J. Cotton Res. Dev. **35**(2), 214-220 (July, 2021) **ISSN No. 0972-8619**

Weed density, dry weight and productivity of cotton - maize cropping system as influenced by conservation agriculture and residue management

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Abstract: Field experiments were conducted at Cotton Research Station, Srivilliputtur for three years from 2017 - 2018 to 2019-2020 to study the effect of conservation agriculture and residue management practices on weed characters and yield of cotton (September to January/February) – maize (February/ March 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 per cent residue management (T_3), ZT with 100 per cent residue management (T_4), Permanent Bed System (PBS) + ZT + No residue management (T_5), PBS + ZT + 50 per cent residue management (T_6), PBS + ZT + 100 per cent residue management (T_7). The results revealed that the sedges population was drastically increased with the cropping period and it was six times higher than from the first crop to sixth crop of the cropping system. The conventional tillage without residue incorporation recorded significantly lower weed density and total weed dry weight at 25 and 50 DAS in all the years of study except the first crop. Though the conventional tillage without residue incorporation recorded the higher yields of cotton and maize in all the years of study, this was *on par* with that of zero tillage with 100 pre cent and 50 per cent residue management during 2017-2018 and 2018-2019 only. The conventional tillage without residue incorporation also registered the highest cotton equivalent yield followed by ZT with 100 pre cent residue management, ZT with 50 per cent residue management and PBS + ZT + 100 pre cent residue management.

Key Words : Cotton, residue management, seed cotton yield, weed density, zero tillage

Cotton also known as “White Gold” and “King of Fibre Crops” is an important 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 2017-2018 with a production of 2.80 lakh bales and productivity of 599 kg/ha which is below the world’s 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, there is 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 2016-2017). 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 for 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 yield of crops.

Conservation agriculture is emerging as a big boost for crop production in India. It is based on minimal soil disturbance (Reduced or no/ zero tillage), which may have great 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 of rice fallow crops either before the harvest of rice (black gram or green gram) or in the stubbles after the harvest (cotton). Similarly scientific study on zero tillage maize in the rice fallow was also attempted and succeeded in Tamil Nadu (Vetrivendhan, 2016 and Sapthagiri, 2017) and it was found technically and economically viable. However, conservation agricultural studies under garden land system is very meager. To manage the crop residues in a productive and profitable manner, conservation agriculture offer a good promise. Development of conservation agriculture based resource conserving technologies which are more resource efficient than conventional method of cultivation is paramount importance for long term sustain ability. Weeds consume 5 to 6 times of N, 5 to 12 times of P and 2 to 5 times of K more than cotton crop and thus reduce the cotton yield from 54 to 85 per cent (Jain *et al.*, 1981). Similarly, weeds compete for water, nutrients, space and light and reduce the growth and yield of maize. Studying of weed characters and weed shift, if any, is also important under the new method of cultivation. Due to conservation of tillage operation in the conservation agriculture, the study on weeds dynamics pertaining to crop survival gains importance (Brajendra Parmar, 2017).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 for three years from 2017-2018 to 2019-2020 to study the effect of conservation agriculture and residue management practices on weed characters and yield of cotton (September to January/February) – maize (February/March 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 per cent residue management (T_3), ZT with 100 per cent residue management T_4), Permanent Bed System (PBS) + ZT + No residue management (T_5), PBS + ZT + 50 per cent residue management (T_6), PBS + ZT + 100 per cent residue management (T_7). The soil of the experimental field wasclay loam with a pH of 8.26. The available nutrient (N, P and K) status of the soil was low (196 kg N/ha), high (40 kg P/ha) and high (446 kg K/ha). 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 appliedto cotton and maize, respectively for all the treatments. Ridges and furrow method of cultivation without residue application was followed in control treatment. The seeds of cotton and maize were dibbled with 75 x 30 and 75 x 20, cm spacing respectively on the surface of soil without tillage under zero tillage treatments. Permanent Bed System was prepared with a bed width of 125 cm and 25 cm furrow width. Pre-emergence application of pendimethal in at 1.0 kg/ha and atrazine at 0.5kg ha for cotton and maize, respectively followed by two hand hoeing on 15- 20 DAS and 35-40 DAS were practiced for all the treatments. Earthing up was carried out during 40 – 45 days after sowing of both cotton and maize crops under zero tillage (T_2, T_3 and T_4), while earthing up was not practiced in PBS treatments (T_5 ,T_6 and T_7). Cotton stalks were applied in between rows on the surface of maize field and vice versaby weight basis as per treatment schedule. The cotton crop was harvested during January and February months in three pickings and the maize was harvested during June after attaining physiological maturity. The data on weed density and dry weight were recorded at 25 and 50 DAS. Observations on seed cotton yield and grain yield of maize were recorded.

