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Effect of potash management through gliricidia green leaf manuring on soil fertility and yield of soybean in Vertisols

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Abstract
A field experiment was conducted to assess the effect of potash management through gliricidia green leaf manuring on soil fertility and yield of soybean in Vertisols at Research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *kharif* 2018. The experiment comprised of six treatments and four replications laid out in Randomized Block Design. The results indicated that application of 75% N +100% P+15 kg K (inorganic) +15 kg K through gliricidia resulted in improvement in soil fertility with higher soybean yield and was on par with application of 75% N +100% P +30kg K through gliricidia, application of 50% N +100% P+30kg K through gliricidia and application of 100% RDF (30:75:30 NPK kg ha^{-1}). Hence, it is concluded that the integrated application of 75% N +100% P+ 50% K through chemical fertilizer and 50% K through gliricidia green leaf manuring at 30 DAS resulted in improvement in soil fertility and yield of soybean grown in Vertisols.

Keywords: Gliricidia green leaf manure, Soil fertility and 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 21st century mainly due to its high protein content -40%, oil-20%, carbohydrates-30%, fibre-0.5%, lecithin - 0.5% and saponins - 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 has great potential as an exceptionally nutritive and very rich protein food. It can supply the much needed protein to human diets, because it contains above 40 per cent protein of superior quality and all the essential amino acids such as glycine, tryptophan and lysine, similar to cow's milk and animal proteins.

Potassium is an essential plant nutrient and is required in large amounts for proper growth and reproduction of plants. It plays a major role in the regulation of water in plants (osmoregulation); both uptake of water through plant roots and its loss through the stomata are affected as well as it improves drought resistance. It is essential at almost every step of the protein synthesis. In starch synthesis, the enzyme responsible for the process is activated by potassium. Potassium plays several roles in plants such as enzyme activation, protein synthesis, ion absorption and transport, photosynthesis and respiration.

Gliricidia sepium plant belongs to leguminous family with subfamily Papilionoideae. The leaves of gliricidia contain N (2.4%), P (0.1%), K (1.8%) and these leaves decompose relatively fast, providing nitrogen and potassium. Gliricidia leaf manuring improves organic matter content in the soil. Gliricidia as green leaf manure plays important role in increasing the fertility status of soils and helps in conserving soil through reduced soil erosion also. Patil (1989) [10] stated that 1 tonne dry weight of leaves was equivalent to 27 kg N while Kang and Mulongoy (1987) [7] reported that up to 15 t/ha/year of gliricidia leaf biomass could be produced on good soils in Nigeria providing the equivalent of 40 kg N/ha/year.

Materials and Methods
A field experiment conducted on Vertisols was initiated on the Research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola since 2015-16. The present study was undertaken during 2018-19 with six treatments replicated four times with soybean as a test crop. The details of various treatments undertaken in the experiment are control (T_1), 100% RDF (30:75:30 NPK kg ha^{-1}) (T_2), 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia

(T_3), 75% N +100% P+30kg K through gliricidia (T_4), 50% N +100% P+30kg K through gliricidia (T_5) and 100% K through gliricidia (T_6).

Results and Discussion

Yield of soybean

The data pertaining to the grain and straw yield of soybean as influenced by different treatments is presented in Table 1 and was found to be statistically significant. The significantly higher soybean grain yield (1738.67 kg ha^{-1}) was observed with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) and it was on par with the application of 75% N +100% P+30kg K through gliricidia (T_4), application of 100% RDF(30:75:30 NPK kg ha^{-1}) (T_2) and application of 50% N +100% P+30kg K through gliricidia (T_5). The increase in grain yield of soybean with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) was 41.96 % and 8.13% higher as compared to control (T_1) and 100 % RDF (30:75:30 NPK kg ha^{-1}) (T_2) treatments respectively. The lowest soybean grain yield (1224.27 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control.

