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Effect of potash management through gliricidia green leaf manuring on physico-chemical and biological properties of vertisols

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Abstract
A field study was conducted to evaluate the effect of potash management through gliricidia green leaf manuring on physico-chemical and biological properties of Vertisol during *Kharif* 2016 at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The six treatments replicated four times in randomized block design comprised of control, 100% RDF (30:75:30 NPK kg ha^{-1}), 75% and 50% N and 100% P through chemical fertilizers and the combinations of 15 and 30 kg K ha^{-1} through gliricidia green leaf manure at 30 DAS and remaining recommended dose of potassium as basal dose through inorganic fertilizers. The results indicated that application of 100 % RDF (30:75:30 NPK kg ha^{-1}) resulted in higher nutrient uptake and soybean yield and was found to be on par with application of 75% N +100% P+15 kg K (inorganic) +15 kg K through gliricidia. However, the significant improvement in biological properties of soil was recorded with application of 75% N +100% P+15 kg K through chemical fertilizers +15 kg K through gliricidia. Hence, it is concluded that conjunctive application of 75% N +100% P+15 kg K through chemical fertilizers +15 kg K through gliricidia green leaf manuring at 30 DAS resulted in improvement in Physico-chemical and biological properties of Vertisols under rainfed conditions.

Keywords: Potash, gliricidia green leaf manure, vertisols

Introduction
Soybean (*Glycine max.* L.) is one of the important oil seed as well as leguminous crop. It is originated in Eastern Asia/China and is second largest oilseed crop in India after groundnut. It is a miracle "Golden bean" of the 21^{st} century mainly due to its high protein content-40%, oil-20%, carbohydrates-30%, fibre-0.5%, lecithin -0.5% and saponin -4%, and it is now making headway in Indian agriculture. In India, it is mainly grown as oil seed crop and is the cheapest and richest source of high quality protein. It supplies most of the nutritional constituents essential for human health. Soybean occupies an intermediate position between legumes and oilseeds. *Gliricidia sepium* belongs to leguminous family with subfamily Papilionoideae. It is a leguminous multipurpose tree and adopts very well in a wide range of soils. The application of green manures to soil is considered a good management practice in any agricultural production system because it stimulate soil microbial growth and activity, with subsequent mineralization of plant nutrients (Eriksen, 2005) [9] and therefore improve soil fertility and quality (Doran *et al.*,1988) [8].

Material and Methods
The experiment conducted at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, which is situated in between 22^0 41' N latitude and $77^0$02' E longitude at an altitude of 307.4 m above mean sea level and has a subtropical climate. The climate is characterized by three distinct seasons viz., summer becoming hot and dry from March to May. Monsoon characterized as warm rainy from June to October and winter with dry mild cold from November to February. Most of the rainfall is received from south west monsoon. The representative soil samples (0-20 cm) were collected from all the plots at harvest of soybean crop and were analyzed as per standard procedures. Bulk density was determined by clod coating method as described by Blake and Hartge (1986) [6], Saturated hydraulic conductivity was determined by constant head method as described by Black (1965) [5], Hydrogen ion activity expressed as pH was measured with pH meter using 1:2.5 soil-water suspension (Jackson, 1973) [12], Electrical conductivity (EC) the clear supernatant extract obtained from soil-water suspension used for pH was utilized for the EC measurement using a conductivity bridge (Jackson, 1973) [12]. and Walkley and Black method as described by Jackson (1973) [12] was used to determine organic carbon content of soil.

Soil microbial carbon biomass (Jenkinson and Powlson, 1976) [13], Dehydrogenase activity (Klein *et al.* 1971) [16], CO_2 evolution (Anderson., 1982) [3]. and Alkaline phosphatase (Tabatabai and Bremner, 1969) [24]. were estimated to find out the biological activity of the soil.

Results and Discussion

Physical and chemical properties of soil

Importance of physical and chemical properties of soil in relation to plant growth is widely recognized. Continuous application of inorganic fertilizers increases productivity but soil fertility status is generally reduced whereas, the combined application of organic manures and chemical fertilizer regulate quality; improve crop yield and physical environment of soil.

