Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 2 (1): 18-22, 2003
ISSN 1682-3974

Effects of Different Mechanisation Applications on Weed Control in Cotton Farming and its Significance in Terms of Mechanisation Management

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Abstract: The study was conducted to determine the degrees of weed density and the role of weed control methods in the total production costs of two different cotton farming methods, namely conventional and reduced tillage. In each method, four different cotton sowing norms were applied. It was found out that reduced tillage, unlike the conventional method, increased weed density. Therefore, 22.83% more working time and 24.14 % more cost was required in the reduced tillage application when compared to the conventional tillage method. On the other hand, the reduced tillage method was brought about lower total production costs and working time in cotton farming in terms of mechanisation management. Besides, no difference was observed between the two tillage methods in terms of seed cotton yield, but 9.1% earliness was observed in the reduced tillage method.

Key words: Tillage methods, cotton, weed density, weed control, mechanisation management

Introduction

Cotton, with its various uses, has a significant place in world agriculture, industry and trade. Augmenting population of the world and increasing prosperity levels of nations have increased the demand for cotton as well as its consumption.

As a method applied commonly in cotton farming, conventional methods require extensive use of equipment which leads to higher costs. On the other hand, this method is effective for obtaining appropriate conditions for germination and early growth. The required conditions for effective root development can not be provided by the conventional method. Precision tillage, a reduced tillage method, provides the required conditions for effective root development and reduces costs due to less use of equipment (Carter *et al.*, 1965; Önal, 1990).

In the reduced tillage method, rows, where cotton is planted are deep tilled. Over the rows, ridges are formed by the lister, and seed sown. Conditions at present which lead the producers to think more economically also leads them to sow cotton with reduced tillage methods. (Kolstad *et al.*, 1981; Carter *et al.*, 1991; Mobley and Albers, 1993).

Despite the advantages of reduced tillage methods, conventional tillage methods have been preferred in cotton farming in the Aydin province (Yalçin, 1999). According to this method, some weed species and their population m^{-2} are shown in Table 1 (Boz, 2000). The conventional tillage applied in cotton farming has a considerable role in the development of weed population (Table 1). Deep ploughing prevents the germination of weed seeds.

Throughout the deep ploughing process, weeds emerged are destroyed and buried under the soil. This brings about the hunger for carbohydrates and suppresses the emerging of weed. In reduced tillage practices involving fewer process than the conventional method, weed control should be given priority before it develops into a great problem (Nemli, 1983).

In this study, the weed control in the total costs throughout the applications of two cotton farming methods is determined. Additionally, in each of the methods, the weed density, hoeing periods, amount of herbicide applied, spraying periods and values were compared.

Materials and Methods

This study was carried out on the Plantations of Adnan Menderes University, Research and Production Farm during 1998-1999. The soil was a sandy loam. In the study tractors, equipment, and machines were used for the tillage, sowing and cultural procedures were adopted as reported by Yalcin (1999). A split-plot experiment design was used (Açikgöz *et al.*, 1994). Due to the prerequisites of each method, different sowing techniques were practiced. Thus, conventional sowing was applied on the plots designed on the basis of conventional tillage method, whereas ridge sowing was applied on the plots where the reduced tillage method was applied (Yalçin, 1999).

Table 1: Some species of weed and their population per m^2 calculated in the cotton sown lands in Aydin province (Boz, 2002)

Weed species	m^{-2}	Weed species	m^{-2}
Cyperus rotundus L.	6.52	*Amaranthus retroflexus* L.	3.56
Portulaca oleracea L.	1.94	*Cynodon dactylon* (L.) Pers.	3.34
Xanthium strumarium L.	1.40	*Solanum nigrum* L.	0.57
Sorghum halepense L.Pers.	0.48	*Echinochioa cruss-galli* (L.) P.B.	0.24
Setaria verticillata (L.)P.B.	0.74	*Datura stramonium* L.	0.19

Table 2: The system designating the tillage and sowing method procedures

Methods	Sowing methods	Systems
Conventional tillage method	MCSD-50 kg ha^{-1}	1
	MCSD-30 kg ha^{-1}	2
	PSD-3.6 cm over the row	3
	PSD-8.5 cm double seed	4
	MCSD-50 kg ha^{-1}	5
Reduced tillage method	MCSD-30 kg ha^{-1}	6
	PSD-3.6 cm over the row	7
	PSD-8.5 cm double seed	8

MCSD: Mechanical cotton seed drill PSD: Pneumatic spacing drill

In the sowing application on the plots, the row spacing was 70 cm. Nazilli 84 delinted cotton seed, a regional cotton seed type, was used throughout the sowing process. In the sowing application, 50 and 30 kg ha^{-1} cotton seeds were sowed using a mechanical cotton seed drill. Single seed in 3.6 cm of sowing space, and double seed in 8.5 cm of sowing space were sowed by pneumatic spacing drill (Yalçin, 1999).

