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Impact of Zero Tillage Technology in Wheat and Summer Greengram Cultivation in Kymore Plateau and Satpura Hill Regions of Madhya Pradesh

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ABSTRACT

The Kymore Plateau and Satpura Hills region, which spans the districts of Sidhi, Rewa, Satna, Panna, Jabalpur, and Seoni, is a vertical strip that runs through the center of Madhya Pradesh. Medium to heavy cotton soils predominate in the area, while in the irrigated tracts, rice-wheat-greengram is the main cropping system. Conventional tillage techniques, such as preparing the seed bed for wheat by tillage with a cultivator and then breaking lumps with a rotavator, and preparing the seed bed for greengram by a similar procedure, further postpone the sowing by a further 12 to 15d. In 2019–20 and 2020–21, technology demonstrations on wheat and summer greengram were carried out with conventional and zero tillage while taking the aforementioned into account. ZT+R and CT-R plots showed grain yields of 51.99 and 48.77 q/ha, respectively, which were 41.55 and 32.78 per cent more than FP (36.73 q/ha). The cost of cultivation in ZT+R plots was found to be 0.63 per cent lower than in farmer's practices, but 9.57 per cent higher in CT-R. Wheat could have been sown 15–18 d earlier than with the CT–R method. With 10–12 d early sowing in ZT+R plots, greengram seed yield under ZT+R and CT-R fields was recorded to be 12.65 and 12.28 q/ha, with yield increases of 29.74 and 25.95 per cent over FP (9.75 q/ha). The cost for cultivating greengram was 0.38 perent higher in CT-R technology but 4.87 per cent lower in ZT+R technology than in FP. In the disseminated area of 6385 ha, zero tillage technique minimized 675.92 MT CO_2 emissions, which was predicted to be 76% less than that of CT-R. This resulted in fuel savings of 252207 liters and decreased environmental pollution. In addition to the previously mentioned, it saved the need for one irrigation in greengram and wheat, saving a total of 5.795 million cubic feet of water in the disseminated area, valued at 63.85 lakh.

Key Words: Carbon dioxide, Conventional tillage, Emission, Zero tillage, Residue, Resource Retention.

INTRODUCTION

Madhya Pradesh is a significant producer of oilseeds, pulses, and cereal grains. It is the second-biggest producer of food grains in the nation. It is projected that in 2022–2023 the state will produce 352.7 lakh tonne of wheat (Anonymous, 2023). Additionally, Madhya Pradesh is the nation's second-biggest producer of greengram. In the Kymore Plateau and Satpura Hills region, a vertical band extending throughout central Madhya Pradesh that encompasses the districts of Sidhi, Rewa, Satna, Panna, Jabalpur, and Seoni, the major crops grown in rice-based farming systems are wheat and summer greengram. In the Jabalpur district, where it is grown on 45385 ha., greengram is usually sown in the summer season (Singh *et al,* 2020). Medium to heavy black soils make up around 70% of the district's arable area, and in the irrigated tracts, the most common cropping pattern is rice-wheat-greengram. Although there are 22 to 25 d between the harvest of rice and the following planting of wheat in these soils, it is preferable to seed greengram early in order to reach crop maturity prior to the start of the monsoon season. These crops are traditionally produced on well-tilled soil that has had the remnants of previous crops burned or removed. Intensive tillage processes increase production costs

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and energy requirements. Annual crop waste removal reduces biological activity and soil organic content. Burning crop residue, on the other hand, pollutes the environment. Traditional tillage methods, which include preparing the seed bed for wheat by tillage with a cultivator and then breaking up lumps with a rotavator, as well as preparing the seed bed for greengram, further postpone the sowing by 12 to 15 d.

