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Effect of Organic and Inorganic Sources of Nutrients on the Physico-Chemical Properties Under Different Cropping System in Vertisol

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Abstract: *A field experiment was conducted at Dry land Research Station,VNMKV, Parbhani during 2003-04 and 2004-05 in Vertisol with application of organics and inorganics sources of nutrients under different cropping system viz., soybean- pigeon pea and sorghum- pigeon pea. The treatment consisted of 50% RDF +FYM@ 2.5 t ha^{-1} and other treatments organic sources such as Glyricidia, FYM, Vermicompost, plant and weed residues, press mud cake ,Neem seed cake, Biofertiliser and recommended dose of fertilizer and last is control. The data were generated on physico-chemical properties of soil after harvest of soybean, pigeon pea, sorghum, pigeon pea after each crop in cropping sequence. The physico-chemical properties viz. bulk density, pH, EC were slightly decreased from their initial values with organic treatments ,while porosity, infiltration rate ,moisture content ,organic carbon ,CaCO3 increased significantly as compared to inorganic treatment in different cropping systems .Thus, application of organic sources helps in improving the physic-chemical properties of soil.*

Keywords: *Physico-chemical properties, Cropping Systems.*

INTRODUCTION

It is well known that the cropping sequence plays a key role in the transformation ,recycling and availability of plant nutrients in soil .These studies further indicated that use of organic sources of nutrients along with chemical fertilizers or separately will be able to maintain soil fertility and sustain crop productivity.

Organic manures helps to maintain the soil organic carbon and nutrient status. Besides this organic manures also helps for better moisture retention and influences favorably other physico-chemical properties of soil. Variation in multiple cropping systems and continuous use of manure and fertilizers exert great deal of influence in modifying the physical properties of soils.

MATERIAL AND METHODS

The experiments involving two cropping systems such as Soybean (*cv.* JS -335) pigeon pea (cv. BSMR-853) and Sorghum (*cv.* CSH-9) pigeon pea (*cv.* BSMR - 853) were conducted at Organic farming and Dry Land Agricultural Research Farm at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The field experiment was conducted for successive two years *viz.*, 2003-2004 and 2004-2005. The experiment was laid out on fixed site in randomized block design with the ten treatments and three replications. The treatments comprised of inorganic and organics sources such as FYM, glyricidia, vermicompost , plant and weed residues, biofertilizers, neem seed cake ,press mud cake etc which were replicated thrice in a randomized block design. Treatment details of experiment are given below in Table 1.

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Table 1
The treatment details of experiment are as given below

(A) Cropping systems	
C_1= Soybean + Pigeonpea (4:2)	
C_2 = Sorghum + Pigeonpea (4:2)	
(B) Treatment details	
Treatment codes	*Treatment details*
T_1	50% RDF + FYM@ 2.5t ha^{-1}
T_2	Glyricidia @ 6 t ha^{-1}
T_3	FYM @ 5 t ha^{-1}
T_4	Vermicompost @ 1 t ha^{-1}
T_5	Plant and weed residues (*in situ*)
T_6	Pressmud cake @ 3 t ha^{-1}
T_7	Neem seed cake @ 1t ha^{-1}
T_8	Biofertilizer (Rhizobium and Azotobacter)
T_9	Recommended dose of fertilizer, NPK (30:60:30)
T_{10}	Control (No manures or fertilizers)

Composite surface (0-30 cm) soil samples collected at the initial flowering and harvesting stages from each plot between rows of each crop. The soil physico-chemical properties were carried out as per the methods such as bulk density by core method (Black 1965),infiltration rate by infiltrometer method (Black 1965),moisture content of soil by gravimetric method (Singh 1980) and pH, EC by Jackson method (1973) and organic C by Walkley and Black method (1934)and $CaCO_3$ by Rapid titration method given by Puri(1949). The soil was having initial bulk density 1.24gcm^{-3} , infiltration rate 1.21 cm hr^{-1},moisture content 16.60%, porosity 53.25 %, pH 7.80, EC 0.3 dSm^{-1}, organic carbon 4.2 gm kg^{-1} ,$CaCO_3$ 84.0 gm kg^{-1} and available N, P, K 174.52, 14.29, 203.83 gm kg^{-1}, respectively.

