whereas, the least amount of EC was recorded in T1 [control(N0P0K0)] and T2(100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake) plots (0.166 dSm-1) followed by T3(75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS), (0.170 dSm-1) in 15-30cm(subsurface) soil depth. The EC of soil increases due to used of conjunction with inorganic fertilizer. Initial value of soil EC was 0.246dSm-1(0-15cm) and 0.169dSm-1 (15-30cm). The effect of integrated nutrient management on soil physical properties using soybean as indicator crop under temperate conditions. This might be due to release of electrolytes upon the decomposition of applied manure and fertilizers. While the lowest value of EC was found in control where no fertilizer was applied (Aziz *et al.*, 2014) [2].

Table 1: Effect of different organic and inorganic treatment on soil pH and electrical conductivity (EC) in soybean at post-harvest

Treatment	pH		EC (dSm-1)	
	0-15	15-30	0-15	15-30
T1- Control (N0P0K0)	7.73	7.78	0.213	0.166
T2- 100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake)	7.71	7.77	0.178	0.166
T3- 75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 -30 DAS and 50-60 DAS	7.72	7.77	0.173	0.170
T4- 50% N through Inorganic + 50% N through Organic	7.74	7.78	0.245	0.183
T5- 75% N through Organic + 25% N through Inorganic	7.72	7.76	0.233	0.199
T6- 100% N through Inorganic	7.74	7.75	0.194	0.180
SEm±	0.028	0.015	0.040	0.018
CD (P = 0.05)	NS	NS	NS	NS
Initial	7.74	7.78	0.246	0.169

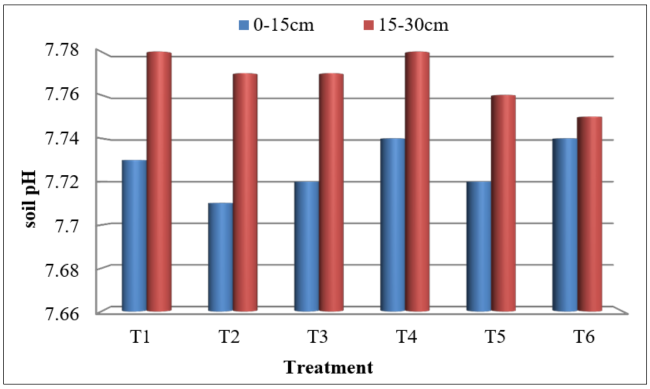

Fig 1: Effect of different organic and inorganic treatment on soil pH in soybean at post-harvest

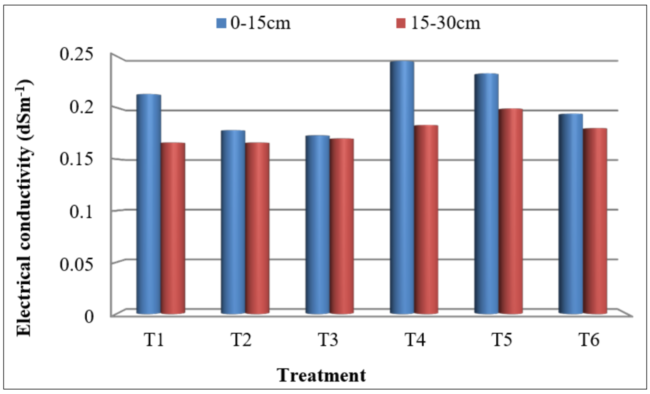

Fig 2: Effect of different organic and inorganic treatment on soil electrical conductivity (EC) in soybean at post-harvest

Organic Carbon (g kg-1)

The effect of different organic and inorganic treatments on organic carbon after harvest of soybean crop presented in table 2 and figure 3. All treatments not significantly affected the soil organic carbon (SOC). The highest soil organic carbon founded in treatment T2 (100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake) and T3 (75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS) which was 6.97 g kg-1and the minimum OC(organic carbon) value was observed under T1[control (N0P0K0)] (6.80g kg-1) at 0-15cm depth treated plot. At the sub-surface soil (15-30cm), the highest value was observed in T2 treatment (6.71g kg-1), which plot was receiving nutrient through organic sources (1/3 FYM, Vermicompost, 1/3 Neem cake) and the lowest value of organic carbon was recorded in T1 [control (N0P0K0)] (6.67 g kg-1). The initial value of soil OC was 6.88g kg1 (0-15cm) and 6.66g kg-1 (15-30cm).

The content OC was increase in 0-15 cm soil depth due to addition of organic matter (OM) by FYM on the surface of the soil. It may be enhanced the crop growth with concomitantly higher root biomass production. It was also supported by Rajput *et al.*, (2016) [16] and Kapoor *et al.*, (2015) [11].