RESULTS AND DISCUSSION

Weed density

The major weed species observed in the experimental field were *Echinocloaspp, Cyperusspp* and *Trianthema portulacastrum* in the grasses, sedges and broad leaved weeds respectively. As the cropping system forwards, there was not much different difference in weed density of grasses and broad leaved weeds. However the sedges population was drastically increased with the cropping period (Table 1 and 2). It was observed that the sedges population was about six times higher than from the first crop to sixth crop of the cropping system. There was no much difference in the population of other weeds due to tillage methods. The weed population of grassy and BLW was significantly lesser in T1than other treatments. The lesser weed population in conventional ridges and furrow method of cultivation was due to through preparatory tillage activities like disk ploughing, tiller ploughing. Andrew *et al.*, (2016) also observed variation in the weed species due to crop residue and conservation agriculture in maize- cotton cropping system.

Different tillage practices exerted significant influence on weed density of both the crops in the cropping system (Table 1and 2). The conventional tillage without residue incorporation recorded the significantly the lowerweed density during both at 25 and 50 DAS

Table1. Effect of conservation agriculture and residue management on weed density (No./m2) of cotton – maize cropping system at 25 DAS

Treatments	2017-2018						2018-2019						2019-2020					
	Cotton			Maize			Cotton			Maize			Cotton			Maize		
	G	S	BLW	G	S	BLW	G	S	BLW	G	S	BLW	G	S	BLW	G	S	BLW
T_1	57	61	28	25	48	21	7	46	29	31	48	22	4	51	26	13	44	22
T_2	56	66	26	45	345	48	21	361	41	51	385	32	20	414	72	18	448	68
T_3	58	68	24	44	340	46	20	355	36	50	380	30	19	401	70	17	440	64
T_4	58	67	26	43	342	45	18	344	34	52	371	28	18	392	66	16	431	66
T_5	59	68	28	47	351	51	22	358	44	57	392	34	22	426	76	20	456	67
T_6	60	66	26	46	346	47	20	351	37	54	384	30	19	411	73	18	449	68
T_7	64	65	24	49	339	43	17	348	38	50	370	21	17	401	71	17	441	64
SEd.	3.7	3.4	2.1	2.5	16.2	3.0	1.5	20.1	2.9	2.8	19.8	1.9	1.4	22.1	4.1	1.5	21.6	3.1
CD (p=0.05)	NS	NS	NS	5.3	33.0	6.3	3.1	42.2	6.1	5.9	41.6	4.0	3.0	46.4	8.6	3.1	45.2	6.5

G- Grassy weeds, S- Sedges, BLW- Broad leaved weeds

Table 2. Effect of conservation agriculture and residue management on weed density (No./m2) of cotton – maize cropping system at 50 DAS

