CONSERVATION AGRICULTURE FOR ENHANCED YIELD AND INCOME FROM SOYBEAN-WHEAT SYSTEMS: EFFORTS OF ICAR-IISS, BHOPAL

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Conservation agriculture (CA) is a management system where soil is minimally disturbed and kept covered under crop residues. Under conventional tillage, excessive tillage mostly leads to destruction of soil structure, excess utilization of energy, low input use efficiency and poor farm economics. The CA concepts like minimum tillage, zero tillage, stubble mulch tillage etc. manage these problems to a greater extent. The immediate benefit of adoption of conservation tillage adoption is the reduced land preparation cost. Further, as machineries used in CA like happy seeder and zero till seed drills are capable of sowing wheat and other crops in the standing residues of previous crops without much disturbance to the soil.. Hence, farmers won't be forced to burn crop residues to clear the field and that also resolve many field burning associated issues like environmental pollution, decline in soil health due to loss of soil biodiversity, soil organic carbon and other nutrient elements present in soil etc.

Farmers can adopt conservation tillage effectively either by minimising tillage operation for land preparation activities which do not yield much economic benefits or by performing agricultural operations like sowing, seeding and fertilizer application together. With adoption CA gradually improve natural resource base of the farm and practices like no tillage, crop rotations and cover crops with the prudent use of inputs ensure an optimum yield and profit margin to farmers. Thus, farmers achieve a balanced farm economics along with environmental benefits.

EFFORTS OF ICAR-INDIAN INSTITUTE OF SOIL SCIENCE IN POPULARISING CONSERVATION AGRICULTURE

ICAR-Indian Institute of Soil Science, Bhopal has been conducting farmer field trials and demonstrations of CA technologies for the past six years through its two externally funded projects (1) demonstration of best-bed conservation agriculture practices on farmers' fields in Vertisols of Central India (2) ensuring food security, sustainability and soil health through resource conservation based farmer FIRST approach in central India. These projects cover 600 farm families of Khamkheda, Bhairopur, Raipur, Kanchbawli, Kalyanpur, Raslakhedi, Kanera, Karond khurd villages located in the Huzur division of Bhopal district. The area generally receive an average annual rainfall of 1070 mm. Soils are deep black occupying an area of approximately 1000 hectares.

Major cropping systems prevalent in these villages are soybean-wheat and rice-wheat. Farmers practice conventional agriculture, plough their fields 3-4 times using tractor drawn tillers, and burn crop residues before the winter wheat crop. Major problems identified include poor resource utilization, nutrient deficiencies in soil, low crop yields, and poor farm economics.

The ICAR-IISS project team has carried out several farmer-scientist interface meetings, awareness camps, and training programmes in the beginning to sensitize the farming community of the selected villages about CA technologies, benefits with its adoption, and the challenges in the initial phase of adoption (Figure 1). Farmers were motivated for adoption of CA based cultivation of soybean and wheat, soil test based nutrient application, and retention of crop residues by organizing different interaction meets and exposure visits. Initially, innovative farmers of the selected villages were encouraged to adopt zero tillage and reduced tillage practices under the CA intervention in their soybean-wheat fields. Soil health assessment was carried out in beneficiary farmers' fields and determined the soil nutrients status. Soils were mostly low in available N, S and Zn. STCR based approach were adopted to prescribe balanced nutrient recommendations to soybean and wheat crops. Suitable machinery for sowing of crops under zero tillage, management of weeds and pests under conservation agriculture and machinery for managing wheat residue were also demonstrated to these farmers (Figure 2,3).

Figure 1. training organized for the beneficiary farmers of CA demonstration at ICAR-IISS Bhopal

Figure 2. Farmer field demonstration of mechanical harvest born residue management using baler machine

Evaluation-cum-demonstrations of conservation tillage practices were carried out in a participatory mode in farmer fields @ 0.5 acre with conventional tillage in an equal area (figure 3). Observations were made through regular field visits (Figure 4,5,6,7).

