



Effect of tillage system on yield of wheat under different cropping sequences

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ABSTRACT

The field experiment was conducted three consecutive years during *kharif* and *rabi* seasons of 2013-14, 2014-15 and 2015-16 at JNKVV - Zonal Agricultural Research Station, Powarkheda, District- Hoshangabad (Madhya Pradesh). The experiment was laid out with 6 treatments and three replications. The treatments were T₁- Soybean – Wheat in conventional tillage, T₂ - Soybean – Wheat in FIRBS, T₃ - Soybean – Wheat in zero tillage, T₄ - Paddy – Wheat in conventional tillage, T₅ - Paddy – Wheat in FIRBS, T₆ - Paddy – Wheat in zero tillage. The maximum seed yields of wheat (4030.6 kg ha⁻¹) was recorded under soybean – wheat in FIRBS (T₂) and was found significantly superior over other cropping sequence and lowest yield was recorded in Paddy – Wheat in conventional tillage (T₄). The paddy – wheat crop sequence proved to be far better in terms of wheat equivalent yield (106.8 q ha⁻¹), NMR (Rs.86331 ha⁻¹) and B:C ratio (2.16) as compared to soybean – wheat sequence.

Key words: Soybean, Paddy, Wheat yield, Tillage, Economics

INTRODUCTION

Soybean (*Glycine max* L.)-wheat (*Triticum aestivum* L.) and paddy (*Oryza sativa* L.)-wheat are the most dominant cropping systems on the Vertisols of Central India. Cultivation of soybean and paddy in rainy season (June to October) has witnessed a phenomenal growth in the last two decades in the region, while wheat in winter season (November to April) has a considerable potential due to congenial climate. The rice–wheat cropping system (RWCS) plays a vital role in global food security as it provides staple foods to the world's population (Laik *et al.*, 2014; Banjara *et al.*, 2021). More than 85% of the RWCS practiced in South Asia is distributed in the Indo-Gangetic Plains (Banjara *et al.*, 2021). In India, the pre-dominant rice–wheat system covers an area of 9.2 mha, thus playing a key role in the nation's food security (Jat *et al.*, 2020). India has a remarkable track record of cereal production from 87.4 million tons (mt) in 1961 to 324.3 mt in 2019 (FAOSTAT, 2021). In India, rice occupies an area of nearly 43.8 mha, with a total production of 177.6 mt and

productivity of 4,057 kg ha⁻¹, whereas, wheat has 29.3 mha area, 103.6 mt production, and 3,533 kg ha⁻¹ productivity (FAOSTAT, 2021). Rice is the staple in the diet of >70% of the Indian population, and the rest of the population consumes rice along with wheat or other grains (USDA, 2019). Tillage is the most important input, constituting about 25-30 percent of energy requirement for crop production. In view of the continued energy crisis, there is a need for exploring the possibilities of reducing the tillage requirements for various crops and assessing their residual impact on the succeeding crops when grown in the system (Sharma and Arora, 2015). In soybean based cropping system, the productivity of succeeding *rabi* crops was considerably influenced by tillage across the country. There is ample scope for reducing the tillage operations in various *rabi* and *kharif* crops without significant reduction in their yields and without any adverse impact on succeeding crops in various systems at different locations, leading to energy saving in tillage practices in various cropping systems. Research work on

Soybean– wheat and paddy based cropping system is lacking in Narmadapuram region. This research was designed to develop a feasible and economically viable soybean based cropping system by using Resource Conservation Technologies (RCTs) that could benefit the farmers as well researchers in the locality.

MATERIALS AND METHODS

The field experiment was conducted during kharif and rabi seasons of 2013-14, 2014-15 and 2015-16 at JNKVV - Zonal Agricultural Research Station, Powarkheda, District– Hoshangabad, (Madhya Pradesh). Certified seed for crop soybean (JS 95-60), paddy (Pusa sugandha-5) and wheat (GW-273) were used under research trial. The recommended dose of nitrogen, phosphorus and potassium was 20:80:20 kg/ha, 100: 60: 40 kg/ha and 120:60:40 kg/ha, respectively for soybean, paddy and wheat crops. The source of nutrients was urea, di-ammonium phosphate and muriate of potash. The gross plot size for each treatment was 5.6 m X 6 m and net plot size was 4.70 m X 5.0 m. The experiment was laid out with 6 treatments and three replications. The treatments were T₁- Soybean – Wheat in conventional tillage, T₂ - Soybean – Wheat in FIRBS, T₃ - Soybean – Wheat in zero tillage, T₄ - Paddy – Wheat in conventional tillage, T₅ -Paddy – Wheat in FIRBS, T₆ - Paddy – Wheat in zero tillage.

RESULT AND DISCUSSION

The data presented in Table 1 revealed that the maximum seed yield of wheat (4030.6 kg ha⁻¹) was recorded under soybean–wheat in FIRBS (T₂) and was found significantly superior over other cropping sequence. The next highest seed yield of wheat

(3734.3 kg ha⁻¹) was recorded in Soybean – Wheat in zero tillage (T₃) followed by 3725.6 kg ha⁻¹ in Paddy – Wheat in FIRBS (T₅) and 3577.0 kg ha⁻¹ in Soybean – Wheat in conventional tillage (T₁) and all three were significantly at par with each other. The lowest seed yield of wheat (3215.6 kg ha⁻¹) was recorded in Paddy – Wheat in conventional tillage (T₄).

