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Consequence of resource conservation practices on yield and nutrient uptake of soybean under cotton-soybean rotation in vertisols

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Abstract

The present study was undertaken during 2016-17 at Research farm, Dr. PDKV, Akola. The experiment was laid out in Randomized Block Design with nine treatments replicated three times in Vertisols. The objectives were to evaluate the effect of different resource conservation practices on yield and nutrient uptake by soybean. The cotton based soybean rotation was followed since 2011-12. The present experiment was superimposed on soybean during 2016-17. The treatments comprised for soybean crop was recommended dose of fertilizer (RDF) alone and their compensation with organics viz., FYM, phosphocompost (PC), neemcake, bio mulch (farm waste) and green leaf manuring. The results of the present experiment indicated that, comparatively higher seed (27.20 q ha⁻¹) and straw yield (31.25 q ha⁻¹) of soybean was recorded with RDF alone to soybean and 25% N through Neemcake + RDF compensation to cotton crop under cotton-soybean rotation. The application of RDF alone with 25% N through Neemcake + RDF compensation to cotton crop recorded higher N (187.6 kg ha⁻¹), whereas, application of RDF + PC with 100% N (FYM) + compensation of P through phosphocompost to cotton recorded higher P uptake (18.41 kg ha⁻¹). The K (51.78 kg ha⁻¹) uptake was influenced significantly with the application of RDF with 25% N through Dhaincha loppings + RDF compensation to cotton. Hence, combined application of organic sources along with inorganic fertilizers is the most vital way to maintain yield of soybean relatively at higher level and uptake under cotton-soybean rotation in Vertisol.

Keywords: Conservation practices, soybean, FYM, phosphocompost, yield, uptake, vertisols

Introduction

In India, the area under soybean crop increased considerably during recent year due to its high yielding potential and multifarious industrial uses. In India, at present area under soybean crop is 116.28 lakh ha. with the production of 86.42 lakh tonnes. In Maharashtra area under soybean is about 35.85 lakh ha. with a total production 27.83 lakh tonnes having average productivity of 1255 kg ha⁻¹. In Vidarbha region area under soybean crop is 19.22 lakh ha. with production of 18.45 lakh tonnes (Anonymous, 2015) [2]. Out of total soybean cultivated area in Maharashtra 80 to 83% area is in Vidarbha. The area under soybean cultivation in Vidarbha is 19.32 lakh ha with production of 14.77 lakh MT and productivity 776 kg ha⁻¹ (Anonymous, 2015) [2]. The soybean has great potential to produce large amount of shaded biomass. Considering the magnitude of the produced biomass and its utilization in enhancement of soil carbon the present study was framed to identify the enormity of soybean in sequestering the carbon in soil.

Resource conservation technologies is gaining acceptance in many parts of the world as an alternative to both conventional agriculture and to organic agriculture. Although the practice of conservation agriculture on a large scale emerged out of Brazil and Argentina, similar developments were occurring in many other areas of the world, notably North America in zero tillage, and Africa and Asia with technologies such as agroforestry. Conservation agriculture is based on the principles of rebuilding soil, optimizes the crop production input, including labour, and optimizing the profit.

Distribution of soil organic carbon in soils varies with respect to climate, vegetation and also with respect to soil horizons. It plays an important role in crop production through positive beneficial influence on nutrient availability in soil. For sustainable utilization of soil resources,

SOM should be maintained at a threshold level. The status of soil organic matter of tropical countries like India is generally much below the threshold levels (Jenny and Raychaudhari, 1960) [7]. Intensification of agriculture with adoption of multiple cropping systems and energy intensive cultivation practices, especially excessive tillage and imbalanced use of chemical fertilizers led to further deterioration of soil organic matter. Hence, for efficient management of SOM, is necessary to quantify the soil organic carbon content under various cropping systems and investigate its relationship with the factors that regulate its amount and nature. Climate, by virtue of its direct and indirect influence, alters the soil biota interactions in a given agricultural production system. Different resource conservation practices increase organic carbon content in soil with increasing carbon sequestration and influence majority of soil physical, chemical and biological properties. It is essential to build up the organic matter status of the soil by using various available organic resources. Therefore, more logical way to manage long term soil fertility and crop productivity is by integrated use of inorganic and organic sources of plant nutrients and adoption of different resource conservation technologies.

