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Effect of combined use of potassic fertilizer and gliricidia green leaves on soil fertility, nutrient balance and yield of rainfed cotton in Vertisols

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ABSTRACT

A field experiment was conducted at research farm of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra), to assess the effect of potash management through gliricidia green leaves on soil fertility, nutrient balance and yield of rainfed cotton (Gossypium spp.) in Vertisols during kharif season of 2020. The results revealed that there was significant increase in hydraulic conductivity, organic carbon and available N, P, K of soil and decrease in soil pH, EC and bulk density in the gliricidia incorporated treatments as compared to control. The highest available N (211.1 kg ha^{-1}), P (16.7 kg ha^{-1}) and K (361.5 kg ha^{-1}) was observed with the application of 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia which increased by 16, 31.7 and 13.7% respectively over control. Similarly, the nutrient balance after six years of experiment was also higher with the application of 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia being 25.4 kg ha^{-1} for available N, 2.15 kg ha^{-1} for available P and 39.6 kg ha^{-1} for available K. There was significant reduction in the bulk density of soil, being lowest (1.40 Mg m^{-3}) in the treatment 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia as compared to control. Significant improvement in the seed and stalk yield of cotton was recorded with the application of 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia, with increment of 60, 18% and 64, 22% over control and 100% RDF, respectively.

Keyword: Vertisols, Cotton, gliricidia, soil fertility, nutrient balance, yield

INTRODUCTION

Potassium is an essential plant nutrient and is required in large amounts for the proper growth and development of plants. Although it is not incorporated into the structural component like nitrogen it is found in the cell sap in ionic form (K^+) and plays a major role in osmotic regulation, maintaining ion balance, translocation of assimilates, photosynthesis, protein and starch synthesis and several metabolic processes. Long-term crop production on a same piece of land with improper potassium management will negatively impact the plant growth and soil fertility. Application of chemical fertilizers with organic manures improves soil physical, biological properties and soil fertility and crop yields. Hence, integrated nutrient management is the tool that will help us to transit from inorganic to fully sustainable agriculture.Gliricidia plant is fast-growing and is quite adaptable to various agroclimatic conditions in tropical regions. It decomposes faster than FYM because of its simpler composition which is easy to decompose, the C:N ratio is lower than FYM which facilitate a better microbial population growth for decomposition. Application of 1t gliricidia ha^{-1} leaf manure provides 21 kg N, 2.5 kg P, 18 kg K, 85 g Zn, 164 g Mn, 365 g Cu, and 728 g Fe besides considerable quantities of S, Ca, Mg, B, Mo etc. Its application in correct dose along with inorganic fertilizer improves soil fertility, physical, chemical and biological factors of soil, yield of crop, which also indirectly helps to reduce all the malefic effects of conventional practices and conserve the natural resources. Hence, the present study was planned to witness how the conjugation of inorganic fertilizers with gliricidia green leaves at various doses stimulate the soil fertility and cotton productivity in Vertisols under rainfed conditions.

MATERIALS AND METHODS

A field experiment was conducted during 2020-21 on the research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola in a long-term fertilizer experiment which was initiated during 2015-16. The experimental site is characterized by sub-tropical climate with average maximum high temperature of 42.9^0 C