The systems designating the tillage and sowing method procedures are shown in Table 2. To find out the effects of the systems on weed density, counts were made in 1 m^2 frames and repeated three times per plot. To determine the total numbers in each plot, weeds were counted as one whole organism. In the 3rd and 4th counting, those with larger leaves were considered as a whole organism while those with smaller leaves were considered as stalks. Also, by controlling each plot, the extension area of weeds were found out separately in terms of species, and totally (Odum, 1971).

Fluazifop applied post-emergence is the most commonly used herbicide for selective control of *Sorghum halepense* L. Pers. and other seedling grasses in broad leaved crops (Haitas *et al*., 1993). In this research, after the 1st and 2nd counts, hoeing was applied. After the 3rd counting, fluazifop-p-butyl herbicide application was used to control *Sorghum halepense* L. Pers. and *Cynodon dactylon* (L.) Pers. After the 4th counting, hand weeding was used to control *Sorghum halepense* L. Pers. After the 3rd counting, 80 cc herbicides (fluazifop-p-butyl/preparat) was applied to all the ridge sown plots and 24 cc herbicides (fluazifop-p-butyl/preparat) was applied to conventional sown plots. To find out the cost of each application, cost analysis was conducted. To calculate the weed control costs, $ 0.35 were considered per one hour working time. The time a worker spent in hoeing, herbicide application, and hand weeding was taken as the basis for determination of total weed control costs.

In this research the elements constituting the machine use costs were analyzed in two major groups as, fixed costs and variable costs. By analysing the costs, total machinery and system costs were calculated (Uçucu, 1981; Yalçin, 1999).

Fixed costs	**Changeable costs**
Amortization	Maintenance cost
Interest	Repair cost
Insurance	Labour cost
Tax	Fuel and oil cost
Protection cost	

Results and Discussion

CYNDA, SORHA and CYPRO were the most commonly observed weed species in all plots before the first hoeing (Table 3). These weed species were the commonest ones in the reduced tillage/ridge sowing areas. Similar result was also reported by Bilalis *et al.* (2001). When the percentage of extension areas was considered, a considerable difference exists between the conventional tillage/conventional sowing (systems 1, 2, 3, 4 total extension area average 3.50 %) and reduced tillage/ridge sowing areas (systems 5, 6, 7, 8 total extension area average 19 %) (Table 3). Boz (2000) reported the similar results, pointing out the density of CYNDA, SORHA and CYPRO in the cotton farming areas in Aydin. In relation with weeding, it was found that an average of 112.23 h ha^{-1} working time was required in systems 5, 6, 7, 8 and 91.93 h ha^{-1} working time was required in systems 1, 2, 3, 4 for weed control. According to these results, it is obvious that an average of 18.09 % less working time and costs were required in systems 1, 2, 3 and 4 in the first hoeing. This result showed that weeding was more in the reduced tillage method (Table 3). All weed species considered before the 2nd hoeing was observed more

Table 3: Weed density before 1st hoeing and requirements of working time and cost values in weed control

	Weed species								
	CYNDA		SORHA		CYPRO		Total extension	Working time	Hoeing cost
Systems	m^{-2}	(%)	m^{-2}	(%)	m^{-2}	(%)	area (%)	(h ha^{-1})	(\$ ha^{-1})
1	1.56	0.50	1.45	0.33	15.11	2.00	2.83	92.98c	38.74
2	1.45	0.83	2.83	0.83	15.11	2.33	3.99	112.95b	47.06
3	2.33	1.16	1.67	0.67	12.00	1.50	3.33	85.18d	35.49
4	0.89	0.50	0.77	0.66	12.78	2.67	3.83	76.58e	31.91
Average	1.56	0.75	1.68	0.62	13.75	2.13	3.50	91.93B	38.30
5	3.55	2.00	11.66	7.67	18.33	5.67	15.34	128.30a	53.46
6	3.11	2.17	4.44	6.50	41.89	15.33	24.00	127.97a	53.32
7	3.55	1.83	4.55	2.33	18.65	9.33	13.49	98.80c	41.17
8	3.00	6.33	27.55	4.83	38.11	12.00	23.16	93.84c	39.10
Average	3.30	3.08	12.05	5.33	29.30	10.58	19.00	112.23A	46.76

LSD value at 0.05 for all systems=7.629 and for tillage methods= 16.101

Table 4: Weed density before the 2nd hoeing and cost values of working time requirements in weed control