Treatments	2017-2018						2018-2019						2019-2020					
	Cotton			Maize			Cotton			Maize			Cotton			Maize		
	G	S	BLW	G	S	BLW	G	S	BLW	G	S	BLW	G	S	BLW	G	S	BLW
T_1	53	59	31	15	31	6	11	41	3	4	33	7	12	56	12	15	32	13
T_2	54	61	33	36	321	28	47	358	53	50	395	38	41	425	20	36	459	36
T_3	53	65	32	35	314	27	47	354	50	48	394	36	40	420	16	35	451	32
T_4	52	64	34	33	305	25	45	351	51	43	388	36	40	415	13	31	446	30
T_5	57	59	35	38	326	28	49	365	55	48	398	39	43	432	26	34	465	33
T_6	52	53	35	34	315	27	47	351	53	47	394	37	41	426	22	33	457	29
T_7	55	51	34	32	307	25	47	342	51	44	386	35	39	423	20	30	451	28
SEd.	2.7	2.8	2.1	2.5	15.0	2.4	2.7	18.1	2.6	2.4	20.2	2.0	2.5	20.1	1.1	1.8	24.1	2.2
CD (p=0.05)	NS	NS	NS	5.3	31.5	5.1	5.7	37.8	5.5	5.1	42.3	4.2	5.3	42.0	2.3	3.8	50.6	4.6

G- Grassy weeds, S- Sedges, BLW- Broad leaved weeds

in all the years of study except first crop. Being first crop of crop rotation, residues application and zero tillage were not practiced for cotton and hence non significant effect on weed density was noticed during first year. The levels of residue management practices did not show any significant influence on weed density during both the time of observation in all the years of cotton-maize cropping system. Similarly there was not much difference in the weed density due to Permanent Bed System also during all the years of copping systems. The higher weed density in the zero tillage and PBS was due to not carrying out of primary tillage operations throughout the study. Among the stages of crop, weed population was higher at 25 DAS than 50 DAS which was due to carrying out one hoeing on 26 DAS and also without carrying out any tillage operation after the harvest of the crop in zero tillage treatments. Cardina *et al.*, (2002) noticed higher weed density with conservation agriculture which is in accordance with the results of present study. Sosnoskie *et al.*, (2006) also found higher weed population in the conservation agriculture based crop rotation.

Total weed dry weight

The total weed dry weight recoded at 25 and 50 DAS in both the crops of the cropping system are furnished in the Table 3. The conventional tillage without residue incorporation recorded the significantly lowerweed dry weight both at 25 and 50 DAS during all the years of study except in first crop. As residues application and zero tillage could not be practiced in the first crop of cotton in the crop rotation, there was no significance among the treatments. The residue management practices and PBS did not show any significant impact on total weed dry weight during both the time of observation. Because of more number of sedges particularly Cyperus spp and its fast growth after 25 DAS, the dry weight of weeds at 25 DAS was nearly similar at 50 DAS. The higher weed dry weight in the zero tillage and PBS treatments were due to not carrying out of primary tillage operations continuously throughout the study and the corresponding higher weed density. Teasdale and Mohler (2000) found higher weed dry weight in the conservation agriculture based cropping system. Bauer and Reeves (1999) also observed higher weed biomass in cotton grown under conservation agricultural system.

Yield of cotton and maize

The results on the yield of crops (Table 4) revealed that conventional tillage without residue incorporation recorded the highest seed cotton yield of cotton in all the years of study, but this was *on par* with that of zero tillage with 100 per cent and 50 per cent residue management during 2017-2018 and 2018-2019 and significantly superior

Table 3. Effect of conservation agriculture and residue management on total weed weight (kg/ ha) of cotton- maize cropping system

Treatments	2017-2018 (DAS)				2018-2019 (DAS)				2019-2020 (DAS)			
	Cotton		Maize		Cotton		Maize		Cotton		Maize	
	25	50	25	50	25	50	25	50	25	50	25	50
T_1	144	151	108	112	120	113	101	108	115	108	121	114
T_2	148	152	665	704	733	755	781	804	822	841	857	878
T_3	147	151	661	700	726	743	772	800	806	831	850	862
T_4	145	153	653	689	721	730	762	792	801	822	843	854
T_5	149	154	667	714	740	761	789	809	830	846	869	888
T_6	148	155	669	704	733	762	777	807	824	836	856	869
T_7	146	153	652	701	724	758	769	801	817	829	845	853
SEd.	3.1	3.2	10.2	13.1	12.5	13.5	13.7	14.5	14.4	15.7	17.9	19.1
CD (p=0.05)	NS	NS	21.1	27.4	26.7	28.3	28.8	30.1	29.9	32.9	37.7	40.1