In order to ensure the long-term sustainability of intensive cropping systems, resource conservation technologies (RCTs) including residue retention and zero tillage have emerged in recent decades (Sharma *et al*, 2012). RCTs increase soil fertility by increasing carbon accumulation and biological activity and lowering energy inputs, in addition to lowering cultivation expenses and enhancing table yields (Meena *et al*, 2015). The application of zero tillage (ZT) approach, involving the planting of crops in loose and anchored wastes using a "Happy Seeder" zero till equipment, has the potential to reduce the adverse effects of conventional tillage (CT) and increase crop yield at a lower cost of cultivation. Taking the afore mentioned into account, technology demonstrations were conducted on wheat and summer greengram using conventional and zero tillage in order to evaluate crop performance as well as time, energy, and resource savings.

MATERIALS AND METHODS

In the *rabi* and summer seasons of 2019–20 and 2020–21, respectively, farmer's fields under conventional and zero tillage in Dehri Khurd and Pipariya Kalan villages of Kundam and Shahpura blocks of Jabalpur district hosted integrated crop management (ICM) demonstrations on bi-fortified bread wheat variety WB 2 and greengram variety IPM 02–03. (Fig. 1 & 2). In fields that were labeled as CT-R (conventional tillage after residue removal) and ZT+R (zero tillage with residue retention), biofertilizers containing azotobacter and phosphate solubilizing bacteria (PSB) were applied at a rate of 5 kg/ha each during seed-bed preparation and prior to sowing. The recommended fertilizer dosage was 75% NPK of 100:60:40 kg/ha, along with 5 kg/ha of zinc. Urea, single super phosphate, and potash muriate were used to apply potassium, phosphorus, and nitrogen. Phosphatic fertilizer was placed two to three cm below the seed placement, and the seed rate used was 100 kg/ha. Prior to sowing, the seed was treated with a pre-mix fungicide (12% carbendazim and 63% mancozeb) at a rate of 2g/kg of seed fallowed by Azotobacter and PSB at a rate of 10 g/kg seed. In the CT-R and ZT+R plots, respectively, seed cum fertilizer drill and zero tillage machine 'happy seeder' were used for the sowing process. As a basel, full dose of phosphorus, potassium and zinc was applied; however, three equal splits of nitrogen were applied during the seeding, CRI and pre-flowering stages, respectively.

In the summer of 2020 and 2021, greengram was seeded at a rate of 25 kg/ha following seed treatment with a pre-mix fungicide (carbendazim 12% + mancozeb 63% WP) at a rate of 2 g/kg of seed fallowed by Rhizobium and PSB at a rate of 10 g/kg seed. PSB and *Trichoderma viridae* were inoculated into the soil at a rate of 5 and 2.5 kg/ha, respectively. During the sowing of the CT-R and ZT+R plots, 75% NPK of 20:50:20 kg/ha was applied using di-ammonium phosphate and muriate of potash. For the control of grassy and broadleaved weeds, pre-mix weedicide (sulphosulfuron 75% WP @ 25 g a.i./ha + metsulfuron methyl 5% WP @ 6 g a.i./ha) was used at 25–28 DAS in wheat and Imazethapyr 35% + Imazamox 35% WG @ 75 g/ha at 18–20 DAS in greengram. In order to control white fly and other sucking pests in greengram, pre-mix insecticide Betacyfluthrin + imidacloprid 300 OD @ 500 ml/ha was applied as foliar application at 32–35 DAS. *Pseudomonas fluorescence* was applied as spray in standing crop at the pre-flowering stage @ 2.5 l/ha to promote profuse flowering and pod development.