	Weed species								
	CYNDA		SORHA		CYPRO		Total extension	Working time	Hoeing cost
Systems	m^{-2}	(%)	m^{-2}	(%)	m^{-2}	(%)	area (%)	(h ha^{-1})	(\$ ha^{-1})
1	0.22	0.16	1.11	1.16	4.78	1.33	2.65	74.73b	31.14
2	1.22	0.16	2.11	1.33	8.33	1.50	2.99	55.02c	22.93
3	1.78	0.83	2.66	0.66	6.66	0.66	2.15	50.60d	21.08
4	1.33	0.33	-	1.00	9.67	1.50	2.83	40.08e	16.70
Average	1.14	0.37	1.96	1.04	7.36	1.25	2.66	55.11A	22.96
5	0.55	0.83	10.11	3.67	5.66	1.83	6.33	80.09a	33.37
6	2.88	1.00	5.88	5.33	13.89	4.66	10.99	56.21c	23.42
7	1.89	1.33	0.66	0.66	14.33	1.83	3.82	47.75d	19.90
8	0.55	4.00	12.89	4.83	13.44	2.33	11.16	48.08d	20.03
Average	1.47	1.79	7.39	3.62	11.83	2.66	8.08	58.03A	24.18

LSD value at 0.05 for all systems=3.289 and for tillage methods = 3.735 Means followed by different letters differ significantly at $p<0.05$
CYNDA: *Cynodon dactylon* L. Pers SORHA: *Sorghum halepense* L. Pers CYPRO: *Cyperus rotundus* L.

Table 5: Weed density in the 3rd and 4th counting and values of working time and cost in weed control process

	Weed species								
	CYNDA		SORHA		CYPRO		Total extension	Working time	Spraying+Hand weeding cost
Systems	m^{-2}	(%)	m^{-2}	(%)	m^{-2}	(%)	area (%)	(h ha^{-1})	(\$ ha^{-1})
(3rd Counting)									
1-2-3-4	1.36	0.21	3.02	1.12	9.67	0.79	2.12	2.50	9.63
5-6-7-8	1.72	0.42	12.66	7.16	11.70	2.16	9.74	9.67	32.98
(4th Counting)									
1-2-3-4	3.16	0.92	3.32	1.17	29.00	1.46	3.55	11.70	4.88
5-6-7-8	4.30	0.75	3.64	2.37	28.86	2.62	5.74	29.00	12.08

CYNDA: *CYNODON dactylon* L. Pers SORHA: *SORGHUM halepense* L. Pers CYPRO: *CYPERUS rotundus* L.

Table 6: The role of working time requirement and cost values of weed control process in total production

	Working time				Total costs			
Systems	Weed control (h ha^{-1})	Total procedures* (h ha^{-1})	Total (h ha^{-1})	TWT (%)	Weed control (h ha^{-1})	Total procedures* (h ha^{-1})	Total** (h ha^{-1})	TC (%)
1	181.91b	20.37	202.28	89.93	76.39	344.42	420.81	18.15
2	182.17b	20.37	202.54	89.94	76.49	344.42	420.91	18.17
3	149.98c	19.72	169.70	88.38	63.08	355.43	418.51	15.07
4	130.86d	19.72	150.58	86.90	55.12	355.43	410.55	13.43
Average	161.23B	20.05	181.28	88.78	67.77	349.93	417.70	16.22
5	247.06a	14.47	261.53	94.47	105.22	256.29	361.51	29.11
6	222.85a	14.47	237.32	93.90	95.14	256.29	351.43	27.07
7	185.22b	13.82	199.04	93.06	79.46	268.63	348.09	22.83
8	180.59b	13.82	194.41	92.89	77.53	268.63	346.16	22.40
Average	208.93A	14.15	223.08	93.58	89.34	262.46	351.80	25.35

*: (Yalçin, 1999) **: The values related to harvest and irrigation procedure are excluded TWT: Total working time TC: Total cost
LSD value at 0.05 for all systems=14.211 and for tillage methods = 7.323

Table 7: Values of seed cotton yield and earliness (Yalçin, 1999)

Systems	Seed cotton yield (kg ha^{-1}) (1st stage)	Seed cotton yield (kg ha^{-1}) (2nd stage)	Seed cotton yield (kg ha^{-1}) (Total)	Earliness (%)
1	3411	1032	4443	76.8
2	2927	1178	4105	71.3
3	2837	1122	3959	71.7
4	2885	1433	4318	66.8
Average	3015	1191	4206	71.6B
5	4117	653	4770	86.3
6	3498	797	4295	81.4
7	3098	842	3940	78.6
8	3625	1117	4742	76.4
Average	3585	852	4437	80.7

LSD value at 0.05 for tillage methods = 8.710

Means followed by different letters differ significantly at $P<0.05$

System 1 : Conventional tillage method + Mechanical cotton seed drill (50 kg ha^{-1} sowing norm)