The enhanced carbon status helps to improve physical and biological properties of soil like bulk density, mean weight diameter, soil microbial biomass carbon, soil microbial biomass nitrogen and other enzymatic activities. The organic carbon is the key parameter in soil which influences all the physical, chemical and biological properties of soil. In recent days the content of organic carbon in the soils of semi arid areas is seriously declining. This has resulted into emergence of multi nutritional deficiencies in the soils. The shedding of leaves by the standing crops is having great potential to raise

the organic carbon content in soil. Considering the changing climatic conditions and diversified cropping systems, it is necessary to monitor the changes in soil organic carbon levels. The harvested crop residues are usually burn in the field after harvesting. The magnitude of addition of organic carbon through crop residues is having good potential for improving SOC of soils.

With this in view, the present investigation was carried out to study the effect of different resource conservation practices on yield and nutrient uptake of soybean and various soil properties.

Materials and Methods

The present experiment was carried out during 2016 -17 on cotton based soybean rotation at Research Farm, Department of Soil Science and Agriculture Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in Randomized Block Design with nine treatments replicated three times located at between on 22°42' N latitude and 77°02'E longitude at an altitude of 307.42 m above MSL and has a subtropical climate. The soil of the experimental site was clayey in nature, Bulk density 1.41 mgm⁻³ with pH 8.33 (1:2 soil: water) (Piper, 1996) [10], low in EC (Piper, 1996) [10], low in organic matter content of 5.4 g kg⁻¹ (Jackson, 1967) [6], low in available N (Kjeldahls method) (Subbiah and Asija, 1956) [14], medium in available P (Jackson, 1967) [6] and high in available K (Jackson, 1967) [6] at the start of experiment.

The experiment was laid out in Randomized Block Design with nine treatments replicated three times. The treatments for cotton based soybean rotation is given below.

Table 1: Treatment details under cotton based soybean rotation

Tr.	Rotation	
	Cotton	Soybean
T ₁	100% RDF(50:25:00 kg NPK ha ⁻¹)	RDF
T ₂	<i>Sesbania aculeata</i> 25% N + compensation of RDF	RDF
T ₃	Cotton stalk 25% N composted with <i>trichoderma viride</i> + compensation of RDF	RDF
T ₄	Wheat straw 25% N + compensation of RDF	RDF
T ₅	Bio mulch (farm waste) 25% N + compensation of RDF	RDF
T ₆	Conc. organics (Neemcake) 25% N + compensation of RDF	RDF
T ₇	100% N through FYM+ compensation of P through phosphocompost	RDF through FYM + remaining P through phosphocompost
T ₈	50% N through FYM + compensation of P through phosphocompost & remaining N through urea	RDF through FYM + remaining P through phosphocompost
T ₉	<i>Leucaena loppings</i> 50% N + compensation of P through phosphocompost & remaining N through urea	RDF through FYM + remaining P through phosphocompost

The RDF of soybean was 30:75: kg N, P and K ha⁻¹. The N, P and K were applied through fertilizers viz. urea, single super phosphate (SSP) and muriate of potash containing 46, 16.0 and 60 per cent N, P₂O₅ and K₂O, respectively. The treatment wise grain and plants samples were collected randomly from each plot at harvest of the soybean crop. The plants were carefully uprooted retaining most of the roots intact. The grain and plant samples were processed as per standard protocol to analyze nutrient content. Total nitrogen was determined by digesting the plant sample in microprocessor based digestion system (KES-20L) using conc. H₂SO₄ and salt mixture and

distillation with automatic distillation system (Piper, 1966) [10].

Total phosphorus was estimated from di-acid digested sample by Vanadomolybdate phosphoric acid yellow colour method using UV based double beam spectrophotometer (Kitson and Mellon, 1944) [8]. The total K content was determined in di-acid extract by using flame photometer as described by Piper (1966) [10]. The plant biomass dry matter of each net plot were threshed, cleaned and weighed. Net plot yield and yield per hectare was calculated separately. The data on different parameters were tabulated and analyzed statistically by the methods described by Panse and Sukhatme (1971) [9].

Table 2: Effect of different resource conservation practices on grain and straw yield of soybean

Tr.	Treatment details	Soybean	Grain (q ha ⁻¹)	Straw (q ha ⁻¹)
	Cotton			
T ₁	RDF	RDF	26.55	29.60
T ₂	25% N (Dhaincha loppings) + RDF compensation	RDF	25.64	31.25
T ₃	25% N (Cotton stalk) composted + RDF compensation	RDF	26.27	28.76
T ₄	25% N (Wheat straw) + RDF compensation	RDF	23.55	27.44
T ₅	25% N (Bio mulch)+ RDF compensation	RDF	26.19	30.90
T ₆	25% N (Neemcake) + RDF compensation	RDF	27.20	31.25
T ₇	100% N (FYM) + compensation of P (phosphocompost)	RDF + PC	26.88	29.43
T ₈	50% N (FYM) + P compensation (phosphocompost) + N compensation (Urea)	RDF + PC	22.34	26.45
T ₉	50% N (Leucaena loppings) + P compensation (phosphocompost) + N compensation (Urea)	RDF + PC	23.85	27.24
	SE (m) ±		0.95	1.04
	CD at 5%		2.84	3.13