RESULTS AND DISCUSSION

The influence of various nutrient sources and their combination on various soil physico-chemical properties such as bulk density, infiltration rate, moisture content, porosity and also the pH, EC, organic carbon and $CaCO_3$ of soils as influenced by nutrient management treatment for Soybean + Pigeon pea and Sorghum + Pigeon pea cropping systems in year 2003-04 and 2004-05.

In the year 2003-04, we have observed that the influence of various nutrient sources and their combination on soil physico-chemical properties

Table 2
Physico-chemical properties of soil as influenced by various organic and inorganic sources of nutrients in year 2003-04 after harvest of soybean and pigeon pea.

	Bulk density (mg m^{-3})		*Infiltration rate (cm hr^{-1})*		*Moisture content (%)*		*Porosity (%)*	
Treatments	*After harvest of soybean*	*After harvest of pigeon pea*	*After harvest of sorghum*	*After harvest of pigeon pea*	*After harvest of soybean*	*After harvest of pigeon pea*	*After harvest of soybean*	*After harvest of pigeon pea*
T_1	1.20	1.21	2.70	2.50	21.10	15.95	54.83	54.33
T_2	1.19	1.19	3.10	3.00	24.00	17.34	55.83	55.09
T_3	1.19	1.19	3.00	2.80	24.51	17.21	54.83	54.00
T_4	1.19	1.20	2.80	2.70	23.22	16.88	55.75	54.91
T_5	1.20	1.20	2.90	2.70	23.00	16.50	55.43	55.03
T_6	1.19	1.20	2.90	2.70	23.82	16.90	54.96	54.71
T_7	1.20	1.21	2.80	2.60	21.00	15.32	54.60	54.33
T_8	1.20	1.22	2.60	2.50	20.22	14.21	54.30	53.96
T_9	1.21	1.23	2.60	2.40	20.00	14.22	54.33	53.58
T_{10}	1.21	1.22	2.60	2.40	20.10	14.18	53.40	53.95
Mean	1.20	1.21	2.796	2.626	22.095	15.872	54.828	54.389
SE (±)	0.01	0.06	0.07	0.03	0.24	0.42	2.23	0.59
CD at 5%	NS	NS	0.21	0.09	0.72	1.23	NS	NS
Initial	1.24	–	2.30	–	16.60	–	53.25	–

Table 3
Physico-chemical properties of soil as influenced by various organic and inorganic sources of nutrients in year 2004-05 after harvest of sorghum and pigeon pea.

	Bulk density (mg m^{-3})		*Infiltration rate (cm hr^{-1})*		*Moisture content (%)*		*Porosity (%)*	
Treatments	*After harvest of sorghum*	*After harvest of pigeon pea*	*After harvest of sorghum*	*After harvest of pigeon pea*	*After harvest of sorghum*	*After harvest of pigeon pea*	*After harvest of sorghum*	*After harvest of pigeon pea*
T_1	1.20	1.20	2.55	2.45	20.06	15.12	54.71	54.20
T_2	1.18	1.20	2.95	2.85	22.75	16.39	55.47	55.26
T_3	1.19	1.21	2.71	2.80	23.46	16.21	55.09	54.86
T_4	1.19	1.20	2.55	2.66	22.08	15.99	55.09	55.00
T_5	1.22	1.20	2.66	2.57	21.18	15.50	55.47	55.26
T_6	1.21	1.22	2.80	2.45	22.63	15.96	55.09	54.71
T_7	1.20	1.19	2.66	2.30	19.91	14.53	54.71	54.33
T_8	1.22	1.21	2.61	2.27	19.21	13.46	54.71	54.92
T_9	1.20	1.22	2.51	2.22	19.00	13.50	54.33	53.60
T_{10}	1.21	1.21	2.43	2.33	19.10	13.36	54.33	54.03
Mean	1.20	1.21	2.647	2.4491	20.942	15.006	54.901	54.620
SE (±)	0.03	0.01	0.08	0.03	0.31	0.40	0.31	0.53
CD at 5%	NS	NS	0.23	0.09	0.72	1.23	NS	NS
Initial	1.25	–	2.40	–	16.60	–	54.00	–