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and minimum low temperature of 12.5^0 C. The soil was Vertisols belonging to smectite, hyperthermic family of Typic Haplusterts. The soil was clay in texture with slightly alkaline pH (8.07), organic carbon (5.1 g kg^{-1}), available N (185.8 kg ha^{-1}), P (14.6 kg ha^{-1}) and available K (322.0 kg ha^{-1}). The experiment was conducted with nine treatments comprising T_1: Control, T_2: 100 % RDF (60:30:30 NPK kg ha^{-1}), T_3: 100 % NP + 15 kg K (inorganic) + 15 kg K through gliricidia, T_4: 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia, T_5: 100 % NP + 30 kg K through gliricidia, T_6: 75 % N + 100 % P + 15 kg K (inorganic) + 15 kg K through gliricidia, T_7: 75 % N + 100 % P + 30 kg K through gliricidia, T_8: 50 % N + 100 % P + 30 kg K through gliricidia, T_9: 100 % K through gliricidia, with three replications in randomized block design. The recommended basal dose of fertilizer was applied to the soil using urea, single superphosphate and muriate of potash at sowing. Cotton variety "AKH 9916" was sown on 19th of June 2020. Gliricidia green leaves were incorporated 30 days after sowing. Picking of cotton was done on 2nd November and 23rd December, 2020. Surface (0-15 cm) soil samples collected from plots after harvest of cotton were analyzed for pH, EC, organic carbon (Jackson, 1973), available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen, 1954), available potassium (Black, 1965), soil bulk density (Blake and Hartge, 1986), saturated hydraulic conductivity (Klute and Dirksen, 1986). The mean data on various parameters were subjected to statistical analysis as per procedure given by Gomez and Gomez (1984). Least significant difference (LSD) values at P = 0.05 were used to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Physical Properties

The bulk density of soil was influenced by various treatments significantly and it ranged from 1.40 to 1.46 Mg m^{-3}, being lowest (1.40 Mg m^{-3}) in 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia and 100 % NP + 30 kg K through gliricidia (Table 1). The higher value of bulk density (1.46 Mg m^{-3}) was found in control. The lower value of bulk density in gliricidia treated plots may be due to increased organic matter following gliricidia incorporation that favors the soil aggregation and aggregate stability thereby improves the soil pore spaces. Moreover, dilution effect of gliricidia green leaf manure may also result into lower bulk density in gliricidia incorporated plots. The hydraulic conductivity of soil ranged from 0.74 to 0.91 cm hr^{-1} being highest in treatment 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia and lowest in control (Table 1). Inorganic fertilizer in conjugation with gliricidia green leaves recorded higher saturated 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 Rao and Janawade (2009) and Jadhao *et al.* (2019).

Table 1: Effect of various treatments on physical and chemical properties of soil and yield of rainfed cotton

Treatments	BD (Mg m^{-3})	HC (cm hr^{-1})	pH (1:2.5)	EC (dSm^{-1})	Yield (kg ha^{-1})	
					Seed cotton	Cotton stalk
T_1	1.46	0.74	8.05	0.31	470.85	673.61
T_2	1.45	0.80	8.04	0.29	638.88	905.62
T_3	1.42	0.89	7.99	0.27	712.82	1004.81
T_4	1.40	0.91	7.98	0.26	755.21	1104.42
T_5	1.40	0.89	7.97	0.25	655.35	930.23
T_6	1.43	0.82	8.01	0.28	653.97	851.59
T_7	1.41	0.87	8.00	0.27	577.71	748.93
T_8	1.42	0.78	8.00	0.28	558.02	721.81
T_9	1.43	0.83	8.03	0.29	548.90	693.43
SE (m) ±	0.01	0.014	0.02	0.01	37.27	61.10
CD at 5%	0.03	0.041	0.05	0.02	111.73	183.19

T_1: Control, T_2: 100 % RDF (60:30:30 NPK kg ha^{-1}), T_3: 100 % NP + 15 kg K (inorganic) + 15 kg K through gliricidia, T_4: 100 % NP + 10 kg K (inorganic) + 20 kg K through gliricidia, T_5: 100 % NP + 30 kg K through gliricidia, T_6: 75 % N + 100 % P + 15 kg K (inorganic) + 15 kg K through gliricidia, T_7: 75 % N + 100 % P + 30 kg K through gliricidia, T_8: 50 % N + 100 % P + 30 kg K through gliricidia, T_9: 100 % K through gliricidia

