Madras Agric. J., 2020; doi:10.29321/MAJ 2020.000347

RESEARCH ARTICLE

Effect of Conservation Agriculture and Residue Management on Yield and Economics of Cotton – Maize Cropping System

Veeraputhiran R*
Cotton Research Station, Tamil Nadu Agricultural University, Srivilliputtur - 626 135.

Received : 17th November, 2019
Revised : 20th January, 2020
Revised : 06th February, 2020
Accepted : 27th February, 2020

ABSTRACT

Field experiments were conducted at Cotton Research Station, Srivilliputtur, during 2017-18 and 2018-19 to study the effect of conservation agriculture and residue management practices on yield and economics of cotton (September to January) – maize (February to June) cropping system under irrigated conditions. The experiments were carried out in a Randomized Block Design with three replications. The treatments consisted of control (T_1 - Conventional tillage + No residue management), Zero tillage (ZT) + No residue management (T_2), ZT with 50 % residue management (T_3), ZT with 100 % residue management (T_4), Permanent Bed System (PBS) + ZT + No residue management (T_5), PBS + ZT + 50 % residue management (T_6), PBS + ZT + 100 % residue management (T_7). The results revealed that though the conventional tillage without residue incorporation recorded higher yields of cotton and maize in both the years of study, this was on par with that of zero tillage with 100% and 50% residue management and significantly superior to other treatments. The conventional tillage without residue incorporation also registered the highest cotton equivalent yield (3584 and 4046 kg.ha^{-1} during the first and second year of study, respectively) which were followed by ZT with 100 % residue management (3514 and 3924 kg/ha in the first and the second year) and ZT with 50 % residue management (3481 and 3841 kg/ha in first and second year) and PBS + ZT + 100 % residue management (3413 and 3770 kg/ha in first and second year) in maize - cotton cropping system. The labour requirement was minimized by 20 laborers/crop/ha under ZT than conventional tillage. Adoption of ZT and PBS in the cotton – maize cropping system reduced the total cost of cultivation by Rs. 12,000/ha/year and Rs.15,500/ha/year, respectively. Though the higher gross income was associated with conventional tillage without residue application, higher net income and BC ratio were registered by zero tillage with residue application. Thus, it is concluded from the study that zero tillage under cotton - maize cropping system was technically feasible, which was comparable with conventional tillage without residue application on yield besides higher economic benefits and lesser labor use.

Keywords: Cotton, zero tillage, stubble management, seed cotton yield, economics

Cotton, also known as "white gold" and "king of fibre crops," is a critical fibre cum cash crop of India and Tamil Nadu as well. In Tamil Nadu, cotton is cultivated in an area of 1.48 lakh ha during 2017-18 with a production of 2.80 lakh bales and productivity of 599 kg/ha which is below the world average yield of 788 kg/ha (Anonymous, 2018). Maize, queen of cereals, is the most versatile crop with wider adoptability in varied agro-ecological conditions. In India, an increasing trend is observed in the cultivation of maize in recent years (5.98 M ha in 1993 to 8.33 M ha in 2009 and 9.6 M ha in 2016-17). Among the total residues available in India, cereals including maize and cotton contribute 70 per cent (352 Mt) and 11 per cent (53 Mt), respectively. In addition, the surplus quantity of residues from cereals and fibre crop contribute 58 and 23 per cent, respectively, to the total, and approximately 80 per cent of surplus cotton residues are subjected to on-farm burning (IARI, 2012). The crop residues which are having enormous value if utilized properly will have great potential for improving soil fertility, creation of pollution-free environment besides improving the yield of crops.