Fig. 1: Sowing of wheat with happy seeder and zero tilled wheat crop (WB 2)

Fig. 2: Sowing of summer greengram with happy seeder and zero tilled crop (IPM 02-03)

RESULTS AND DISCUSSION

Promising Parameters and economics

In wheat, ICM frontline demonstrations using ZT+R and CT-R methods revealed 359 and 336 tillers/m^2, respectively, which were 60.98 and 50.67 per cent more than farmers' practices (Table 1). The grain yield of ZT+R and CT-R plots, which were determined as 51.99 and 48.77 q/ha, was 32.78% and 41.55% greater than that of FP (36.73 q/ha). ZT+R plots showed a 0.63 per cent low cultivation cost, but with 9.57 per cent high CT-R compared to farmer's practices. The net return seen under ZT+R plots was 56.53 per cent higher than FP, and CT-R came in second at 43.64 per cent. In ZT+R, CT-R, and FP plots, the B:C ratio was 4.05, 3.8, and 3.14, respectively. With the least amount of soil disturbance attainable, the crop was directly seeded in the field shortly after the previous crop was harvested, by the use of zero-tillage technique with residue retention. Notwithstanding the afore mentioned, it shortened the duration and energy-intensive conventional tillage operations while lowering cultivation expenses and enabling wheat crop to be sown 15 to 18 d earlier than with the CT-R method. Gupta *et al (*2019) reported identical results from their study carried out in the Bhagalpur district of Bihar.

Table 1. Effect of ICM demonstrations on promising parameters of wheat under CT and ZT technology.

Particular	Tillers/m ^{2}	Per cent change over FP	Grain yield (q/ha)	Per cent change over FP	Cost of cultivation (Rs/ha)	Per cent change over FP	Gross return (Rs/ha)	Net return (Rs/ha)	Per cent change over FP	B:C ratio
FP	223	-	36.73	-	22530	-	70696	48166	-	3.14
CT-R	336	50.67	48.77	32.78	24688	9.57	93873	69185	43.64	3.80
ZT+R	359	60.98	51.99	41.55	22388	-0.63	100081	75393	56.53	4.05

It was found that ZT+R and CT-R summer greengram demonstrations exhibited 32.65 and 31.92 pods/plant, respectively, which were 23.39% and 20.63% more than farmers' practices. ZT+R and CT-R fields recorded seed yields of 12.65 and 12.28 q/ha, respectively, with yield increases of 29.74 and 25.95 per cent relative to FP (9.75q/ha). ZT+R technology recorded a cultivation cost of Rs17430/ha, 4.87 per cent less than FP; in contrast, CT-R technology recorded a 0.38 per cent higher cultivation cost (Rs18350/ha) than FP (Rs18280/ha). The ZT+R and CT-R demonstrations generated a net return that was 56.53% and 43.64% greater, respectively, than farmers' practices with B:C ratios of 5.22 and 4.82. Compared to the CT-R approach, the ZT+R approach allowed greengrams to be sown 10 to 12 d earlier, resulting in lower cultivation costs and increased yield. It was evident that the retention of residue as mulch on the soil contributed to the benefits of zero tillage. Higher N uptake was the outcome of residue additions that also increased the overall N, C, and other nutrient levels in the soil. In a study conducted in 2002, Halvorson *et al* (2002) found that in a cereal-legume cycle such as maize-chickpea-greengram, the biological N-fixation likely increased the N availability.

Table 2. Effect of ICM demonstrations on promising parameters of greengram under CT and ZT technology.

Particulars	Pods/plant	Per cent change over FP	Seed yield (q/ha)	Per cent change over FP	Cost of cultivation (Rs/ha)	Per cent change over FP	Gross return (Rs/ha)	Net return (Rs/ha)	Per cent change over FP	B:C ratio
FP	26.46	-	9.75	-	18280	-	70161	48166	-	3.84
CT-R	31.92	20.63	12.28	25.95	18350	0.38	88367	69185	43.64	4.82
ZT+R	32.65	23.39	12.65	29.74	17430	-4.87	91029	75393	56.53	5.22