Table 3: Effect of different resource conservation practices on sustainable yield index of soybean

Tr.	Treatment details	Soybean	SYI	
	Cotton		Grain	Straw
T ₁	RDF	RDF	0.45	0.44
T ₂	25% N (Dhaincha loppings) + RDF compensation	RDF	0.49	0.49
T ₃	25% N (Cotton stalk) composted + RDF compensation	RDF	0.43	0.44
T ₄	25% N (Wheat straw) + RDF compensation	RDF	0.38	0.41
T ₅	25% N (Bio mulch)+ RDF compensation	RDF	0.39	0.43
T ₆	25% N (Neemcake) + RDF compensation	RDF	0.43	0.44
T ₇	100% N (FYM) + compensation of P (phosphocompost)	RDF + PC	0.48	0.55
T ₈	50% N (FYM) + P compensation (phosphocompost) + N compensation (Urea)	RDF + PC	0.51	0.48
T ₉	50% N (Leucaena loppings) + P compensation (phosphocompost) + N compensation (Urea)	RDF + PC	0.52	0.55

Fig 1: Uptake of nitrogen in seed and straw of soybean as influenced by various treatments **Fig 2:** Uptake of phosphorus in seed and straw of soybean as influenced by various treatments

Fig 3: Uptake of potassium in seed and straw of soybean as influenced by various treatments

Table 4: Effect of different resource conservation practices on nutrient uptake of soybean

Tr.	Treatment details		Total Nutrient Uptake (kg ha ⁻¹)		
	Cotton	Soybean	N	P	K
T ₁	RDF	RDF	182.5	17.44	49.47
T ₂	25% N (Dhaincha loppings) + RDF compensation	RDF	180.5	18.28	51.78
T ₃	25% N (Cotton stalk) composted + RDF compensation	RDF	179.5	16.42	47.05
T ₄	25% N (Wheat straw) + RDF compensation	RDF	161.5	14.88	42.96
T ₅	25% N (Bio mulch) + RDF compensation	RDF	179.6	16.58	47.91
T ₆	25% N (Neemcake) + RDF compensation	RDF	187.6	18.22	50.02
T ₇	100% N (FYM) + compensation of P (phosphocompost)	RDF + PC	185.2	18.41	50.42
T ₈	50% N (FYM) + P compensation (phosphocompost) + N compensation (Urea)	RDF + PC	154.6	14.36	42.48
T ₉	50% N (Leucaena loppings) + P compensation (phosphocompost) + N compensation (Urea)	RDF + PC	164.6	15.65	45.02
	SE (m) ±		3.52	0.25	1.76
	CD at 5%		10.57	0.76	5.28

Results and Discussion

Seed and straw yield of soybean

Perusal of data (Table 2) indicated that, the seed and straw yield of soybean influenced significantly with different resource conservation practices. The application of RDF (25% N through Neem cake + RDF compensation to previous cotton), recorded higher seed and straw yield of soybean (27.20 and 31.25 q ha⁻¹, respectively) followed by RDF through FYM and remaining P through PC (100% N through FYM and compensation of P through phosphocompost), RDF, RDF (25% of cotton stalk N composted with *trichoderma viride* + compensation of RDF in previous crop), and RDF 25% N (Bio mulch) + RDF compensation of previous crop. However, these treatments were found at par with each other. The application of RDF (25% N through bio mulch with compensation of RDF through chemical fertilizers to previous crop, showing at par value with each other. Application of RDF through FYM and remaining P through PC (*Leucaena loppings* 50% N + compensation of P through phosphocompost and remaining N through urea to previous cotton crop recorded seed and straw yield to the extent of 23.85 and 27.24 q ha⁻¹, respectively. Whereas, application of RDF with 25% N through wheat straw + compensation of RDF) of previous crop, RDF through FYM + remaining P through phosphocompost (50% N through FYM + compensation of P through phosphocompost and remaining N through urea resulted substantial reduction in the seed and straw yield of soybean respectively. The integrated supply of nutrients found beneficial in recording higher seed and straw

yield of soybean. This can be attributed to the fact that addition of organics through FYM which supply N, P, K and micronutrients in addition to the recommended dose of fertilizers. The results are in close conformity with the findings of Sharma and Subehia (2014) [12]. In the same line of work, the highest seed yield of soybean was recorded with the application of 100% N through phosphocompost + remaining P through chemical fertilizer by Aage *et al.* 2019 [1].