such as bulk density of soil at harvest of soybean ranged from 1.19 (T_2, T_3, T_4 and T_6) to 1.20 (T_1, T_7 and T_8) Mg m^{-3} with a mean value of 1.20 Mg m^{-3} and from 1.19 (T_2 and T_3) to 1.23 (T_9) Mg m^{-3} with a mean value of 1.21 Mg m^{-3} after harvest of pigeon pea. The infiltration rate at harvest of soybean ranged from 2.60 (T_8, T_9 and T_{10}) to 3.10 (T_2) cm hr^{-1} with a mean value of 2.80 cm hr^{-1} and from 2.40 (T_9 and T_{10}) to 3.00 (T_2) cm hr^{-1} with a mean value of 2.63 cm hr^{-1}after harvest of pigeon pea. The moisture content at harvest of soybean ranged from 20.00 (T_9) to 24.51% (T_3), with a mean value of 22.10 % and from 14.18 (T_{10}) to 17.34 % (T_2) with a mean value of 15.87 % after harvest of pigeon pea.

The values of porosity at harvest of soybean ranged from 53.40 (T_{10}) to 55.83 (T_2) per cent, with a mean value of 54.83 per cent and from 53.58 (T_9) to 55.09 (T_2)) per cent, with a mean value of 54.39 per cent after harvest of pigeon pea. However, the values of soil pH ranged from 7.76 (T_8) to 7.81 (T_5 and T_9) with a mean value of 7.79 after harvest of soybean and from7.76 (T_2 andT_8) to 7.80 (T_3, T_5 T_9 and T_{10}) with a mean value of 7.79 after harvest of pigeon pea. The values of electrical conductivity at harvest of soybean ranged from 0.32 (T_3 and T_4) to 0.39 (T_9) dS m^{-1} with a mean value of 0.35 dS m^{-1} and from 0.30 (T_3) to 0.38 (T_9) dS m^{-1} with a mean value of 0.35 dS m^{-1} after harvest of pigeon pea. The values of organic carbon at harvest of soybean ranged from 4.2 (T_{10}) to 5.2 (T_3) g kg^{-1} with a mean value of 4.87g kg^{-1} and from 4.6 (T_{10}) to 5.3 (T_3) g kg^{-1} with a mean value of 4.99 g kg^{-1}after harvest of pigeon pea. The contents of soil calcium carbonate ranged from 77 (T_2) to 83 (T_{10}) g kg^{-1} with a mean value of 80 g kg^{-1} after harvest of soybean and from 76 (T_2 and T_5) to 82 (T_{10}) g kg^{-1} with a mean value of 79 g kg^{-1} after harvest of pigeon pea.

In the year 2004-05, we have observed that the influence of various nutrient sources and their combination on soil physico-chemical properties such as the values of bulk density after harvest of sorghum ranged from 1.18 (T_2) to 1.22 ($T_5$and T_8) Mg m^{-3} with a mean value of 1.20 Mg m^{-3} and from 1.19 (T_7) to 1.22 (T_6 and T_9) Mg m^{-3} with a mean value of 1.21 Mg m^{-3} after harvest of pigeon pea. The values of infiltration rate after harvest of sorghum ranged from 2.43 (T_{10}) to 2.95 (T_2) cm hr^{-1} with a mean value of 2.65 cm hr $^{-1}$ and from 2.22 (T_9) to 2.85 (T_2) cm hr^{-1} with a mean value of 2.45 cm hr^{-1} after harvest of pigeon pea. The values of