System 2 : Conventional tillage method + Mechanical cotton seed drill (30 kg ha^{-1} sowing norm)

System 3 : Conventional tillage method + Pneumatic spacing drill (3.6 cm over the row)

System 4 : Conventional tillage method + Pneumatic spacing drill(8.5 cm double seed)

System 5 : Reduced tillage method + Mechanical cotton seed drill (50 kg ha^{-1} sowing norm)

System 6 : Reduced tillage method + Mechanical cotton seed drill (30 kg ha^{-1} sowing norm)

System 7 : Reduced tillage method + Pneumatic spacing drill (3.6 cm over the row)

System 8 : Reduced tillage method + Pneumatic spacing drill(8.5 cm double seed)

common in the reduced tillage/ridge sowing areas (Table 4). However, when the working time requirements weed control was taken into consideration similar interpretation is unacceptable. Because in hoeing was applied in all plots after the first counting. When the values of working time requirements were examined, no statistical difference was observed between the average values of the systems 1, 2, 3, 4 (55.11 h ha^{-1}) and systems 5, 6, 7, 8 (58.03 h ha^{-1}). Similar evaluations were done for the varying cost values related to the working time requirements.

After the second hoeing equal amount of cotton plant (70000 plant ha^{-1}) was left on each plot. For this reason, at the 3rd and 4th counting, the evaluations were done by considering the conventional sowing and ridge sowing plots (Table 5). The herbicide application after the 3rd counting and working time requirement and cost values estimated throughout the weed control process was higher in systems 5, 6, 7, 8 than systems 1, 2, 3, 4 (Table 5). Systems 1, 2, 3 and 4 were 69.34% more advantageous in terms of working time requirements and 70.80 % in terms of cost when compared to systems 5, 6, 7 and 8. Due to higher weeding density in reduced tillage/ridge sowing areas, these results were obtained. Bilalis *et al.* (2001) reported weed species such as *Sorghum halepense* was more common than the others in the minimum tillage and no-tillage areas than the areas which the conventional method was applied. Likewise, in the hand weeding application after the 4th counting, systems 5, 6, 7, 8 required more working time and cost than systems 1, 2, 3, 4 (Table 5). At this stage, when the values of working time requirements of the systems were examined systems 1, 2, 3 and 4 were observed 59.65% more advantageous than systems 5, 6, 7 and 8. In terms of procedural cost, systems 1, 2, 3 and 4 were observed cost 59.60% less. High density of weeding was observed again at this stage, on the areas of reduced tillage/ridge sowing. Phillips and Phillips (1983), Önal and Aykas (1999) and Bilalis *et al.* (2001) reported that application of minimum tillage, reduced tillage and no-tillage increased weeding.

Throughout the production period, working time requirements and cost values were estimated for each system (Table 6). When the total production estimations were considered, the conventional tillage/conventional sowing applications required 22.83% less working time in weed control in comparison with the reduced tillage/ridge sowing applications. Likewise, weed control costs 21.57 \$ ha^{-1} less in conventional tillage/conventional sowing. In other words, the conventional tillage/conventional sowing applications were 24.14 % advantageous. Systems 1, 2, 3, 4 had an average portion of 88.78 % working time in total cotton production (Table 6). This portion in the systems 5, 6, 7, 8 averages 93.58%. When total cost values in weed control were examined, the portion of systems 1, 2, 3, 4 was 16.22 % in total cotton production cost. This portion in systems 5, 6, 7, 8 was 25.35 %. This findings signify the fact that weeding density was higher in the reduced tillage method than in the conventional method. Similar results were also reported by Phillips and Phillips (1983), Önal and Aykas (1999) and Bilalis *et al.* (2001).

Values of seed cotton yield and earliness showed no differences between the values of the seed cotton yields (Table 7). Besides, the values of earliness disposed that the plots on which reduced tillage/ridge tillage were applied are more advantageous. Carter *et al.* (1965), Kolstad *et al.* (1981), Önal, (1990) and Yalçin, 1999) reported that reduced tillage/ridge sowing led to earliness in cotton farming.

In conclusion, the amount and density of weed in cotton farming applied by reduced tillage method were observed higher than the conventional method. Likewise, in the weed control procedure, working time requirements (22.83%) and cost values (24.14%) were higher than the conventional method. The cotton farming practiced by the reduced tillage method was observed more advantageous than conventional method when total working time requirements and cost were considered. It was found out that reduced tillage method increased weeding. On the other hand, when the whole production is taken into consideration, reduced tillage method costs 65.95 $ ha^{-1} less than conventional method. It can be assumed that, although it increases weeding, reduced tillage method requires less working time and cost and having the advantage of earliness (9.1%), it can replace the conventional method.

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