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Potentials of Conservation Agriculture in Vertisols of Madhya Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study aimed to assess the potentials of conservation agriculture in Vertisols of Madhya Pradesh in terms of productivity and economics of cultivation in soybean-wheat cropping system. Vertisols are characterized by more clay content, swell-shrink behavior, high water holding capacity, poor drainage and creaking on drying which results in narrow workability and high erodibility causes soil and nutrients loses, whereas, high CEC and inter-layer spacing in minerals results in fixation of cationic nutrients and nature of self inversion causes low organic carbon content. Potential of different crop establishment method under soybean-wheat cropping system for nutrients recycling through crop residue management was also studied to highlight the importance of crop residue recycling. It is concluded that planting of soybean and wheat on permanent beds and with no-till along with retention of crop residue on surface has been more effective and remunerative.

Keywords: Agriculture; vertisols; cropping system; erodibility.

1. INTRODUCTION

Vertisols are characterized by more clay content, swell-shrink behavior, high water holding capacity, poor drainage and creaking on drying which results in narrow workability and high erodibility causes soil and nutrients loses, whereas, high CEC and inter-layer spacing in minerals results in fixation of cationic nutrients and nature of self inversion causes low organic carbon content. Vertisol is the other important soil order which constitutes a significant portion of the rainfed regions. The fine clay percentage is more in Vertisol soils compared to the other soils present in rainfed areas. The clay content of Vertisols remains uniformly high (>35%),

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throughout the profile to a depth of at least 50 cm or more [1,2] Vertisols occurs extensively in India (76.4 M ha), Australia (70.5 M ha), Sudan (40.4 M ha), Chad (16.5 M ha) and Ethiopia (10.0 M ha) contributing 82.1 per cent of global area (260 M ha) of Vertisols [3]. It is estimated that 16.7 M ha area of Madhya Pradesh is covered under Vertisols which are vulnerable to erosion and high runoff losses and cropped only during post rainy season on profile stored moisture and remains fallow or poorly utilized during rainy season [4,5]. The soil moisture range in which the physical condition of Vertisols is suitable for tillage and planting operations is quite narrow [6].

Conservation agriculture (CA) is one of the most promising technologies to address the problems associated with Vertisols in Madhya Pradesh. Soil and water are critical natural resources that must be kept in harmony with the environment for agro ecosystems to be sustainable [7-9]. Conservation agriculture includes minimum disturbance of soil, managing the crop residues on soil surface and alteration in crop sequencing/rotation to derive maximum benefits from inputs and minimize adverse environmental impacts. The rationale for developing CA systems (i.e., reducing soil degradation and production costs), and its guiding principles and practices were considered valid for Africa and consequently sparked large interest among research organizations and funding agencies [10,11]. Conservation agriculture have potential to minimize the sowing time, soil erosion, surface runoff, cost of production and maximizing the resource use efficiency and sustainability. While, the research and development efforts over the past decade have contributed to increasing farmer acceptance of conservation agriculture in Vertisols of Madhya Pradesh, this has raised a number of questions related to institutional, technological and policy aspects and focused on technology generation, adaptation and further improvement, which need to be addressed for accelerated adoption of conservation agriculture practices on a sustained basis. Keeping above facts in view, present study has been carried out to assess the potentials of conservation agriculture in Vertisols of Madhya Pradesh in terms of productivity and economics of cultivation in soybean-wheat cropping system.

2. MATERIALS AND METHODS

Field experiment in soybean-wheat cropping system was conducted during five successive years from 2012-13 to 2016-17 at research farm of JNKVV, Jabalpur to evaluate the effect of methods of crop establishment viz. conventional till soybean (CTS)- conventional till wheat (CTW), conventional till soybean (CTS)- no-till wheat (NTW), no-till soybean (NTS)- no-till wheat (NTW) and bed planted soybean (BPS)- bed planted wheat (BPW) no-till (NT) and bed planting (BP) on productivity and economics of soybean-wheat system under a Vertisol. Entire crop residue was removed under conventional till (CT) system, while crop residue has been retained on soil surface in NT and BP systems as mulch. The experiment was laid out in randomized block design with four treatments of crop establishment methods replicated five times. The standard agronomic procedures were adopted to raise the crops except those under treatments.