Bulk density

The data pertaining to the bulk density of soil as influenced by various treatments was statistically non-significant and it ranged from 1.46 to 1.48 Mg m^{-3}, indicating that the lowest (1.46 Mg m^{-3}) bulk density was recorded with the application of 75% N +100% P+15kg K (inorganic)+15 kg K through gliricidia (T_3) and 75% N +100% P+30kg K through gliricidia (T_4). The higher value of bulk density (1.48 Mg m^{-3}) was found in treatment T_1 *i.e.* control. The lower values of bulk density in gliricidia treated plots may be due to aggregation of soil particle due to increasing organic matter as well as stability of aggregates which leads to increase the total pore space in soil. Similar results were also reported by Guled *et al.* (2002) [10], Selvi *et al.* (2005) [21]. and Kalhapure *et al.* (2013) [14].

Table 1: Effect of gliricidia green leaf manuring on physical properties of soil

	Treatments	BD (Mg m^{-3})	HC (cm hr^{-1})
T_1	Control	1.48	0.83
T_2	100 % RDF (30:75:30 NPK kg ha^{-1})	1.47	0.85
T_3	75% N +100%P+15 kg K(inorganic)+15 kg K through gliricidia	1.46	0.92
T_4	75% N +100%P+30 kg K through gliricidia	1.46	0.90
T_5	50% N +100%P+30 kg K through gliricidia	1.47	0.87
T_6	100% K through gliricidia	1.47	0.88
	SE (m) $\pm$	0.01	0.01
	CD at 5%	NS	0.03

Hydraulic conductivity

The data pertaining to the hydraulic conductivity of soil as influenced by different treatments was statistically significant and it ranged from 0.83 to 0.92 cm hr^{-1} indicating that the highest (0.92 cm hr^{-1}) hydraulic conductivity was recorded with the application 75% N +100% P+15kg K (inorganic)+15 kg K through gliricidia (T_3) and it was found to be on par with application of 75% N +100% P+30kg K through gliricidia (T_4). The lower value of hydraulic conductivity (0.83 cm hr^{-1}) was found in treatment T_1 *i.e.* control. Green manuring with gliricidia and inorganic fertilizer applied in combination recorded higher hydraulic conductivity which might be due to the better soil particle aggregation, microbial respiration, increased pore space and decreased soil bulk density. Similar results were also reported by Bellakki and Badanur (1997) [4], Guled *et al.* (2002) [10]. and Kalhapure *et al.* (2013) [14].

pH (1:2.5)

The pH of soil ranged from 8.05 to 8.15, indicating that soil was moderately alkaline in reaction. The higher value of pH (8.15) was recorded in control treatment. The lowest pH (8.05) was recorded with the application of 75% N +100% P+15 kg K (inorganic)+15 kg K through gliricidia (T_3). However, treatment wise variation in pH was found to be non-significant. The lower value of pH in integrated nutrient management treatments may be due to application of organics which produce organic acids, thereby reduce the pH of soil. Decrease in pH may be due to organic matter added with gliricidia green leaf manuring which acts as a pH buffer, releasing H^+ which is responsible for reducing alkalinity of the soil. Similar results were also reported by Rao and Janawade (2009) [19], Kalhapure *et al.* (2013) [14] and Sanjay Kumar *et al.* (2015) [20].

EC (dS m^{-1})

The data in respect of electrical conductivity of soil ranged from 0.33 to 0.37 dS m^{-1}. However, the data indicated that the lower value (0.33 dS m^{-1}) was observed with application of 75% N +100% P+15 kg K (inorganic)+15 kg K through gliricidia (T_3). However, treatment wise variation in EC indicated that all the treatments were found to be on par with each other, except control. The higher value (0.37 dS m^{-1}) of electrical conductivity was recorded in treatment T_1 *i.e.* control. Electrical conductivity did not vary much in different treatments with incorporation of green manures over fertilizer application. Similar results were also reported by Vaiyapuri *et al.* (2008) [26], Rao and Janawade (2009) [19]. and Hababi *et al.* (2013) [11].

