Effect of tillage and residue management practices on cotton-wheat cropping system in the canal command area of north-west Rajasthan (India)

P.L. Nehra[1] and P.D. Kumawat[2]
[1] Agricultural Research Station, Sri Ganganagar INDIA
[2] Rajasthan Agricultural University, Bikaner INDIA

ABSTRACT

*A field experiment was conducted on sandy loam soil, alkaline in reaction (pH 8.1), low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium during kharif and rabi seasons of 2000-2001 and 2001-2002 at Agricultural Research Station, Sri Ganganagar to find out the effect of tillage and residue management practices on cotton (*Gossypium hirsutum L*) - wheat (*Triticum aestivum L*) cropping system in canal command area of North-West, Rajasthan (INDIA). Among tillage practices, deep ploughing before cotton sowing once in two years + reduced preparatory tillage with rotovator + herbicide application for early season weed control significantly increased seed cotton yield (16.37 q/ha), boll weight, number of bolls per plant and plant height as compared to reduced preparatory tillage with rotovator (12.33 q/ha). However, residue treatments did not influence seed cotton yield significantly. In view of wheat crop, one disc + double cultivator produced significantly higher wheat grain yield (43.53 q/ha), tillers/m² and number of grains per spike than reduced preparatory tillage with rotovator (39.41 q/ha). Residue management practice where cotton stalks and wheat straw shredded and incorporated produced significantly higher wheat grain yield (43.20 q/ha) over control (39.41 q/ha).*

Introduction

Cotton-wheat is a dominant cropping system in North India but recently, the productivity of a cotton-wheat cropping system is decreasing day by day. Farmers are facing several constraints like decline in soil organic carbon content, acute labor shortage during critical operations and improper tillage and residue management under cotton-wheat cropping system due to paucity of time between harvest and non availability of suitable farm implements. Keeping in view, the available information and the present situation, a field experiment was conducted with the objective to study the effect of tillage and residue management practices on the production of cotton and wheat in canal command area of North-West, Rajasthan, India.

Experimental procedure

A two year field study was established during the kharif and rabi seasons of 2000-2001 to 2001-2002 on sandy loam soil, low in organic carbon and nitrogen, medium in available potash and high in available potassium at the Agricultural Research Station, Sri Ganganagar, Rajasthan Agricultural University, Bikaner, India. The experiment was laid out in a split plot design with three tillage treatments, viz. the first design treatment was disc harrow + double cultivator for cotton and wheat (T_1), the second design treatment was reduced preparatory tillage with rotovator for cotton and wheat (T_2) and the third design was deep ploughing before cotton sowing once in two years + reduced tillage with rotovator + herbicide application for early season weed control (T_3) in main plots and five residue treatments viz. cotton stalks and wheat straw removed, i.e. control (R_1), cotton stalks removed and wheat straw retained (R_2), cotton stalks retained and wheat straw removed (R_3), wheat straw burnt *in situ* (R_4) and cotton stalks and wheat straw shredded and incorporated (R_5) in sub plots which were replicated thrice. The *G. hirsutum* cotton variety RS-810 was sown by dibbling 2-3 seeds/hill at a spacing of 67.5 x 30 cm in the second fortnight of May during both the crop seasons. Half dose of nitrogen (40 kg/ha) and full dose of phosphorus (40 kg/ha) was applied basal through urea and DAP, respectively. Remaining nitrogen was top-dressed at first irrigation. Weeds were controlled with the application of pendimethalin @ 1.5 kg a.i./ha. The data on plant height, boll weight, and number of bolls/plant were recorded from randomly selected five plants in each plot and seed cotton yield was recorded on per plot basis. Adequate plant protection measures were taken as per recommendations.

The wheat variety Raj-3077 was sown in the first fortnight of December during both the crop seasons with a row spacing of 22.5 cm. A half dose of nitrogen and full amount of phosphorus was applied at the time of sowing through urea and DAP and the remaining half dose of nitrogen was applied in two splits. Weeds were controlled with the application of 2, 4-D @ 0.5 kg ai/ha + isoproturon @ 1.0 kg a.i./ha in 500 liters of water at 30 days after sowing as per treatments. Observations were recorded on yield and its component characters.

Soil samples were taken at periodic intervals from 0-15 and 15-30 cm soil depths for chemical analysis i.e. pH, organic carbon content, EC (dsm-1) and available nutrient status (Jackson, 1967).

To test the significance of variance in the data obtained for various characters, the analysis of variances technique (Fisher, 1950) for "split plot design" was adopted. Wherever "F" test was found significant at 5 percent level of probability, the critical difference was calculated to assess the significance of differences between the treatments.