Conservation agriculture is emerging as a big boost for crop production in India. It is based

*Corresponding author's e-mail: veeraagri@yahoo.co.in

on minimal soil disturbance (Reduced or no/ zero tillage), which may have enormous scope to save labour, time, fuel, and machinery wear. The main concept of zero tillage is to avoid preparatory cultivation and without carrying any tillage operations. The ideal examples of zero tillage in Tamil Nadu are sowing offallow rice crops either before the harvest of rice (black gram or green gram) or in the stubbles after the harvest of cotton. Similarly, zero tillage maize in the rice fallow was also attempted in Tamil Nadu (Vetrivendhan, 2016, and Sapthagiri, 2017), and it was found technically and economically viable. However, conservation agricultural studies under the garden land system are very meagre. To manage the crop residues in a productive and profitable manner, conservation agriculture offers a good promise. Development of conservation agriculture-based resource-conserving technologies which are more resource-efficient than the conventional method of cultivation is paramount importance for long term sustainability. With this background, the present study was carried out to investigate the effect of conservation agriculture and residue management practices in cotton- maize cropping system.

MATERIALS AND METHODS

Field experiments were conducted at Cotton Research Station, Srivilliputtur, during 2017-18 and 2018-19 to study the effect of conservation agriculture and residue management practices on yield and economics of cotton (September to January) – maize (February to June) cropping system under irrigated conditions. The experiments were carried out in a Randomized Block Design with three replications. The treatments consisted of control (T_1 - Conventional tillage + No residue management), Zero tillage (ZT) + No residue management (T_2), ZT with 50 % residue management (T_3), ZT with 100 % residue management (T_4), Permanent Bed System (PBS) + ZT + No residue management (T_5), PBS + ZT + 50 % residue management (T_6), PBS + ZT + 100 % residue management (T_7). The soil of the experimental field was clay loam with a pH of 8.26. The available nutrient N, P, and K status of the soil was low (196 kg/ha), high (40 kg/ha) and high (446 kg/ha), respectively.

The cotton variety SVPR 6 and hybrid maize (S 6668) were used for the study. The recommended fertilizer dose of 80:40:40 and 135:62.5:50 kg NPK/ ha were applied to cotton and maize, respectively, for all the treatments. Ridges and furrow method of cultivation without residue application was followed in the control treatment. The seeds of cotton and maize were dibbled with 75 x 30 and 75 x 20 cm, respectively, on the surface of the soil without tillage under zero tillage treatments. The permanent Bed System was prepared with a bed width of 125 cm and 25 cm furrow width. Earthing up was carried out during 40–45 days after sowing of both cotton and maize crops under zero tillage while earthing up was not practiced in PBS. Cotton stalks were applied in between the rows on the surface of the maize field and vice versa by volume basis as per schedule. Observations on seed cotton yield and grain yield of maize were recorded, and economics was also worked out.

RESULTS AND DISCUSSION

The yield of cotton and maize

The results on the yield of crops (Table 1) revealed that conventional tillage without residue incorporation recorded the highest kapas yield of cotton in both the years of study, but this was on par with that of zero tillage with 100 % and 50 % residue management and significantly superior to other treatments except the first year of cotton crop.

Table 1. Effect of conservation agriculture and residue management on yield of cotton - maize cropping system

Treatments	2017-18				2018-19			
	Seed cotton yield (kg/ha)	Grain yield of maize (kg/ ha)	CEY of maize (kg/ha)	Total CEY of cropping system (kg/ha)	Seed cotton yield (kg/ha)	Grain yield of maize (kg/ha)	CEY of maize (kg/ha)	Total CEY of cropping system (kg/ha)
T1	2028	5618	1556	3584	2069	4787	1977	4046
T2	2017	5036	1395	3412	1873	4311	1781	3654
T3	2019	5277	1462	3481	1966	4539	1875	3841
T4	2022	5385	1492	3514	2012	4628	1912	3924
T5	1986	4904	1358	3344	1804	4033	1666	3470
T6	1995	5005	1386	3381	1837	4308	1779	3616
T7	2001	5093	1411	3412	1925	4467	1845	3770
SEd	74.2	180.2	-	-	71.1	141.2	-	-
CD (P=0.05)	NS	376.6	-	-	148.6	295.1	-	-