Table 1: Effect of potash management through gliricidia green leaf manuring on soybean yield and rain water use efficiency

Treatment		Soybean yield (kg ha^{-1})		RWUE (kg ha^{-1} mm^{-1})
		Grain	Straw	
T_1	Control	1224.27	1346.70	1.89
T_2	100% RDF (30:75:30 NPK kg ha^{-1})	1597.21	1788.88	2.46
T_3	75% N +100% P+15kg K (inorganic) + 15 kg K through gliricidia	1738.67	2173.34	2.68
T_4	75% N +100% P+30kg K through gliricidia	1659.97	1991.96	2.56
T_5	50% N +100% P+30kg K through gliricidia	1517.48	1745.10	2.34
T_6	100% K through gliricidia	1365.73	1529.62	2.11
	SE (m) ±	101.69	117.92	-
	CD at 5%	306.47	355.38	-

The significantly higher soybean straw yield (2173.34 kg ha^{-1}) was observed with the application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) and it was on par with application of 75% N +100% P+30kg K through gliricidia (T_4). The increase in straw yield of soybean with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) was 61.38 % and 21.49 % higher as compared to control (T_1) and 100 % RDF (30:75:30 NPK kg ha^{-1}) (T_2) treatments respectively. The lowest (1346.70 kg ha^{-1}) soybean straw yield was recorded in treatment T_1 *i.e.* control.

Higher yield of soybean with conjunctive application of gliricidia green leaf manure along with chemical fertilizers may be due to balanced supply of nutrients to the crop throughout the crop growth period. Green leaf manure undergo decomposition during which series of nutrient transformation takes place which helps in their higher availability to the crops and higher uptake of nutrients by the crops will result in higher yield. The results are in conformity with the findings of Odyuo *et al*. (2015) [9], Shariff *et al*. (2017) [14] and Jadhao *et al*. (2018) [6].

Rain water use efficiency (RWUE)

The highest rain water use efficiency (2.68 kg ha^{-1} mm^{-1}) was observed with the application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) followed by 75% N +100% P+30kg K through gliricidia (T_4).The lowest rain water use efficiency (1.89 kg ha^{-1} mm^{-1}) was recorded in treatment T_1 *i.e.* control.

Soil fertility

Importance of soil fertility 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 fertilizers regulate quality; improve crop yield and physical environment of soil. The data pertaining to the organic carbon and available nutrients in soil as influenced by different treatments are presented in Table 2.

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 0.50% to 0.63% indicating that the highest (0.63%) organic carbon was recorded with the application of 75% N +100% P+15 kg K(inorganic)+15 kg K through gliricidia (T_3) and 75% N +100% P+30kg K through gliricidia (T_4) and it was on par with application of 100% RDF (30:75:30 NPK kg ha^{-1}) (T_2). The increase in organic carbon content was 0.13% and 0.01% higher with application of 75% N +100% P+15 kg K(inorganic)+15 kg K through gliricidia (T_3) as compared to control (T_1) and 100 % RDF (30:75:30 NPK kg ha^{-1}) (T_2) treatments respectively. The lower value (0.50%) 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 Surekha and Rao (2009) [16], Ghalavand *et al.* (2009) [4] and Hababi *et al.* (2013) [5].

Available nitrogen

The data on available nitrogen status of soil was significantly influenced by various treatments. The available N in soil varied from 174.40 to 214.04 kg ha^{-1} indicating that the soil was low in available N content.

The higher available N (214.04 kg ha^{-1}) was observed with the application of 75% N +100% P+15 kg K(inorganic)+15kg 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) and application of 100% RDF (30:75:30 NPK kg ha^{-1}) (T_2). It was also noted that 22.72% and 0.97% increase in available N content was recorded with application of 75% N +100% P+15 kg K(inorganic)+15kg K through gliricidia (T_3) as compared to control (T_1) and 100 % RDF (30:75:30 NPK

kg ha^{-1}) (T_2) respectively. The lower value (174.40 kg ha^{-1}) of available N was observed in treatment T_1 *i.e.* control.

The increase in available N due to incorporation of gliricidia green leaf manuring may be due to higher amount of nitrogen content in leaves and the favourable soil conditions under green leaf manuring might have helped the mineralization of soil N leading to build-up of higher available N. Similar results were also given by Ghalavand *et al.* (2009) [4], Vidyavathi *et al.* (2011) [18] and Rajashekarappa *et al.* (2013) [11].