Organic carbon

Organic carbon is an indication of organic carbon fraction of soil formed due to microbial decomposition of organic residue. The data pertaining to the organic carbon content of soil as influenced by different treatments was statistically significant and it ranged from 0.48 to 0.64% indicating that the highest (0.64%) organic carbon was recorded with the application of 75% N +100% P+15 kg K(inorganic)+15 kg K through gliricidia (T_3) and it was found to be on par with application of 100% RDF (30:75:30 NPK kg ha^{-1}) (T_2), and treatment receiving 75% N +100% P+30 kg K through gliricidia (T_4). It was also observed that 33.3% and 3.2 increase in organic carbon content was recorded in treatment T_3 as compared to control and 100 % RDF (30:75:30 NPK kg ha^{-1}) treatments respectively. The lower value (0.48%) of organic carbon was found in treatment T_1 *i.e.* control. The higher values of organic carbon content with application of gliricidia green leaf manuring may be attributed to addition of organic materials and greater root biomass with their addition as evidenced from the higher yields obtained in these treatments. Similar results were also reported by Malewar and Hasnabade (1995) [17], Surekha and Rao (2009) [22], Hababi *et al.* (2013) [11] and Aher *et al.* (2015) [2].

Table 2: Effect of gliricidia green leaf manuring on chemical properties of soil

Treatments		pH (1:2.5)	EC (dS m^{-1})	OC (%)
T_1	Control	8.15	0.37	0.48
T_2	100 % RDF (30:75:30 NPK kg ha-1)	8.10	0.36	0.62
T_3	75% N +100%P+15 kg K(inorganic)+15 kg K through gliricidia	8.05	0.33	0.64
T_4	75% N +100%P+30 kg K through gliricidia	8.07	0.34	0.61
T_5	50% N +100%P+30 kg K through gliricidia	8.08	0.34	0.54
T_6	100% K through gliricidia	8.08	0.35	0.52
	SE (m) +	0.04	0.01	0.01
	CD at 5%	NS	0.03	0.03

Biological properties of soil

The observations in respect of soil microbial biomass carbon and dehydrogenase activity are presented in the Table 3 while, the results in respect of alkaline phosphatase and CO_2 evolution are presented in the Table 4.

Soil microbial biomass carbon

The results pertaining to soil microbial biomass carbon status of soil was significantly influenced by various treatments. The soil microbial biomass carbon in soil varied from 99.36 mg kg^{-1} soil to 144.48 mg kg^{-1} soil. The results specified that treatment with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) recorded highest soil microbial biomass carbon (144.48 mg kg^{-1}soil) and it was found to be on par with application with 75% N +100% P+30kg K through gliricidia (T_4) and lowest soil microbial biomass carbon was noted in control treatment (T_1). Increase in soil microbial biomass carbon might be due to application of gliricidia green leaf manuring which adds mineralizable and readily hydrolyzable carbon which resulted in higher microbial activity and in turn higher SMBC content. Moreover, the SMBC acts as the transformation agent of the organic matter in the soil. Similar results were also reported by Kirchner *et al.* (1993) [15], Chander *et al.* (1997) [7] and Mali *et al. (*2015) [18].

Dehydrogenase activity

The results regarding dehydrogenase activity in soil was significantly influenced by different treatments. The dehydrogenase activity in soil varied from 25.52 µg TPF g^{-1} 24 h^{-1} to 33.51 µg TPF g^{-1} 24 h^{-1}.