CEY – Cotton Equivalent yield

Sale price of kapas was Rs. 45/kg and Rs. 46/kg during first and second year respectively

Sale price of maize grain was Rs. 12.50/kg and Rs. 19/kg during first and second year respectively

A similar trend of comparable yield under conventional tillage and zero tillage with both 100 and 50 per cent of residue application was observed in maize. Being first crop of crop rotation, residues application and zero tillage were not practiced for cotton, and hence non-significant effect on seed cotton yield was noticed during the first year. Similar results from the field experiment at Cotton Research Station, TNAU, Srivilliputtur revealed that incorporating rice stubbles in the fields of summer irrigated cotton resulted in increasing the yield than without incorporation (Srinivasan, 2013). Naveen Kumar and Babalad (2017) also found that both the conservation agricultural systems of no and reduced tillage with crop residue application registered significantly higher yield of cotton than conventional tillage at UAS, Dharwad. At Akola, minimum tillage registered comparable seed cotton yield with conservation tillage under rainfed conditions (Sonune *et al*., 2013). Somasundaram *et al*., (2007) observed improved grain yield of succeeding cowpea crop by the incorporation of the cotton stalk was also in conformity with the present investigation

Table 2. Effect of conservation agriculture and residue management on the economics of cotton - maize cropping system- First year rotation

Treatments	Cotton				Maize				Cotton- maize cropping system			
	Cost of cultivation (₹ / ha)	Gross income (₹ / ha)	Net income (₹ / ha)	BCR	Cost of cultivation (₹ / ha)	Gross income (₹ / ha)	Net income (₹ / ha)	BCR	Cost of cultivation (₹ / ha)	Gross income (₹ / ha)	Net income (₹ / ha)	BCR
T_1	56500	93288	36788	1.65	41700	70225	28525	1.68	98200	163513	65313	1.67
T_2	50500	92782	42282	1.84	35700	62950	27250	1.76	86200	155732	69532	1.81
T_3	50500	92874	42374	1.84	35700	65963	30263	1.85	86200	158837	72637	1.84
T_4	50500	93012	42512	1.84	35700	67313	31613	1.89	86200	160325	74125	1.86
T_5	49000	91356	42356	1.86	34200	61300	27100	1.79	83200	152656	69456	1.83
T_6	49000	91770	42770	1.87	34200	62563	28363	1.83	83200	154333	71133	1.85
T_7	49000	92046	43046	1.88	34200	63663	29463	1.86	83200	155709	72509	1.87

Cotton Equivalent Yield of cropping system

The CEY of cotton – maize cropping system (Table 1) showed that conventional tillage without residue incorporation registered the highest cotton equivalent yield of 3584 and 4046 kg/ha during the first and second year of study, respectively. This was followed by ZT with 100 % % residue management (3514 and 3924 kg/ha in first and second year) and ZT with 50 % residue management (3481 and 3841 kg/ha during 2017-18 and 2018-19) and PBS + ZT + 100 % residue management (3413 and 3770 kg/ha during 2017-18 and 2018-19) in maize - cotton cropping system.

Table 3. Effect of conservation agriculture and residue management on the economics of cotton- maize cropping system- II year rotation

Treatments	Cotton				Maize				Cotton- maize cropping system			
	Cost of cultivation (₹/ha)	Gross income (₹/ ha)	Net income (₹/ ha)	BCR	Cost of cultivation (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	BCR	Cost of cultivation (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	BCR
T_1	56500	95174	38674	1.68	54400	90953	36553	1.67	110900	186127	75227	1.68
T_2	50500	86158	35658	1.71	48400	81909	33509	1.69	98900	168067	69167	1.70
T_3	50500	90436	39936	1.79	48400	86241	37841	1.78	98900	176677	77777	1.79
T_4	50500	92552	42052	1.83	48400	87932	39532	1.82	98900	180484	81584	1.82
T_5	49000	82984	33984	1.69	46900	76627	29727	1.63	95900	159611	63711	1.66
T_6	49000	84502	35502	1.72	46900	81852	34952	1.75	95900	166354	70454	1.73
T_7	49000	88550	39550	1.81	46900	84873	37973	1.81	95900	173423	77523	1.81