Bulk Density (Mg m-3)

The effect of different organic and inorganic treatments on bulk density after harvest of soybean crop depicted in table 2 and figure 4.

The bulk density of soil did not significantly show any visible trend in all the treatment at both soil depth 0-15cm and 15-

30cm.The highest BD recorded in treatment T1 [control (N0P0K0)] and T6 (100% N through Inorganic) as compared to the other treatments at depth 0-15cm the vale was (1.33 Mg m-3). Whereas, the highest BD in T4 (50% N through Inorganic + 50% N through Organic), T5 (75% N through Organic + 25% N through Inorganic) and T6 (100% N through Inorganic) that was (1.42 Mg m-3) in the sub-surface soil (15-30cm).The lowest value of BD in T2 [100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)] treated plot at both depth of the soil *i.e.* 0-15cm depth (1.31 Mg m-3) and 15-30cm (1.40 Mg m-3) depth. The initial value of soil BD was 1.34Mg m-3(0- 15cm) and 1.42Mg m-3 (15-30cm) respectively.

The bulk density was decrease due to organic matter resulted in considerable increase in polysaccharides and microbial gum synthesis in the soil. The microbial decomposition product, act as binding agent. It might be help in soil aggregation resulting lower bulk density of soil (Bhatt *et al.*, 2018) [4]. Similar result also founded by (Kumar *et al.*, 2011) [12].

Table 2: Effect of different organic and inorganic treatment on soil organic carbon (OC) and bulk density (BD) in soybean at post-harvest

Treatment	OC (g kg-1)		BD (Mgm-3)	
	0-15	15-30	0-15	15-30
T1- Control (N0P0K0)	6.80	6.67	1.33	1.41
T2- 100% N through Organic Source (1/3 FYM, 1/3 vermicompost, 1/3 Neem cake)	6.97	6.71	1.31	1.40
T3- 75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 -30 DAS and 50-60 DAS	6.97	6.68	1.32	1.41
T4- 50% N through Inorganic + 50% N through Organic	6.93	6.70	1.32	1.42
T5- 75% N through Organic + 25% N through Inorganic	6.93	6.69	1.32	1.42
T6- 100% N through Inorganic	6.90	6.69	1.33	1.42
SEm±	0.059	0.008	0.007	0.005
CD (P = 0.05)	NS	NS	NS	NS
Initial	6.88	6.66	1.34	1.42

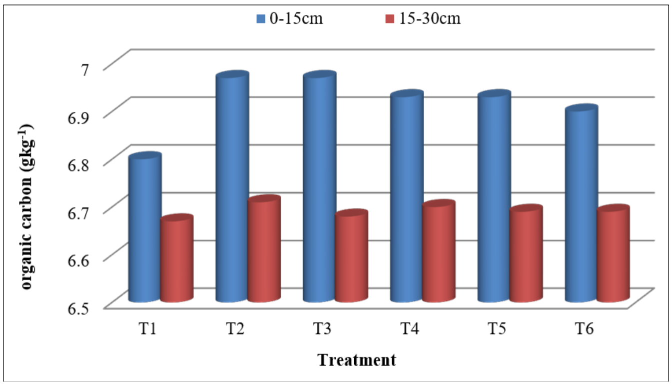

Fig 3: Effect of different organic and inorganic treatment on organic carbon (OC) in soybean at post-harvest

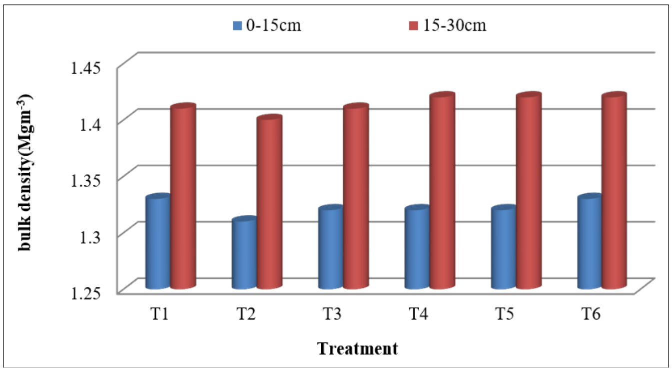

Fig 4: Effect of different organic and inorganic treatment on bulk density (BD) in soybean at post-harvest

Available Nitrogen (kg ha-1)

The effect of different treatments on soil available nitrogen in soil after harvest of soybean crop presented in table 3 and Figure 5. The data pertaining to soil available Nitrogen was ranged between 248.44-258.64 kg ha-1at 0-15cm depth and 241.75-247.49 kg ha-1 at 15-30 cm depth respectively. The data was found to be non-significant difference among the various treatments. The higher available Nitrogen was recorded in T3 (75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS) at 0-15 cm (258.64 kg ha-1) and T4 (50% N through Inorganic + 50% N through Organic) at subsurface (247.49 kg ha-1). Whereas, the minimum soil available N was recorded in T1 [control (N0P0K0)] at surface (248.44 kg ha-1) and subsurface soil (241.75 kg ha-1) respectively at the post-harvest stage of soybean. The initial mean value of available Nitrogen was obtained (250.50 kg ha-1) at 0-15cm depth and (240.20 kg ha-1).