Table 4
Physico-chemical properties of soil as influenced by various organic and inorganic sources of nutrients in year 2003-04 after harvest of sorghum and pigeon pea.

	pH of soil		*EC (dS m⁻¹)*		*Organic C (g kg⁻¹)*		*$CaCO_3$ content (g kg⁻¹)*	
Treatments	*After harvest of soybean*	*After harvest of pigeonpea*	*After harvest of soybean*	*After harvest of pigeonpea*	*After harvest of soybean*	*After harvest of pigeonpea*	*After harvest of soybean*	*After harvest of pigeonpea*
T_1	7.78	7.78	0.37	0.36	4.8	5.0	80	79
T_2	7.77	7.76	0.35	0.35	5.1	5.2	77	76
T_3	7.80	7.80	0.32	0.30	5.2	5.3	79	78
T_4	7.78	7.78	0.32	0.33	5.0	5.1	78	77
T_5	7.81	7.80	0.33	0.33	4.8	4.8	78	76
T_6	7.80	7.79	0.38	0.37	5.0	5.1	80	79
T_7	7.79	7.78	0.36	0.36	4.9	4.9	81	80
T_8	7.76	7.76	0.37	0.37	4.9	4.8	80	79
T_9	7.81	7.80	0.39	0.38	4.9	5.0	82	81
T_{10}	7.80	7.80	0.34	0.34	4.2	4.6	83	82
Mean	7.79	7.79	0.353	0.350	4.87	4.99	79.80	78.67
SE (±)	0.26	0.18	0.03	0.03	0.32	0.38	3.45	3.32
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Initial	7.80	–	0.35	–	4.2	–	79	–

moisture content after harvest of sorghum ranged from 19.00 (T_9) to 23.46 % (T_3) with a mean value of 20.94 % and from 13.36 (T_{10}) to 16.39 % (T_2) with a mean value of 15.01 % after harvest of pigeon pea. The values of porosity after harvest of sorghum ranged from 54.33 (T_9, T_{10}) to 55.47(T_2 and T_5) per cent, with a mean value of 54.90 per cent and from 53.60 (T_9) to 55.26 (T_2, T_5) per cent, with a mean value of 54.62 per cent after harvest of pigeon pea . The values of pH after harvest of sorghum ranged from 7.70 (T_2) to7.82 (T_9) with a mean value of 7.75 and from 7.7 5 (T_1) to 7.81 (T_5 and T_6) with a mean value of 7.79 after harvest of pigeon pea.

The values of electrical conductivity after harvest of sorghum ranged from 0.31 (T_3) to 0.38 (T_1, T_6, T_7, T_8 and T_9) dS m^{-1} with a mean value of 0.36 dS m^{-1} and from 0.31 (T_3) to 0.38 (T_9) dS m^{-1} with a mean value of 0.36 dS m^{-1} after harvest of pigeonpea. The soil organic carbon content after harvest of sorghum ranged from 4.4 (T_{10}) to 5.2 (T_3) g kg^{-1} with a mean value of 4.84 g kg^{-1} and from 4.6 (T_{10}) to 5.3 (T_3) g kg^{-1} with a mean value of 4.97 g kg^{-1} after harvest of pigeon pea. The calcium carbonate content in soil after harvest of sorghum ranged from 77 (T_2) to 82 (T_9 and T_{10}) g kg^{-1} with a mean value of 80 g kg^{-1} and from 78 (T_9 and T_{10}) to 83 (T_2 and T_5) g kg^{-1} with a mean value of 81 g kg^{-1} after harvest of pigeon pea.

However, the results of bulk density were non-significant. This may because of the fact that bulk density of soil hardly undergoes changes in short run. Variation in multiple cropping systems and continuous use of manure and fertilizers exert great deal of influence in modifying the physical properties of soils. In this context, Singh and Sandhu (1980) recorded that only the legume crops in rotation had favourable effects on bulk density by creating porous condition in soil. The decrease in bulk density with organic treatments may be due to addition of organic matter and increase in porosity of soil. Use of only chemical fertilizers had no effect on bulk density (Chaphale *et al.* 2000).