Table 3: Effect of gliricidia green leaf manuring on SMBC and DHA in soil

Treatments		SMBC (mg kg^{-1} soil)	DHA (µgTPF g^{-1} 24 h^{-1})
T_1	Control	99.36	25.52
T_2	100 % RDF (30:75:30 NPK kg ha^{-1})	128.27	31.33
T_3	75% N +100%P+15 kg K(inorganic)+15 kg K through gliricidia	144.48	33.51
T_4	75% N +100%P+30 kg K through gliricidia	140.10	31.77
T_5	50% N +100%P+30 kg K through gliricidia	130.20	28.51
T_6	100% K through gliricidia	122.34	27.15
	SE (m) $\pm$	2.01	0.51
	CD at 5%	6.07	1.55

The results showed that treatment with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) recorded highest dehydrogenase activity (33.51µgTPF g^{-1} 24 h^{-1}) and it was found to be on par with application of 75% N +100% P+30kg K through gliricidia (T_4). The lowest dehydrogenase activity in soil was recorded in control (T_1) treatment. Relatively stronger effects of gliricidia green leaf manuring on dehydrogenase activity might be due to the more easily decomposable component- green manure on the metabolism of soil microorganisms and due to the increase in microbial growth with addition of carbon substrate. Similar results were also reported by Chander *et al.* (1997) [7], Tejada *et al.* (2008) [25], Surucu *et al.* (2014) [23], Mali *et al.* (2015) [18]. and Aher *et al.* (2015) [2].

Alkaline phosphatase

The results revealed that alkaline phosphatase was significantly influenced by different treatments in soybean. The treatment with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) recorded significantly highest alkaline phosphatase (201.46µg P-nitriphenol g^{-1} 24 h^{-1}) and it was found to be on par with application of 100% RDF (30:75:30 NPK kg ha^{-1}) (T_2) and 75% N +100% P+30kg K through gliricidia (T_4). The treatment with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) recorded significantly highest alkaline phosphatase (201.46µg P-nitriphenol g^{-1} 24 h^{-1}) and it was found to be on par with application of 100% RDF (30:75:30 NPK kg ha^{-1}) (T_2) and 75% N +100% P+30kg K through gliricidia (T_4). The lowest alkaline phosphatase was observed in control treatment. Significantly higher activities of alkaline phosphatase in soil treated with gliricidia green leaf manuring may be due to enhanced microbial activity and diversity of phosphate solubilizing bacteria. Similar results were also reported by Chander *et al.* (1997) [7], Abdallahi and N'Dayegamiye (2000) [1], Tejada *et al.* (2008) [25], Mali *et al.* (2015) [18] and Aher *et al.* (2015) [2].

Table 4: Effect of gliricidia green leaf manuring on Alkaline phosphatase and CO_2 evolution in soil

Treatments		Alkaline phosphatase (µg P- nitriphenol g^{-1} 24 h^{-1})	CO_2 evolution (CO_2 evolved per 100 g of soil)
T_1	Control	187.97	29.43
T_2	100 % RDF (30:75:30 NPK kg ha^{-1})	197.87	36.99
T_3	75% N +100%P+15 kg K(inorganic)+15 kg K through gliricidia	201.46	40.70
T_4	75% N +100%P+30 kg K through gliricidia	196.65	38.78
T_5	50% N +100%P+30 kg K through gliricidia	192.12	36.58
T_6	100% K through gliricidia	191.89	34.10
	SE (m) ±	2.06	0.95
	CD at 5%	6.20	2.87

CO_2 evolution

The results pertaining to CO_2 evolution in soil was significantly influenced by different treatments. The treatment with application of 75% N +100%P+15 kg K(inorganic)+15 kg K through gliricidia (T_3) recorded significantly highest CO_2 evolution (40.70 CO_2 evolved per 100 g of soil) followed by treatment with application of 75% N +100%P+30 kg K through gliricidia (T_4). The lowest CO_2 evolution was observed in control treatment. The increased metabolically active microbial biomass could have resulted in increased soil respiration rate by the application of gliricidia green leaf manuring. The treatments with inorganic fertilizers alone recorded comparatively lower rate of microbial respiration. Similar results were also reported by Tejada *et al.* (2008) [25] and Mali *et al.* (2015) [18].

The results indicated that the use of gliricidia green leaf manuring at 30 DAS in conjunction with chemical fertilizers resulted in improvement of physico-chemical and biological properties of soil. Hence, it is concluded that the integrated application of 75% N +100% P+15 kg K through chemical fertilizer+15 kg K through gliricidia green leaf manuring at 30 DAS resulted in improvement in physico-chemical and biological properties Vertisols under rainfed conditions.

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