The increase in available N in FYM treated plots was attributed to the increase in total SOC and might have been partially due to a slow release of N from manure (Gami *et al.*, 2001), Similar results also observed by Meena *et al.*, (2018) the farmyard manure is known to stimulate biological N2 fixation in the soil, which may also have been responsible for the increase in soil N over NPK treatment, apart from FYM's own N contribution. In addition, soils under NPK + FYM treated plots produced more biomass and, therefore, possibly had more extensive root systems that may have contributed to increased N levels. Increased significantly with increasing levels of FYM. Which was significant superior with followed by rest of all treatments, while minimum in treatment T1 [control (N0P0K0**)]**.

Available Phosphorus (kg ha-1)

The effect different treatment on soil available Phosphorous in soil after harvest of soybean crop presented in Table 3 and Figure 6. The available Phosphorous was ranged between 19.26-20.82 kg ha-1 at surface soil and 17.77-19.27 kg ha-1 at subsurface soil. The data was found to be non-significant difference among the various treatments. The highest available Phosphorous was observed in treatment T2[100%N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)] (20.82 kg ha-1) followed by T3 (75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS (20.25 kg ha-1) as compared to control (N0P0K0)(19.26 kg ha-1) at 0-15 cm depth. Similarly, treatment T3(75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS)(19.27 kg ha-1)recorded maximum soil available Phosphorous at 15-30cm followed byT4 (50% N through Inorganic + 50% N through

Organic) (19.00 kg ha-1). While, lowest was recorded in T1 [control (N0P0K0)] (17.77 kg ha-1) at 15-30 cm depth. The initial mean value of available Phosphorous was recorded 19.50kg ha-1at 0-15cm and 17.98kg ha-1at 15-30cm. The build-up of available P in the soil may be due to the released of organic acids during the microbial decomposition of Vermicompost increasing the available P in soil. Similar result recorded by (Aziz *et al.*, 2014) [2].

Available potassium (kg ha-1)

The effect of different treatment on soil available potassium in soil after harvest of soybean crop shown in Table 3 and Figure 7. There was no significant difference among the various treatments. The available potassium ranged between 372.05-378.86kg ha-1 at 0-15 cm depth and 344.43-349.05 kg ha-1 at 15-30 cm depth. The value of available potassium was maximum observed in T4 (50% N through Inorganic + 50% N through Organic) at 0-15cm depth (378.86 kg ha-1) and T2 [100% N through Organic Source (1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)] at 15-30cm (349.05 kg ha-1) of the soil depth. While, the least amount soil available potassium was recorded in T1 [control (N0P0K0)] at 0-15cm kg ha-1) and 15-30cm (344.43 kg ha-1). The initial mean value of available potassium was obtained 375.25kg ha-1 at 0-15cm and 345.45kg ha-1at 15-30cm.

Akhila *et al.*, (2018) [1] reported that the highest available potassium was observed in T10 plot witch treated with FYM + Vermicompost + Neem cake + Poultry manure + Arka microbial. An application of organic manure in the soil higher build up of available K in soil due to the reduction of potassium fixation, release of potassium due to the interaction of organic matter(OC) with clay, and direct addition of K to the available pool of soil. The organic manures positive influence the available NPK contents of soil after the crop harvest.

Table 3: Effect of different organic and inorganic treatment on available Nitrogen, Phosphorus and Potassium in soybean at post-harvest

Treatment		0-15	15-30	0-15	15-30	0-15	15-30
T1-	Control (N0P0K0)	248.44	241.75	19.26	17.77	372.05	344.43
T2-	100% N through Organic Source(1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake)	256.23	246.03	20.82	18.26	378.60	349.05
T3-	75% N through Organic Source +10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS	258.64	247.15	20.25	19.27	378.14	345.34
T4-	50% N through Inorganic + 50% N through Organic	255.15	247.49	20.47	19.00	378.86	348.74
T5-	75% N through Organic + 25% N through Inorganic	255.69	247.38	19.95	18.54	376.30	348.74
T6-	100% N through Inorganic	255.15	246.88	19.94	18.62	377.44	345.91
SEm±		2.02	1.60	0.46	0.33	3.55	2.90
CD (P = 0.05)		NS	NS	NS	NS	NS	NS
Initial		250.50	240.20	19.50	17.98	375.25	345.45