The treatment differences in infiltration rate were observed to be significant during both the years of experimentation. The maximum infiltration rate was recorded with glyricidia and other organic sources of nutrients over control besides the inorganic sources of nutrients. The inorganic fertilizers along with the organic manures also improved infiltration rate. The increase in

Table 5
Physico-chemical properties of soil as influenced by various organic and inorganic sources of nutrients in year 2004-05 after harvest of sorghum and pigeon pea

	pH of soil		*EC (dS m⁻¹)*		*Organic C (g kg⁻¹)*		*$CaCO_3$ content (g kg⁻¹)*	
Treatments	*After harvest of sorghum*	*After harvest of pigeon pea*	*After harvest of sorghum*	*After harvest of pigeonpea*	*After harvest of sorghum*	*After harvest of pigeonpea*	*After harvest of sorghum*	*After harvest of pigeonpea*
T_1	7.72	7.75	0.38	0.37	4.8	5.0	80	81
T_2	7.70	7.77	0.36	0.35	5.1	5.2	77	83
T_3	7.75	7.78	0.31	0.31	5.2	5.3	79	82
T_4	7.74	7.76	0.33	0.33	4.9	5.1	78	82
T_5	7.80	7.81	0.36	0.33	4.7	4.8	78	83
T_6	7.74	7.81	0.38	0.37	5.0	5.2	80	81
T_7	7.74	7.79	0.38	0.36	4.8	4.9	81	79
T_8	7.74	7.80	0.38	0.37	4.7	4.8	81	80
T_9	7.82	7.80	0.38	0.38	4.8	4.9	82	78
T_{10}	7.75	7.78	0.32	0.35	4.4	4.6	82	78
Mean	7.75	7.79	0.361	0.356	4.84	4.97	79.90	80.63
SE (±)	0.27	0.27	0.03	0.03	0.30	0.34	3.29	3.21
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Initial	7.85	–	0.38	–	4.3	–	80	–

infiltration rate might be due to the application of organic alone or in combination with inorganic fertilizers. These help to add organic matter to its which having significant role in increasing water stable aggregates, porosity and soil permeability thereby, promoting infiltration rate as observed by More (1994). The infiltration rate was also increased with wheat straw application @ 5 t ha^{-1} and green gram residue incorporation (Karle *et al.*1995). Similarly, Malewar and Hasnabade (1995) concluded that application of 50 % N through inorganic and 50 % through FYM, wheat straw, leaf manure and glyricidia helped to increase infiltration rate of soil.The application of inorganic fertilizer alone did not influence the infiltration rate. However, it was lower than that of organic sources. This can be attributed to deterioration of soil structure with the addition of inorganic fertilizer alone as reported by Bonde (1997).

The soybean + pigeonpea cropping system showed maximum moisture content in soil throughout the growth period, but the results were non-significant. Slight increase in moisture content in soybean + pigeon pea cropping system might be due to addition of crop residues to soil.

Moisture content in soil was significantly influenced by fertility levels. Higher moisture content due to organic treatments might be due to the fact that organic matter makes the soil more porous and in turn improves the ability of soil to retain more moisture (Bhatangar *et al.* 1992). The slow decomposing organic materials when remained in soil for a prolonged period act as an insulator for minimizing moisture loss by evapotranspiration during last rainy days. This could be the possible reason for increasing moisture content of soil profile for a prolonged period. Similar observations were recorded by Ramteke and Kumbhar (2000) who found that the moisture content in soil significantly improved due to application of FYM, paddy straw, glyricidia and poultry manure. Badanur *et al.* (1990) recorded increase in water content of soil due to addition of sorghum stubbles and sunflower stalks. The moisture content of soil was also found to increase with wheat straw application and green residue incorporation (Karle *et al.* 1995).The application of FYM and PMC in combination with inorganic fertilizer also improved the available water content of soil (Dhamak, 2001). Awasarmal *et al.* (2002) also indicated that the application of FYM, glyricidia leaves and wheat straw, proved to be better for moisture conservation over RDF and control.