Results and Discussion

Effect of tillage practices

In the cotton season, tillage treatment T_3 (deep ploughing before cotton sowing once in two years +

reduced tillage with rotovator + herbicide application for early season weed control) gave significantly higher seed cotton yield over T_2 where reduced tillage with rotovator was done. However, T_3 remained statistically at par with T_1 (one disc harrow + double cultivator for cotton and wheat) (Table 1). T_3 gave 32.76% higher seed cotton yield over T_2. This increase in seed cotton yield might be due to increased boll weight, numbers of boll/plant and plant height.

A perusal of data (Table 2) revealed that T_1 (one disc harrow + double cultivator for cotton and wheat) gave significantly higher wheat grain yield over T_2 (reduced preparatory tillage with rotovator for cotton and wheat) and remained statistically at par with T_3 (deep ploughing before cotton sowing once in two years + reduced tillage with rotovator + herbicide application for early season weed control). It gave 10.45 percent higher wheat grain yield than T_2 (reduced preparatory tillage with rotovator). Increased tillers/m^2, number of grains/spike and test weight was mainly responsible for the increased grain and straw yield at this level of significance. The higher seed cotton and wheat yield obtained with tillage operations might be due to favorable effect of these tillage practices on water availability for crops through their effect on water retention at the soil surface (Unger and Stewart, 1983). Soil permeability was increased by breaking the compacted layers. These tillage practices also improved the soil aeration, which helped in multiplication of microorganisms and degradation of herbicide and pesticide residues and harmful allelopathic chemicals exuded by roots of previous crop or weeds. Organic matter decomposition was hastened resulting in higher nutrient availability and hence, increased yields of crop.

A critical examination of data presented in Table 3 indicate that one disc harrow + double cultivator for cotton and wheat (T_1) gave slight increase in the organic carbon content in both 0-15 cm and 15-30 cm soil depth, respectively after the completion of first and second year cotton-wheat rotation.

Effect of residue management practices

Different residue treatments did not influence seed cotton yield significantly (Table 1). However, in the second year of experimentation, seed cotton yield increased significantly where cotton stalks and wheat straw was shredded and incorporated (R_5) followed by R_2 (cotton stalks removed and wheat straw retained) over control. Treatment T_5 gave 15.13 percent higher seed cotton yield over control. This increase in seed cotton yield might be due to significant increase in boll weight and number of bolls/plant. The residue treatment T_5 where cotton stalks and wheat straw was shredded and incorporated produced significantly higher grain and straw yield of wheat over control. It gave 9.62 percent higher grain yield over control. The significant increase in the number of tillers/m^2 was mainly responsible for increased wheat grain and straw yield. However, other growth and yield attributing characters that were increased non-significantly may also have a favorable effect on yield. Other residue treatments remained at par with control. The beneficial effect of crop residues on yield and attributes of cotton and wheat could be credited to the fact that after proper decomposition and mineralization, the crop residues supplied available nutrients directly to the plant and also had solubilizing effect on fixed forms of nutrients in soil. The beneficial effect of retaining crop residues in the field has been reported in a wide variety of crop (Prasad and Power, 1991). The crop residues also improved the organic matter of the soil which is a major source of plant nutrients in soils, promotes soil aggregation (Oades, 1984), leading to reduced soil erosion (Lal, 1986), increased water infiltration, water holding capacity and buffering capacity in low activity clay soils (Swift and Sanchez, 1984). The organic matter also increased the adsorptive power of soil cations and anions particularly phosphates and nitrates and these were released slowly for the benefits during entire crop growth period leading to higher yield. The residue treatment T_5 (cotton stalks and wheat straw shredded and incorporated) gave slight increase in organic carbon content in both 0-15 cm and 15-30 cm in soil depth in comparison to other residue treatments.

Conclusion

It may be concluded from this study that deep ploughing before cotton sowing once in two years + reduced tillage with rotovator + herbicide application for early season weed control combined with the shredding and incorporation of cotton stalks and wheat straw would be better for achieving higher yield advantages of *hirsutum* cotton than other tillage and residue management practices. For maximum wheat yield, one disc harrow + double cultivator was found to be better than other tillage practices. With regards to residue management, the shredding and incorporation of cotton stalks and wheat straw was found most suitable.

References

- Fisher, R.A. (1950). Statistical methods for research workers. Oliver and Soyd. Edinburgh, London.
- Jackson, M.L. (1967). Soil chemical analysis. Prentice Hall Inc., New York.
- Lal, R. (1986). Soil surface management in the tropics for intensive land use and high and sustained production. *Adv. Soil Sci.*, **7**: 1-105.
- Oades, J.M. (1984). Soil organic matter and structural stability. Mechanisms and implications for management. *Plant and Soil,* **76**: 319-337.
- Prasad, R. and Power, J.F. (1991). Crop residue management. *Adv. Soil Sci.,* 205-251.
- Swift, M.J. and Sanchez, P.A. (1984). Biological management of tropical soil fertility for sustainable productivity. *Nature and Resources,* **20**: 1-10.