The pH of soil was reduced in all treatments as compared to its initial value. The higher value of pH (8.05) was recorded in control while the lower (7.97) was recorded with the application of 100 % NP + 30 kg K through gliricidia (Table 1). The lower pH in gliricidia green leaf incorporated treatments may be due to addition of large amount of organics and release of organic acids by microbial decomposition, thereby reduce the pH of soil. Moreover, organic matter added with gliricidia green leaf manuring acts as a pH buffer, releasing H^+ ions responsible for reducing alkalinity of the soil. Similar results were also reported by Rao and Janawade (2009), Yadav *et al.* (2019) and Satpute *et al.* (2019). Electrical conductivity ranged from 0.25 to 0.31 dSm^{-1} (Table 1). The lower value (0.25 dSm^{-1}) was observed with application of 100 % NP + 30 kg K through gliricidia (T_5) which had 19.35 % lower electrical conductivity over control. The higher value (0.31 dSm^{-1}) of electrical conductivity was recorded in control. However, electrical conductivity did not vary much in different treatments with incorporation of gliricidia green leaf manuring over fertilizer application. Similar results were also reported by Rao and Janawade (2009), Hababi *et al.* (2013), Yadav *et al.* (2019) and Satpute *et al.* (2019).

Soil fertility

Organic carbon content of the soil ranged from 5.0 to 6.8 g kg^{-1} (Table 2). The highest (6.8 g kg^{-1}) organic carbon was recorded with the application of 100 % NP + 10 kg K (inorganic) + 20 kg K ha^{-1} through gliricidia and lowest (5.0 g kg^{-1}) in control. The higher values of organic carbon content with incorporation of gliricidia green leaf manuring may be attributed to addition of organic matter and greater root biomass, with their addition as evidenced from the higher yields obtained in these treatments. Similar results were also reported by Hababi *et al.* (2013), Satpute *et al.* (2019) and Yadav *et al.* (2019). The available N in soil varied from 181.8 to 211.1 kg ha^{-1} (Table 2). The higher available N (211.1 kg ha^{-1}) was observed with application of 100 % NP + 10 kg K (inorganic) + 20 kg K ha^{-1} through gliricidia and lowest (181.8 kg ha^{-1}) in control. There was 16 and 6.3% increase in available N content in treatment T_4 over control and 100% RDF, respectively. The increase in available N suggests a rise in the easily oxidizable portion of organic matter, implying that N is more readily available to plants. This rise in available N may be due to incorporation of gliricidia green leaf manuring rich in nitrogen content in its leaves. Good nutrition of both inorganic and organic source in proper conjugation in presence of favourable soil conditions enhances soil biological activity. All these have helped the mineralization of soil N leading to build-up of higher available N. Similar results were also reported by Satpute *et al.* (2019) and Yadav *et al.* (2019).

Table 2: Effect of various treatments on nutrient and organic carbon balance in soil

Treatments	Nutrient Balance						Organic Carbon Balance	
	N (kg ha^{-1})	Loss/gain of N over initial (kg ha^{-1})	P (kg ha^{-1})	Loss/gain of P over initial (kg ha^{-1})	K (kg ha^{-1})	Loss/gain of K over initial (kg ha^{-1})	OC (g kg^{-1})	Loss/gain of organic carbon over initial (g kg^{-1})
T_1	181.8	-3.9	12.7	-1.8	317.7	-4.2		-0.1
T_2	198.6	12.8	15.0	0.4	334.9	12.9	5.0	0.8
T_3	209.0	23.2	16.5	1.9	352.2	30.2	5.9	1.4
T_4	211.1	25.3	16.7	2.1	361.5	39.5	6.5	1.7
T_5	204.8	19.0	15.5	0.9	353.4	31.4	6.8	1.3
T_6	196.5	10.7	15.1	0.5	338.8	16.8	6.4	0.9
T_7	198.6	12.8	15.1	0.5	332.1	10.1	6.0	0.8
T_8	192.3	6.5	14.8	0.2	326.9	4.9	5.9	0.7
T_9	190.2	4.4	14.0	-0.5	324.3	2.3	5.8	0.5
SE (m) ±	4.0	-	0.2	-	6.7	-	5.6	-
CD at 5%	12.0	-	0.6	-	20.2	-	0.1	-
Initial (2015-16)	185.8		14.6		322.0		0.4	5.1