3. RESULTS

Results of successive five years study (Table 1) revealed that average productivity of soybean-wheat cropping system in terms of equivalent wheat yield was highest (7.84 t ha^{-1}) under BPS-BPW system which was significantly superior over all other treatments. While, the productivity of soybean, wheat and equivalent wheat under CTS-NTW and NTS-NTW system were statistically at par but significantly higher than those obtained CTS-CTW system. Net monitory returns (Rs. 71329/-) and benefit-cost ratio (2.50) were also significantly higher under BPS-BPW system over all other treatments.

Potential of different crop establishment method under soybean-wheat cropping system for nutrients recycling through crop residue management was also studied to highlight the importance of crop residue recycling. Nutrients recycling capacity and economics of the system were computed on the basis of crop residue retained in the field and nutrients content present in the crop residues after each cropping season. Data of crop residue and nutrient was averaged for consecutive five years and given in Table 2. Results showed that on an average recycling of crop residue in BPS-BPW was maximum (6.37 t ha^{-1} yr^{-1}) followed by NTS-NTW (6.06 t ha^{-1} yr^{-1}) and CTS-NTW (1.94 t ha^{-1} yr^{-1}), while no residue has been recycled under CTS-CTW system. Results also revealed that conservation agriculture (CTS—NTW, NTS-NTW and BPS-BPW) have potential to recycle 34.9 to 59.1 kg N ha^{-1} yr^{-1}, 8.4 to 34.5 kg P_2O_5 ha^{-1} yr^{-1} and 59.6 to 131.0 kg K_2O ha^{-1} yr^{-1} in soil to sustain the soil fertility and when these values were computed in terms of economics it varied from Rs. 2682.6 (CTS—NTW) to Rs. 6320.9 (PBS—PBW).

Table 1. Effect of crop establishment methods on productivity and economics of soybean-wheat cropping system (mean of 05 years)

Crop establishment method for Soybean-Wheat system	Seed yield (t ha^{-1})			Net monitory returns (Rs. ha^{-1})	B:C ratio
	Soybean	Wheat	Wheat equivalent		
CTS-CTW (Residue of both crops removed)	2.20	5.12	7.13	61322	1.80
CTS-NTW (Residue of wheat removed)	2.03	5.43	7.44	66328	2.10
NTS-NTW (Residue of both crops retained)	2.16	5.23	7.35	65628	2.30
BPS-BPW (Residue of both crops retained)	2.63	5.64	7.84	71329	2.50
SEm ±	**0.053**	**0.072**	**0.048**	**738.4**	**0.039**
CD (p=0.05)	**0.149**	**0.211**	**0.142**	**2174.7**	**0.114**

Table 2. Effect of crop establishment methods on potential of nutrients recycling and in soybean-wheat cropping system (mean of 05 years)

Crop establishment method for Soybean-wheat system	Mean of crop residue recycled (t ha^{-1})			Equivalent of nutrients recycled by crop residue (kg ha^{-1} yr-^{1})			Equivalent cost of nutrients recycled (Rs. ha^{-1} yr-^{1})			Total cost of nutrients recycled (Rs.ha^{-1} yr-^{1})
	Soybean	Wheat	Total	N	P_2O_5	K_2O	N	P_2O_5	K_2O	
CTS-CTW (Residue of both crops removed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTS-NTW (Residue of wheat removed)	1.94	0	1.94	34.9	8.4	59.6	509.8	361.3	1811.5	2682.6
NTS-NTW (Residue of both crops retained)	2.11	3.95	6.06	56.9	32.7	125.5	831.3	1399.5	3814.9	6045.8
BPS-BPW (Residue of both crops retained)	2.16	4.21	6.37	59.1	34.5	131.0	862.7	1475.1	3983.1	6320.9

4. CONCLUSION

Present study concluded that practice of conservation agriculture has immense potential to sustain the productivity, economics and soil fertility under soybean-wheat cropping system in a Vertisol of Madhya Pradesh. It was also found that planting of soybean and wheat on permanent beds and with no-till along with retention of crop residue on surface has been more effective and remunerative.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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