The treatmental differences in porosity were non-significant during both years of experimentation. There was slight increase in porosity with soybean + pigeonpea cropping system. This might be due to addition of plant and weed residues, which improved the soil structure and aeration.

The treatment *i.e.* FYM @ 5 t ha^{-1} recorded maximum soil porosity followed by the treatment *i.e.* glyricidia @ 6 t ha^{-1} in two years of experimentation. The magnitude of increase in porosity was more in organic manuring as compared to inorganic with organic and control. The increase in porosity with organic and organic combined with inorganic may be due to accumulation of high organic matter leading to improvement in soil aggregation. Malewar *et al*. (2000) also reported the beneficial effect of FYM in improving the soil physical properties as a result of better aggregation of soil particles formation of more pore spaces and better aeration. Similar results were reported by Bellakki *et al.* (1998) and Chaphale *et al.* (2000). Ganure (1991) also reported that different cropping sequences *i.e.* soybean + safflower + sesamum and sorghum + sunflower + groundnut did not affect bulk density and porosity of soil. The continuous use of glyricidia as green manure also increases the soil porosity (Chaphale *et al.* 2000).

The soil pH was not much influenced by different nutrient management treatments. The treatment differences were non-significant during both the years of experimentation. Ghuman *et al.* (1997) found that the green manure with sunhemp decreased pH while Bharadwaj and Omanwar (1994) did not find any significant change in pH with long term effect of fertilization and manuring. This could be attributed to relatively higher buffering capacity of soil.

From the results it was observed that there was no much variation in electrical conductivity due to different nutrient management treatments and cropping systems. Similar trend in electrical conductivity values were observed by Sharma *et al.*, (1980)). Brar and Singh (1986) found that there were no differences in electrical conductivity values even after 8 years of experimentation. There was slight decrease in electrical conductivity with organic treatments as compared to inorganic treatments during both the years. Narkhede and Ghugare (1987) found significant decrease in electrical conductivity with long term manuring.

The results on organic carbon content in soil clearly indicated that there was build up of organic carbon over initial values in both the cropping systems. Higher organic carbon content was recorded in soybean + pigeonpea cropping system. This might be due to addition of lot of litter and other organic matters contributed by soybean and pigeonpea. Similar results were observed due to inclusion of legumes in the cropping systems (Ganure, 1991).

Soil organic carbon was influenced by various organic and inorganic nutrient sources. Kanwar and Prihar (1982) indicated that continuous application of inorganic fertilizers with organic material increased the organic carbon content in soil. From the results it was observed that the treatment T_3 *i.e.* FYM @ 5 t ha^{-1} showed highest build up of organic carbon followed by T_2 *i.e.* glyricidia @ 6 t ha^{-1}. This may be due to direct addition of organic matter. Continuous use of FYM helped in maintaining and improving physical properties and organic carbon content of the soil. Subbaih and Kumarswamy, (2000), Tolanur and Badanur (2003) observed that organic carbon content of soil increased significantly with incorporation of FYM or subabul lopping in soil. The results on calcium carbonate content of the soil as influenced by soybean + pigeonpea and sorghum + pigeonpea cropping systems were found to be non-significant. However, the cropping system soybean + pigeonpea showed relatively low calcium carbonate content in soil. This may be due to addition of excess of soybean residues which upon decomposition might have neutralized some free $CaCO_3$.

The treatment (T_2) *i.e.* glyricidia @ 6 t ha^{-1} recorded lowest calcium carbonate content. Bellakki and Badanur (1997) also recorded decline in calcium carbonate content of the soil with the addition of organic material. The organic acids during the decomposition of organic material might have reacted with calcium carbonate releasing CO_2. The non-significant decrease in calcium carbonate content may be attributed to the high buffering capacity of soil (Magdoff and Amadan, 1980).

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