Available P content of soil varied from 12.7 to 16.7 kg ha^{-1} (Table 2). The highest available P (16.7 kg ha^{-1}) was recorded with 100 % NP + 10 kg K (inorganic) + 20 kg K ha^{-1} through gliricidia and lowest (12.7 kg ha^{-1}) in control and increased by 31.4 and 11.3% over control and 100 % RDF, respectively. The higher content of available P may be due to the application of gliricidia green leaf manuring which increases the availability of phosphorus in the soil. During decomposition of green manure, various organic acids are produced which solubilize phosphatase and other phosphate bearing minerals and thereby lowers the phosphate fixation and increase its availability. Similar results were also recorded by Satpute *et al.* (2019) and Yadav *et al.* (2019).The soil was very high in available K and ranged from 317.7 to 361.5 kg ha^{-1} (Table 2). The highest available K (361.5 kg ha^{-1}) was observed in the treatment 100 % NP + 10 kg K (inorganic) + 20 kg K ha^{-1} through gliricidia and lowest (317.7 kg ha^{-1}) in control. It was increased by 13.7 and 7.9% in treatment T_4 over control and 100 % RDF, respectively. The increase in soil available K caused by the application of potassium through gliricidia green leaf manuring may be due to the fact that gliricidia leaves contain a higher amount of K and it is deposited in the soil, and the solubilizing action of certain organic acids produced during decomposition results in a greater capacity to hold K in the available form. Similar results were observed by Satpute *et al.* (2019) and Yadav *et al.* (2019).

Yield

The significantly higher seed cotton yield (755.21 kg ha^{-1}) was observed with application of 100 % NP + 10 kg K ha^{-1} (inorganic) + 20 kg K ha^{-1} through gliricidia (T_4) and lowest (470.85 kg ha^{-1}) in control (Table 1). Treatment T_4 had 60.4% and 18.2% higher seed cotton yield over control and 100 % RDF, respectively. Similarly, the significantly higher cotton stalk yield (1104.42 kg ha^{-1}) was observed with the application of 100 % NP + 10 kg K ha^{-1} (inorganic) + 20 kg K ha^{-1} through gliricidia and lowest (673.61 kg ha^{-1}) in control. Treatment T_4 had 63.95 and 21.95% higher yield of cotton stalk over control and 100 % RDF, respectively. Seed cotton yield in treatment T_4 was statistically at par with T_3, T_5 and T_6. Higher cotton yield with conjunctive application of gliricidia green leaves along with chemical fertilizers may be due to balanced supply of nutrients to the crop throughout the growing period. Green leaf manure addition into soil stimulates microbial activity, nutrient transformation, release and their plant availability as well as higher nutrients uptake by the crops, resulting in higher yield. These results are in conformity with the findings of Doli *et al.* (2015), Yadav *et al.* (2019) and Satpute *et al.* (2019).

Nutrient and organic carbon balance

The nutrient balance *i.e.,* the content of available N, P and K after 6 years of experiment showed that there was net gain in content of available N, P and K in all the treatments except control (Table 2). The highest gain of available nitrogen (25.4 kg ha^{-1}), phosphorus (2.2 kg ha^{-1}) and potassium (39.6 kg ha^{-1}) was recorded with 100 % NP + 10 kg K (inorganic) + 20 kg K ha^{-1} through gliricidia (T_4) followed by application of 100 % NP + 15 kg K (inorganic) + 15 kg K ha^{-1} through gliricidia. Similarly, the organic carbon balance also showed a similar trend like nutrient balance, where 0.17% higher gain was observed in the treatment 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia followed by treatment 100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia and 100% NP + 30 kg K through gliricidia.

From the present investigation, it may be concluded that cotton crop responded significantly to 100% NP + 10 kg K (inorganic) + 20 kg K ha^{-1} through gliricidia green leaf manuring produced highest cotton yield and improved the soil fertility and nutrients balance. Moreover, the present study indicated the superiority of combined use of inorganic and organics in improving the productivity of cotton grown on Vertisols under dryland conditions.

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