The results of the field experiments at Pakhtunkhwa, Pakistan indicated that incorporation of maize stubbles prior to the sowing of wheat lead to earlier emergence of seeds, taller plants, higher tiller production, and higher grain yield of wheat (Abdul Basir *et al.,* 2015). The higher yield under stubble incorporation might be due to greater nutrient availability (Malhi *et al.,* 2006), mineralization of stubbles, resultantly increased microbial carbon and nitrogen pools (Kristensen *et al.,* 2003).

Number of laborers used in the cropping system

The number of laborers used for field operations under conventional tillage system of ridges and

Table 4. Effect of treatments on no. of labours used in cotton - maize cropping system

Treatments	2017-18			2018-19		
	Cotton	Maize	Cotton - Maize cropping system	Cotton	Maize	Cotton - Maize cropping system
T_1 : Conventional tillage+ No residue management	287	122	409	297	145	442
T_2 : Zero tillage + No residue management	267	102	369	277	125	402
T_3 : Zero tillage + 50 % residue management	267	102	369	277	125	402
T_4 : Zero tillage + 100 % residue management	267	102	369	277	125	402
T_5 : Permanent bed system + Zero tillage + No residue management	257	92	349	267	116	383
T_6 : Permanent bed system + Zero tillage + 50 % residue management	257	92	349	267	116	383
T_7 : Permanent bed system + Zero tillage + 100 % residue management	257	92	349	267	116	383

furrows was higher than zero tillage and permanent bed system (Table 4). The total laborers used under conventional tillage during first and second years of crop rotation were 409 and 442, respectively, whereas it was only 369 and 402 under ZT and ZT + PBS, respectively. Totally 40 and 34 labourers / year/ha was minimised under ZT and ZT + PBS, respectively, than conventional tillage. Mal *et al*. (2015) found that conservation tillage reduced the labor requirement up to 30 per cent .

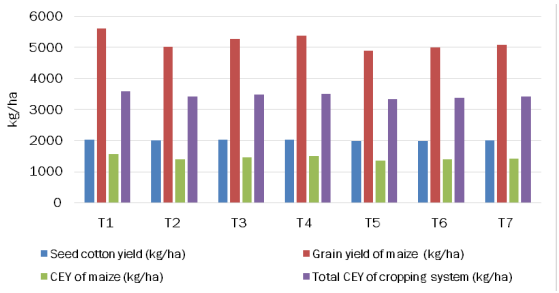

Figure 1. Effect of conservation agriculture and residue management on yield of cotton - maize cropping system during 2017-18.

Similar labor saving due to conservation tillage in cotton than conventional tillage, as reported by Bryant (1998) is also following the results of the present study.

Economics

The economic analysis (Table 3 and 4) revealed that the cost of cultivation was drastically reduced by the zero tillage and permanent bed system as compared to conventional tillage. The saving in the total cost of cultivation in cotton was Rs. 6000 / ha and Rs.7000 / ha, respectively under ZT and PBS as compared to conventional tillage, and for maize, a similar reduction was Rs. 6000 / ha and Rs.7500 / ha, respectively. Thus the adoption of ZT and PBS in the cotton – maize cropping system reduced the total cost of cultivation by Rs. 12,000 / ha and Rs.15,500 / ha, respectively. Though the higher gross income was associated with conventional tillage without residue application, higher net income and BC ratio were registered by zero tillage with residue application. The mean net income registered under ZT with 100 % and 50 % residue management and PBS + ZT with 100 % residue management were Rs. 74125, 72637 and 72509 / ha during first year and Rs 81584, 77777 and 77523 / ha during the second year of crop rotation. However higher benefit-cost ratio was associated with both ZT and ZT + PBS with 100 % residue management during both the years of study. The higher net income and BC ratio in the zero tillage treatments were attributed to the lower cost of cultivation. Uri (2000) observed that conservation tillage was 60 per cent more profitable and reduced the working cost up to 24 per cent.