Horizontal spread of the technology

Technology was made more widely recognized through popular articles, press releases, scientific advisories, folders/pamphlets, and Kisan Goshthies after ICM-ZT demonstrations in wheat and summer greengram. All seven blocks of the district—Jabalpur, Panagar, Majholi, Patan, Shahpura, Sihora, and Kundam—have ZT techniques for wheat and greengram disseminated throughout 86 and 105 villages, respectively, covering 3550 and 2835 ha. of area (Table 3). Since farmers adopted technological advances, the average yield of 44.5 and 11.7 q/ha of wheat and summer greengram was recorded. Under the disseminated technology, wheat and summer greengram generated an average net return of Rs.63802/- and 67143/ha, respectively, with BC ratio of 3.92 and 4.94. According to a number of investigations (Erenstein *et al*, 2007; Farooq *et al*, 2006; Laxmi *et al*, 2007), the ZT method of growing wheat has also been shown to have a number of advantages, including less need for labor, irrigation, and timely crop establishment. These benefits all contribute to increased crop yield and net income.

Table 3. Horizontal spread and net return in adoption of ZT technology in Jabalpur district.

Crop	Horizontal spread (No. of villages)	Area (ha)	Average yield (q/ha)	Average cultivation cost (Rs/ha)	Net return (Rs/ha)	B:C Ratio
Wheat	86	3550	44.5	21860	63802	3.92
Summer Greengram	105	2835	11.7	17050	67143	4.94

Table 4. Fuel consumption in conventional and zero tillage and saving under ZT technology.

Crop	Area (ha)	CT-R			ZT+R			Fuel saving & environmental impact in ZT+R	
		Requirement (l/ha)	Consumption (l)	CO_2 emission in MT	Requirement (l/ha)	Consumption (l)	CO_2 emission in MT	Diesel saving (l)	CO_2 emission reduction (MT)
Wheat	3550	52	184600	494.73	12.5	44375	118.93	140225	375.80
Summer Green gram	2835	52	147420	395.09	12.5	35437.5	94.97	111982.5	300.11
Total	6385	--	332020	889.81	--	79812.5	213.90	252207.5	675.92

Fuel saving vis-a-vis environmental impact

The data (Table 4) reflected that zero-tillage technology saved 39.5 l of fuel per hectare. Diesel consumption under CT-R technology in 6385 ha recorded to be 332020 litres, however in ZT+R, it was 79812.5 litre thus 252207 litre fuel saved in the disseminated area under ZT, was 316 percent less to that of CT-R method. Zero tillage technology also reduced environmental pollution by minimizing 675.92 MT CO_2 emission which was estimated to be 76 percent less to that of CT-R. Above findings suggest that use of zero tillage with residue retention should be advocated for saving of fuel vis-à-vis CO_2 emission.

Irrigation and revenue saving

Zero tillage together with residue retention saved one irrigation for wheat and greengram. In addition, the method assisted in lowering soil disturbance and increasing soil structure, better soil aggregation, carbon accumulation, fertility, and biological qualities. Weed occurrence was also decreased, mostly as a result of wheat and greengram emerging more rapidly.

CONCLUSION

The study revealed that cost and resource savings considerably increased the net return of wheat and summer greengram in zero tillage technology. It helps to reduce machine labour, fossil fuels, and irrigation water under zero tillage compared to conventional and farmers' traditional practices. Furthermore, the method significantly reduced CO_2 emissions, which are a major cause of environmental pollution. As a result, it could be a valuable choice for conserving scarce resources and increasing net farm income. The wider availability of happy seeder can encourage the adoption of zero tillage technology in rice-wheat-summer greengram cropping system.

Table 5. Irrigation water consumption and saving in ZT technology.

Crop	Area (ha)	Irrigation Requirement (cubic feet/ irrigation/ha)	Total water consumption (million cubic feet)	Irrigation saving in ZT+R	Cost per irrigation (Rs/ha)	Total revenue saving per irrigation (in lakh)
Wheat	3550	9075	3.222	1	1000	35.5
Summer Greengram	2835	9075	2.573	1	1000	28.35
Total	6385	--	5.795	2	--	63.85

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