Table 2: Effect of potash management through gliricidia green leaf manuring on organic carbon and available nutrients in soil

Treatment		Organic carbon (%)	Available nutrients (kg ha^{-1})		
			N	P	K
T_1	Control	0.50	174.40	13.94	313.63
T_2	100% RDF (30:75:30 NPK kg ha^{-1})	0.62	211.98	16.51	336.45
T_3	75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia	0.63	214.04	16.64	339.12
T_4	75% N +100% P+30kg K through gliricidia	0.63	212.40	16.49	337.29
T_5	50% N +100% P+30kg K through gliricidia	0.56	197.57	15.22	330.32
T_6	100% K through gliricidia	0.54	194.64	14.23	324.85
	SE (m) ±	0.009	3.64	0.15	3.47
	CD at 5%	0.028	10.96	0.46	10.44

Available phosphorus

It is evident from the data in Table 2 that available phosphorus status of soil varied significantly and it ranged from 13.94 to 16.64 kg ha^{-1} indicating that the soil was low to medium in available phosphorus content.

The highest (16.64 kg ha^{-1}) available P was found with the application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) and it was found to be on par with the application of 100% RDF(30:75:30 NPK kg ha^{-1}) (T_2) and 75% N +100% P+30kg K through gliricidia (T_4). It was noted that 19.36% and 0.78% increase in available P content was recorded with application of 75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia (T_3) as compared to control (T_1) and 100% RDF(30:75:30 NPK kg ha^{-1}) (T_2). The lower value of available P was found in treatment T_1 *i.e.* control (13.94 kg ha^{-1}).

The higher content of available P may be due to the application of potassium through 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 recorded by Regar *et al.* (2009) [12], Shirale and Khating (2009) [15] and Vidyavathi *et al.* (2011) [18].

Available potassium

The data on available potassium status of soil varied significantly from 313.63 to 339.12 kg ha^{-1} indicating that soil was high to very high in available potassium content.

The highest available K (339.12 kg ha^{-1}) was observed with the application of 75% N +100% P+15 kg K(inorganic)+15kg K through gliricidia (T_3) and it was on par with the application of 75% N +100% P+30kg K through gliricidia (T_4), application of 100% RDF (30:75:30 NPK kg ha^{-1}) (T_2), and 50% N +100% P+30kg K through gliricidia (T_5). It was also noted that 8.12 % and 0.79 % increase in available K content was observed with application of 75% N +100% P+15 kg K(inorganic)+15kg K through gliricidia (T_3) as compared to control (T_1) and 100 % RDF (30:75:30 NPK kg ha^{-1})(T_2) respectively. The lower value of available K was observed in treatment T_1 *i.e.* control (313.63 kg ha^{-1}).

The build up of soil available K by the application of potassium through gliricidia green leaf manuring might be due to the fact that gliricidia leaves contains higher amount of K and it is deposited in the soil and due to applied K through gliricidia green leaf manure, the solubilizing action of certain organic acids produced during decomposition results in greater capacity to hold K in the available form. Similar results were observed by Tolanur and Badanur (2003) [17], Surekha and Rao (2009) [16] and Nawlakhe and Mankar (2009) [8].

Available micronutrients

The data in respect of available micronutrient status of soil at harvest of soybean are presented in Table 3.

Available iron

The data in respect of the effect of potash management through gliricidia green leaf manuring on available iron was found to be significant. The higher available iron (8.93 mg kg^{-1}) was observed with the application of 75% N +100% P+30 kg K through gliricidia (T_4) and it was on par with application of 75% N +100% P+15 kg K(inorganic)+15 kg K through gliricidia (T_3). It was also noted that 42.19% and 10.38% increase in available iron content was observed with application of 75% N +100% P+30 kg K through gliricidia (T_4) as compared to control (T_1) and 100 % RDF (30:75:30 NPK kg ha^{-1})(T_2) respectively. The lowest available iron (6.28 mg kg^{-1}) was recorded in control treatment (T_1).Similar findings were reported by Duhan *et al.* (2002) [3], Selvi *et al.* (2003) [13] and Vipin Kumar and Singh (2010) [19].