The significantly higher wheat grain yield (4030.6 kg ha⁻¹) recorded under soybean–wheat in FIRBS (T₂) compared to other treatments may be attributed to the favorable soil physical environment created by raised-bed planting. FIRBS improves soil aeration, root proliferation, infiltration, and nutrient uptake while reducing temporary waterlogging and soil compaction. These improvements enhance crop growth and yield, particularly in intensive cropping systems. Similar findings have been reported by Kumar *et al.* (2023), who observed higher wheat productivity, water-use efficiency, and profitability under raised-bed planting compared with conventional flat sowing in conservation agriculture systems.

The superior performance of the soybean–wheat sequence over the paddy–wheat sequence with respect to wheat yield can also be explained by the beneficial residual effects of soybean. As a legume, soybean contributes biologically fixed nitrogen and promotes soil microbial activity, organic matter turnover, and nutrient cycling, thereby improving soil fertility for the succeeding wheat crop. Meena *et al.*, (2023) reported that soybean-based conservation agriculture systems improved soil health parameters and nutrient availability, resulting in enhanced productivity of subsequent crops. The positive residual effects of legumes on succeeding cereals have also been widely documented as an important mechanism for improving system sustainability and resource-use efficiency.

Table 1. Seed yield and economics of wheat as affected by different treatment of wheat (3 years pooled data)

Treatments	Grain yield (kg ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Gross Income (Rs. ha ⁻¹)	Net Income (Rs. ha ⁻¹)	B : C ratio
Soybean – Wheat in conventional tillage (T ₁)	3577.0	24425.3	51767.6	27342.3	2.11
Soybean – Wheat in FIRBS (T ₂)	4030.6	24808.6	58085.0	33276.3	2.34
Soybean – Wheat in zero tillage (T ₃)	3774.3	22408.6	54428.6	32020.0	2.42
Paddy – Wheat in conventional tillage (T ₄)	3215.6	24492.0	46679.0	22187.0	1.90
Paddy – Wheat in FIRBS (T ₅)	3725.6	24875.3	53649.0	28773.6	2.15
Paddy – Wheat in zero tillage (T ₆)	3245.3	22508.6	46767.0	24258.3	2.07
SEm±	82.04				
CD at 5%	227.9				

Table 2. Economics of wheat as affected by different treatment of wheat (3 years pooled data)

Treatments	Seed yield (q ha ⁻¹)		Wheat equi. yield (q ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Gross Income (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B:C ratio
	Kharif Soybean/ Paddy	Rabi Wheat					
Soybean – Wheat	6.45	37.93	50.83	54076.0	76245	22169.0	1.40
Paddy – Wheat	39.03	33.95	106.8	73869.5	160200	86330.5	2.16

As regards, the sowing methods the FIRBS tillage proved equally efficient as compared to the conventional tillage system. The zero tillage system of sowing in paddy – wheat crop sequence when adopted under general fields may register an advantage of 20 – 25 days early sowing along-with the cost saving in field preparation after paddy. Further, the net monetary returns from wheat were maximum with FIRBS tillage in soybean – wheat (Rs. 33276 ha⁻¹) closely followed by zero tillage (Rs. 32020 ha⁻¹). Similar pattern was observed in paddy – wheat sequence. The paddy – wheat crop sequence proved to be far better in terms of wheat equivalent yield (106.8 q ha⁻¹), NMR (Rs.86331 ha⁻¹) and B:C ratio (2.16) as compared to soybean – wheat sequence.

The higher profitability of these treatments was associated with increased grain yield and reduced production costs resulting from lower tillage and irrigation requirements. Similar economic advantages of conservation agriculture practices have been reported by Sharma *et al.*, (2023), who observed higher net returns and benefit–cost ratios under zero tillage and raised-bed planting compared with conventional tillage systems. Virka *et al.* (2024) also reported that conservation tillage technologies improve profitability by reducing energy inputs and operational costs while sustaining crop productivity.

Although wheat yield was highest under soybean–wheat with FIRBS, the paddy–wheat sequence recorded greater wheat equivalent yield (106.8 q ha⁻¹), net monetary returns (₹ 86,331 ha⁻¹), and benefit–cost ratio (2.16). This indicates that total system productivity and profitability were influenced by the higher economic contribution of the rice crop. Rice–wheat remains one of the most productive and economically viable cropping systems in South Asia due to its high aggregate output and market demand. Recent reviews have emphasized that integrating conservation agriculture practices into rice–wheat systems can further improve resource-use efficiency, profitability, soil health, and environmental sustainability.

The adoption of conservation agriculture technologies such as FIRBS and zero tillage can contribute substantially to sustainable intensification of cropping systems through improved soil health, enhanced resource-use efficiency, reduced production costs, and increased resilience to climatic stresses (Bhatt *et al.*, 2013; Kumar *et al.*, 2023; Sharma *et al.*, 2023; Virka *et al.*, 2024).

CONCLUSION

The highest seed yields of wheat were obtained from soybean – wheat in FIRBS followed by Soybean – Wheat in zero tillage. The sowing methods the FIRBS tillage proved equally efficient as compared to the conventional tillage system. The zero tillage system of sowing in paddy – wheat crop sequence when adopted under general fields may register an advantage of 20 – 25 days early sowing along-with the cost saving in field preparation after paddy.

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