Sustainable yield Index

The magnitude of change in SYI was closely associated with the yield of soybean. The sustainable yield index (SYI) of seed and straw was found to be at higher side with the application of RDF + phosphocompost (Table 3). The highest value of SYI was recorded with the application of RDF + phosphocompost to soybean with 50% N through *leucaena loppings* + P compensation through phosphocompost + N compensation through Urea to cotton which was recorded to the extent of 0.52 and 0.55 for soybean seed and straw, respectively. The higher yield which is closely associated with the seed and straw yield of soybean has been reported by Deshmukh *et al.* 2015 [14].

Uptake of Nitrogen

The results regarding nutrient uptake of soybean are present in (Table 4). The application of RDF (25% N through neemcake + compensation of RDF to previous cotton) recorded significantly higher nitrogen uptake by soybean

(187.6 kg ha⁻¹) followed by 100% N through FYM + compensation of P through phosphocompost (185.2 kg ha⁻¹), RDF (182.5 kg ha⁻¹), 25% N through Dhaincha loppings + RDF compensation (180.5 kg ha⁻¹), 25% N through Cotton stalk composted + RDF compensation (179.5 kg ha⁻¹) and 25% N through Bio mulch + RDF compensation (179.6 kg ha⁻¹), which was found at par with each other. The lowest uptake of N by soybean (154.6 kg ha⁻¹) was observed with the application of RDF through FYM + remaining P through phosphocompost (50% N through FYM + compensation of P through phosphocompost & remaining N through urea applied to previous cotton). This conform the findings of Thakur *et al.* (2011) [16] they observed that substantial increment of N uptake under integrated application of organic manure. The results are in conformity with finding of Talati *et al.*, (2004) and Shirale and Khating (2009) [13]. The trend in nitrogen uptake in seed and straw was noted similar trend as observed in total uptake of nitrogen.

Uptake of Phosphorus

The application of RDF through FYM + remaining P through phosphocompost to soybean (100% N through FYM + compensation of P through phosphocompost to applied to cotton) recorded significantly highest phosphorus uptake by soybean (18.41 kg ha⁻¹), followed by RDF (25% N (Dhaincha loppings) + RDF Compensation), 25% N through Dhaincha loppings + RDF compensation (18.28 kg ha⁻¹) and RDF (25% N (Neemcake) + RDF compensation to cotton crop) (18.22 kg ha⁻¹). However, these treatments were found at par with each other. The application RDF through FYM + remaining P through phosphocompost (50% N (FYM) + compensation of P through phosphocompost) (14.36 kg ha⁻¹) resulted substantial decrease in P uptake. Similar results were also reported by Hati *et al.* (2013) and Sanjay Kumar *et al.* (2015) [11]. The trend in phosphorus uptake in seed and straw was noted similar trend as observed in total uptake of nitrogen.

Uptake of Potassium

The application of RDF (25% N through dhaincha green manuring + RDF compensation to previous cotton), recorded significantly higher potassium uptake by soybean (51.78 kg ha⁻¹) followed by 100% N through FYM + compensation of P through phosphocompost (50.42 kg ha⁻¹), 25% N through neemcake + RDF compensation (50.02 kg ha⁻¹), RDF (49.47 kg ha⁻¹) and 25% N through Bio mulch + RDF compensation (47.91 kg ha⁻¹) which were found at par with each other. The application of RDF + remaining P through phosphocompost (50% N (FYM) + compensation of P through phosphocompost to cotton recorded lowest uptake of K by Soybean (42.48 kg ha⁻¹). Similar results were also reported by Arbad *et al.* (2014) [3]. The trend in potassium uptake in seed and straw was noted similar trend as observed in total uptake of nitrogen.

Conclusions

It can be concluded that, application of 25% recommended N through Dhaincha or neemcake with remaining recommended dose of NPK to cotton along with RDF of soybean through chemical fertilizer or application of 100% recommended dose of N to cotton and soybean through FYM and remaining P and K through phosphocompost was found beneficial for improving yield and uptake of nutrient by soybean in Vertisol. The SYI was higher with the application of RDF + Phosphocompost to soybean with 50% N (Leucaena loppings)

+ P compensation (phosphocompost) + N compensation (Urea) to cotton.

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