Table 3: Effect of potash management through gliricidia green leaf manuring on available micronutrients in soil

Treatment		Available micronutrients (mg kg^{-1})			
		Fe	Mn	Cu	Zn
T_1	Control	6.28	9.56	2.06	0.62
T_2	100% RDF (30:75:30 NPK kg ha^{-1})	8.09	10.91	2.52	0.73
T_3	75% N +100% P+15kg K(inorganic)+15 kg K through gliricidia	8.83	12.22	3.16	0.91
T_4	75% N +100% P+30kg K through gliricidia	8.93	12.09	2.98	0.88
T_5	50% N +100% P+30kg K through gliricidia	8.04	10.85	2.55	0.80
T_6	100% K through gliricidia	7.26	10.50	2.26	0.75
	SE (m) ±	0.13	0.14	0.08	0.04
	CD at 5%	0.41	0.41	0.24	0.11

Available manganese

The effect of potash management through gliricidia green leaf manuring on available manganese was found to be significant. The higher available manganese (12.22 mg kg^{-1}) was observed with the application of 75% N +100% P+15 kg K(inorganic)+15 kg K through gliricidia (T_3) and it was on par with application of 75% N +100% P+30 kg K through gliricidia (T_4). It was also noted that 27.82% and 12% increase in available manganese content was observed with application of 75% N +100% P+15 kg K(inorganic)+15kg K through gliricidia (T_3) as compared to control(T_1) and 100 % RDF(30:75:30 NPK kg ha^{-1}) (T_2) respectively. The lowest available manganese (9.56 mg kg^{-1}) was recorded in control treatment (T_1). Similar findings were reported by Bellakki *et al.* (1998) [1], Selvi *et al.* (2003) [13] and Vipin Kumar and Singh (2010) [19].

Available copper

The effect of potash management through gliricidia green leaf manuring on available copper was found to be significant. The significantly higher available copper (3.16 mg kg^{-1}) was observed with the application of 75% N +100% P+15 kg K(inorganic)+15 kg K through gliricidia (T_3) and it was on par with application of 75% N +100% P+30 kg K through gliricidia (T_4). The increase in available copper content with application of 75% N +100% P+15 kg K(inorganic)+15kg K through gliricidia (T_3) was 53.39% and 25.39% higher as compared to control (T_1) and 100 % RDF (30:75:30 NPK kg ha^{-1})(T_2) respectively. While, the lowest available copper (2.06 mg kg^{-1}) was recorded in control treatment (T_1). Similar findings were reported by Bellakki *et al.* (1998) [1], Duhan *et al.* (2002) [3] and Vipin Kumar and Singh (2010) [19].

Available Zinc

The effect of potash management through gliricidia green leaf manuring on available zinc was found to be significant. The higher available zinc (0.91 mg kg^{-1}) was observed with the application of 75% N +100% P+15 kg K(inorganic)+15 kg K through gliricidia (T_3) and it was on par with application of 75% N +100% P+30 kg K through gliricidia (T_4) and application of 50% N +100% P+30kg K through gliricidia (T_5). The increase in available zinc content with application of 75% N +100% P+15 kg K(inorganic)+15kg K through gliricidia (T_3) was 46.77% and 24.65% higher as compared to control (T_1) and 100 % RDF (30:75:30 NPK kg ha^{-1})(T_2) respectively. The lowest available zinc (0.62mg kg^{-1}) was recorded in control treatment (T_1). Similar findings were reported by Billore *et al*. (1999) [2], Selvi *et al.* (2003) [13] and Vipin Kumar and Singh (2010) [19].

In view of the above, it can be concluded that the integrated application of 75% N +100%P+ 50% K through chemical fertilizer and 50% K through gliricidia green leaf manuring at 30 DAS resulted in higher yield of soybean with improvement in fertility status of Vertisols under rainfed conditions.

Conclusion

It is concluded that the integrated application of 75% N +100%P+ 50% K through chemical fertilizer and 50% K through gliricidia green leaf manuring at 30 DAS resulted in improvement in soil fertility and yield of soybean grown in Vertisols under rainfed conditions.

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