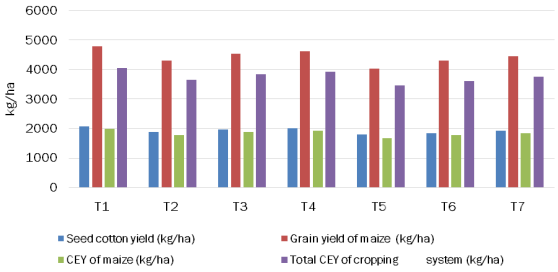

Figure 2. Effect of conservation agriculture and residue management on yield of cotton - maize cropping system during 2018-19

Thus, it is concluded from the study that zero tillage under cotton - maize tillage was technically feasible and zero tillage with 100 per cent residue application registered comparable yield of crops with higher economic benefits with lesser labour use than conventional tillage without residue application.

REFERENCES

Abdul Basir, Mohammad Tariq Jan, Mohammad Arif and Mohammad Jamal Khan. 2015. Response of tillage, nitrogen and stubble management on phenology and cop establishment of wheat. *Int. J.Agric. Bot.* **40:** 1103-1112.

Anonymous, 2018, ICAR- AICCIP Annual Report, Central Institute of Cotton Research, Coimbatore.

Bryant, K.J. 1998. Economic Results of Conservation Tillage in Cotton, University of Arkansas, Cooperative Extension Service Fact Sheet. IARI, 2012. Crop residue management with conservation agriculture

: Potential, constraints and policy needs. Indian Institute of Agricultural Research, NewDelhi. 32 p.

Kristensen, H.L., Debosz, K. and McCarty. G.W. 2003. Short term effects of tillage on mineralisation of nitrogen and carbon in soil. *Soil. Biol. Biochem* **35:** 979- 986

Mal, P., Schmitz, M. and Joachim W. 2015. Economic and Environmental Effects of Conservation Tillage with Glyphosate Use: A Case Study of Germany. Outlooks on Pest Management, **26 (1):** 24-27.

Malhi, S.S., Lenke,.R., Wang, Z.H. and Chhabra, B.S. 2006. Tillage, Nitrogen and crop residue effects on green house gas emissions. *Soils Tillage Res*. **90:** 171-183

Naveen Kumar,B.T. and Babalad, H.B. 2017. Response of cotton (*Gossypium hirsutum*) to different conservation practices under rainfed situations. *Int. J. Curr. Microbiol. App. Sci.* **6 (11):** 2279-2286

Sapthagiri, S. 2017. Optimization of nitrogen requirement for rice-fallow maize under irrigated condition M.Sc. (Ag.) thesis submitted to Agricultural College and Research Institute, TNAU, Madurai

Somasundaram, E., Thirukumaran,K., Mohamed Amanullah and Chandrasekaran, R. 2007. Performance of implements for *in-situ* incorporation of post-harvest cotton stalks. *Res. J. Agric. Bio. Sci.* **3(6):** 835-837

Sonune , B.A., Gabhane, V.V., Nandanwar. V.S. and Rewatkar, S.S. 2013. Effect of tillage and manuring on soil properties and productivity of rainfed cotton on vertisol. *J. Cotton Res,. Dev.* **27 (2):** 234-237

Srinivasan, G. 2013. Effect of stubble management of preceeding rice crop on growth and yield of *Gossypium hirsutum* cotton. *J. Cotton Res. Dev.* **27(1)** : 73-75

Vetrivendhan, E. 2016. Evaluation of rice fallow maize under irrigated condition. M.Sc.(Ag.) thesis submitted to Agricultural College and Research Institute, TNAU, Madurai

Uri, N.D. 2000. An evaluation of economic benefits of conservation tillage. *Envtl. Geology.* **39(4):** 238 -248.