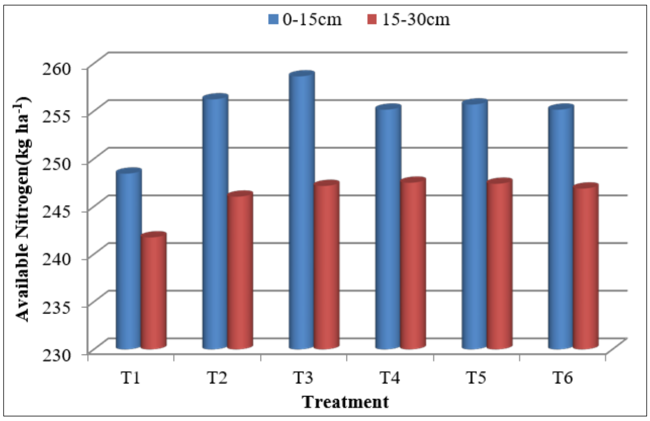

Fig 5: Effect of different organic and inorganic treatment on available Nitrogen in soybean at post-harvest

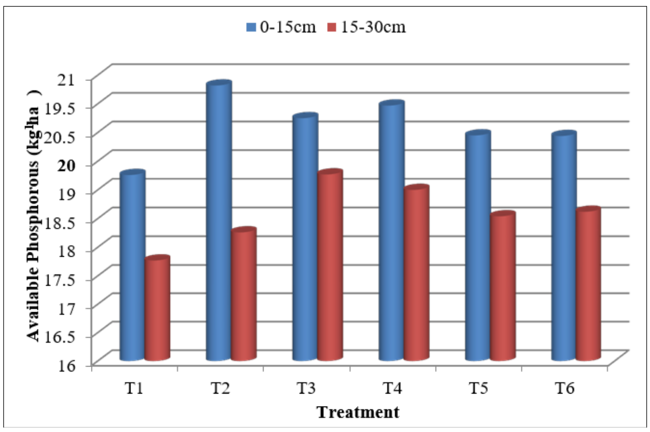

Fig 6: Effect of different organic and inorganic treatment on available Phosphorous in soybean at post-harvest

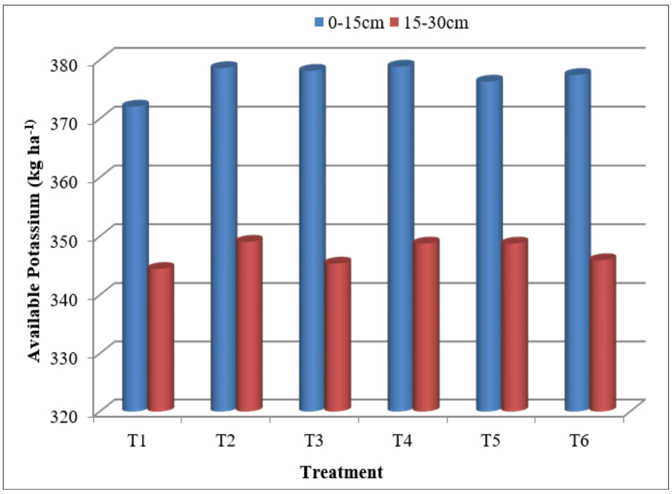

Fig 7: Effect of different organic and inorganic treatment on available Potassium in soybean at post-harvest

Summary and Conclusions

An application of organic and inorganic fertilizers and their combinations, the soil pH, EC, organic carbon (OC) and BD were non-significant in all the treatments. Numerically, the pH value was found higher in T4, T6 at 0-15cm and T1[control((N0P0K0)], T4 at 15-30cm. Maximum EC value observed in T4 OC maximum observed in T2(100% N through Organic Source(1/3 FYM, 1/3 Vermicompost, 1/3 Neem cake), T3(75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS) at 0-15cm and T2 (1/3 FYM, Vermicompost, 1/3 Neem cake) at 15-30cm. Higher bulk density was found in [control(N0P0K0)], T6 (100% N through Inorganic) at 0-15cm andT4,T5, T6 at 15-30cm.

The soil available N P K also not significantly affected by all the treatments. The available N was observed maximum in T3 at 0-15 cm andT4 at 15-30 cm. The available P was maximum in treatment T2 at 0-15cm. Similarly, treatment T3(75% N through Organic Source + 10% foliar spray of Vermiwash and Cow Urine at 25 – 30 DAS and 50-60 DAS) and T4were recorded maximum soil available Phosphorous at 15-30cm. The value of available potassium was maximum recorded in treatment T2 at both surface and subsurface soil, as compare to T1 [control (N0P0K0))].

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