Table 4. Effect of conservation agriculture and residue management on yield of cotton- maize cropping system

Treatments	2017-2018				2018-2019				2019-2020			
	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)**	Seed cotton yield (kg/ha)	Grain yield of maize (kg/ha)	CEY of maize (kg/ha)	**Total CEY of cropping system (kg/ha)**
T_1	2028	5618	1556	**3584**	2069	4787	1977	**4046**	1803	5856	2843	**4646**
T_2	2017	5036	1395	**3412**	1873	4311	1781	**3654**	1526	5017	2435	**3961**
T_3	2019	5277	1462	**3481**	1966	4539	1875	**3841**	1551	5208	2528	**4079**
T_4	2022	5385	1492	**3514**	2012	4628	1912	**3924**	1625	5386	2615	**4240**
T_5	1986	4904	1358	**3344**	1804	4033	1666	**3470**	1517	5122	2486	**4003**
T_6	1995	5005	1386	**3381**	1837	4308	1779	**3616**	1542	5145	2498	**4040**
T_7	2001	5093	1411	**3412**	1925	4467	1845	**3770**	1601	5331	2588	**4189**
SEd.	74.2	180.2	-	**-**	71.1	141.2	-	**-**	80.4	165.1	-	**-**
CD (p=0.05)	NS	376.6	-	**-**	148.6	295.1	-	**-**	168.1	345.5	-	**—**

CEY – Cotton Equivalent yield

Sale price of kapas was Rs 45 / kg ,Rs 46 / kg and Rs 35 / kg during 2017-18, 2018-19 and 2019-20, respectively

Sale price of maize grain was Rs 12.50 / kg, Rs 19.00 / kg and Rs 17.00 / kg during 2018,2019 and 2020, respectively

than other treatments during 2019-2020 except during first year of cotton crop. Similar trend of comparable yield under conventional tillage and zero tillage with both 100 and 50 per cent of residue application was also observed in maize during first two years and there was significantly higher yield was noticed by conventional tillage during third year of cropping system. 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. 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 seed cotton yield than without incorporation (Srinivasan, 2013). 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 cotton stalk was also in conformity with the present investigation.

Cotton equivalent yield of cropping system

The CEY of cotton – maize cropping system (Table 4) showed that conventional tillage without residue incorporation registered the highest cotton equivalent yield of 3584 and 4046 kg/ha during first and second year of study respectively. This was followed by ZT with 100 per cent residue management (3514and 3924 kg/ha in Ist and IInd year) and ZT with 50 per cent residue management (3481 and 3841 kg/ha during 2017-2018 and 2018-2019) and PBS + ZT + 100 per cent residue management (3413 and 3770 kg/ha during 2017-2018 and 2018-2019) in maize - cotton cropping system. However during 2019-2020, cotton equivalent yields were in the order of conventional tillage without residue incorporation followed by ZT with 100 per cent residue management, PBS + ZT + 100 per cent residue management and ZT with 50 per cent residue management which recorded4646, 4240, 4189 and 4079kg/ha, respectively. The results of the field experiments at Pakhtunkhwa, Pakistan indicated that incorporation of maize stubbles

prior to sowing of wheat lead to earlier emergence of seeds, taller plants, higher tiller production and higher grain yield of wheat (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).

Thus, it is concluded from the study that the conventional tillage without residue incorporation recorded significantly lower weed density and total weed dry weight than zero tillage. The sedges population was drastically increased with the cropping period in the conservation agriculture. Zero tillage under cotton- maize tillage was technically feasible for the first two years only by registering comparable yield of crops with conventional tillage without residue application.

ACKNOWLEDGEMENT

The author greatly acknowledges the ICAR – All India Co- ordinate Research Project on Cotton for funding this study.

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Received for publication : April 6, 2021
Accepted for publication : June 9, 2021