- Unger, P.W. and Stewart, B.A. (1983). Soil management for efficient water use: An over view. *In* Taylor, H.M., Jordan, W.R. and Sinclair, T.R. (Eds.) Limitations to efficient water use in crop production. American Society of Agronomy, USA. Madison.

Table 1. *Effect of tillage and residue management practices on growth, yield and yield attributing characters of hirsutum cotton.*

Treatment	Seed cotton yield (q/ha)			Boll weight (g)		Number of bolls/ plant		Plant height (cm)		Plant population/ha	
	2000	2001	Pooled	2000	2001	2000	2001	2000	2001	2000	2001
Tillage practices											
T_1	13.79	17.34	15.57	2.77	3.12	32.00	36.69	141.00	125.00	42549	41913
T_2	11.11	13.55	12.33	2.68	2.96	29.73	32.72	134.00	117.00	42438	41564
T_3	16.11	16.62	16.37	2.90	3.11	35.33	36.33	145.00	123.00	42675	41852
CD (P=0.05)	1.44	1.56	01.24	0.12	0.12	1.91	2.75	4.50	3.50	NS	NS
Residue management practices											
R_1	13.27	14.08	13.68	2.68	2.94	32.00	31.30	139.00	119.00	42728	41872
R_2	14.23	16.63	15.43	2.85	3.10	32.89	36.94	142.00	123.00	42284	41529
R_3	13.27	15.72	14.50	2.74	3.05	31.89	35.42	137.00	121.00	42419	41872
R_4	13.58	15.23	14.41	2.81	3.00	32.44	34.02	140.00	120.00	42318	41666
R_5	13.99	17.51	15.75	2.84	3.22	32.55	38.55	141.00	125.00	43003	41941
CD (P=0.05)	NS*	2.14	NS	NS	0.15	NS	2.92	NS	NS	NS	NS

*NS = Not significant

Table 2. Effect of tillage and residue management practices on growth yield and yield attributing characters of wheat.

	Grain yield (q/ha)			Straw yield (q/ha)		Tillers/m^2		Number of grains/spike		Test weight (g)		Plant stand/m^2	
Treatment	2000	2001	Pooled	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Tillage practices													
T_1	46.22	40.83	43.53	61.08	52.68	425	386.93	42.61	38.70	41.10	41.79	185	184.00
T_2	43.02	35.79	39.41	54.70	46.30	391	347.88	39.68	35.42	38.80	39.17	181	180.00
T_3	44.05	38.68	41.37	56.00	49.50	406	370.84	40.78	36.63	39.00	41.13	187	183.80
CD (P=0.05)	1.83	3.39	2.15	3.04	4.14	21	24.36	1.60	2.07	NS	NS	NS	NS
Residue management practices													
R_1	43.88	34.94	39.41	55.14	46.21	394	334.81	39.03	35.19	39.40	39.82	184	180.89
R_2	44.67	40.01	42.34	56.41	51.21	400	383.43	41.86	37.87	39.30	41.18	183	183.00
R_3	44.95	36.75	40.85	58.48	47.03	418	352.23	40.20	36.02	40.10	39.88	186	181.78
R_4	43.89	38.84	41.37	56.69	49.72	401	373.39	41.13	36.51	39.40	40.80	185	183.44
R_5	44.77	41.62	43.20	59.58	53.28	420	398.56	42.88	38.98	40.10	41.81	184	183.89
CD (P=0.05)	NS	4.75	3.30	NS	5.60	NS	28.05	NS	3.05	NS	NS	NS	NS

* NS = Not significant

Table 3. *Effect of tillage and residue management practices on chemical properties of the soil after the completion of cotton-wheat rotation.*

Treatments	% Organic carbon 2000-2001				% Organic carbon 2000-2001			
	Initial		After rotation		Initial		After rotation	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Tillage Practices								
T_1	0.214	0.203	0.220	0.208	0.220	0.208	0.227	0.214
T_2	0.211	0.198	0.216	0.203	0.216	0.203	0.220	0.210
T_3	0.213	0.201	0.218	0.205	0.218	0.205	0.228	0.210
Residue management practices								
R_1	0.212	0.202	0.216	0.204	0.216	0.204	0.219	0.206
R_2	0.214	0.203	0.222	0.209	0.222	0.209	0.229	0.205
R_3	0.209	0.198	0.219	0.205	0.219	0.205	0.226	0.211
R_4	0.211	0.200	0.216	0.204	0.216	0.204	0.224	0.211
R_5	0.208	0.197	0.220	0.206	0.220	0.206	0.229	0.214