Figure 3. Sowing of soybean seeds in residue retained field

Figure 4. Soybean crop under conservation tillage system

Figure 5. Wheat crop under 90 percent residue retention CA fields

Results showed drastic reduction in cost towards land preparation (100%) and seed (20%) for both soybean and wheat crops and irrigation (16.7%) in wheat crop under conservation tillage than conventional tillage system. However, cost incurred under conservation tillage for soybean and wheat crops was more for activities like sowing (33.3% for soybean, 66.7% for wheat), weed management (29.7% for soybean, 66.7% for wheat) and fertilizer (30% for soybean, 19.3% for wheat). Despite increase in cost of some of the inputs, there is an overall reduction in cost of cultivation for soybean (15%) and wheat (10%) under conservation agriculture due to the cost savings in land preparation. Under conservation tillage crop yields and net profit were slightly higher than that of conventional tillage (Table 1).

System and Water Productivity: system productivity was calculated by comparing crop yields under conventional and zero tillage and converting the results in terms of wheat equivalent yield (WEY). Further, crop water productivity was calculated as the ratio of amount of marketable produce (kg grains) to the amount of input needed to produce that output (m^3 water). Under conservation agriculture, system productivity was 7.36% and water productivity was 24.67% more compared to conventional agriculture. Water productivity of the system increased from 1.08 kg m^{-3} in conventional tillage system to 1.34 kg m^{-3} in water productivity under conservation agriculture (Table 2). In fact, crop residues left in the field acts as a mulch and conserve moisture in soil for longer period of time which result in increased water productivity.

Energy Consumption: An overall reduction in energy consumption was recorded in the conservation tillage system as the diesel consumption by tractor for tillage operations during land preparation and sowing has reduced to 40 Lha^{-1} from 112 Lha^{-1} of conventional tillage. Also, conservation tillage reduced the number of irrigations for the wheat crop to 4 from 5 of conventional tillage system. This made 25.3% reduction in water requirement for wheat crop that resulted saving in power requirement under conservation agriculture.

Figure 6. Wheat crop under conservation tillage system

Figure 7. ICAR-IISS team visit CA demonstration fields

Table 1. Comparison crop yields and economic returns from Soybean- wheat cropping system under conventional and conservation tillage systems

S. No	PARAMETERS	SOYBEAN			WHEAT		
		Conventional Tillage **(1)**	Conservation Tillage **(2)**	Benefit of 2 over 1 (%)	Conventional Tillage **(1)**	Conservation Tillage **(2)**	Benefit of 2 over 1 (%)
A	Yield (qha^{-1})	15.0	16.3	8.67	47.5	50.6	6.55
B	Economic Indicators						
i	Cost of cultivation ($Rs.ha^{-1}$)	25300.00	21500.00	-15.02	40000.00	36000.00	-10.00
ii	Net income (Rs./ha)	20000	28000	40.00	60000	75000	25.00
iii	B:C ratio	1.79	2.30		2.50	3.08	

Table 2. System productivity (WEY) and water productivity under conventional and zero tillage

S. No	PARTICULARS	Crop Productivity ($kg\ ha^{-1}$)		System Productivity (WEY)		Water Productivity	
		Soybean	Wheat	$kg\ ha^{-1}$	% change	$Kg\ m^{-3}$	% change
1	Farmers Practice	1500	4750	7750		1.08	
2	Zero Tillage	1630	5061	8320	7.35%	1.34	24.67%

CONCLUSIONS

Results of the participatory demonstrations clearly indicated several advantages associated with adoption of conservation agriculture like fuel saving, reduced cost of cultivation, less water requirement and increased water productivity for the wheat crop. Despite several advantages machinery intensive practice and requirement of high power tractors for sowing in vertisols act as a major factor that prevent many resource poor farmers from adopting the technology. These farmers require policy and financial support from government to own conservation agriculture. Adoption of conservation agriculture holds key for achieving sustainability resource conservation and environmental security.

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