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Effect of Weeding Frequency on Yield of Cotton (G*ossypium hirsutum L.)* at Werer, Ethiopia

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Weed management practices are one of the main problems of cotton production in Ethiopia. Therefore, an experiment was conducted at Werer Agricultural Research Center during the main cropping season of 2015 to determine the number of weeding frequencies and yield loss of cotton crop due to weed competition. A total of four treatments (Weedy check, one hand weeding at 20 DACE, two hand weeding at 20 and 34 DACE and three hand weeding at 20, 34 and 48 DACE) were laid out in a Randomized Complete Block Design (RCBD) with three replications. A total of 15 weed species, belonging to 11 families were identified in the cotton field. The result showed that weed density, biomass and yield were significantly affected by weeding frequency. The un-weeded (zero-weeding) plots had significantly higher weed density and weed dry mass than all the other treatments. Yield attributes, such as number of bolls, plant population and boll weight increase as the weed-free period increases. A seed cotton yield loss of about 80% was recorded in the control (unweeded) plots. This study shows that weeding two times at 20 and 34 DACE resulted in better yield and yield components and is therefore recommended.

Keywords: *Weed, Density, Biomass*

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INTRODUCTION

The predominant naturally occurring weed species associated with cotton crop in the Middle Awash Valley were: *Brachariacruciformis*, *Borhavia erecta*, *Corchorus olitorius*, *Corchorus trilocularis*, *Cyperus rotundus*, *Echinocloa colona*, *Eragrostis* spp. *Ericula fatumansis*, *Launaea cornut*, *Portulaca oleraceae*, *Sorghum arundillacium*, and *Xanthium strumarium*. The grassy weeds were mainly dominant (92%) during near harvesting stage and were observed to spoil the lint quality by the addition of trash to the produce and reduce harvest efficiency (Esayas *et al*., 2012).

The frequency and density of weeds are differently affected by continuously cotton growing and irrigation. Density and composition of weed flora are strongly affected by crop production system and agricultural practices (Mennan and Işık, 2003). While frequency of some species such as *Amaranthus albus, Amaranthus retroflexus, Convolvulus arvensis, Cynodon dactylon* and *Solanum nigrum,* decreased in contrast, their densities increased. It was assumed that this can be related with weed control methods as well as irrigation. Because irrigation encourages soil salinity and so the species that prefer these conditions are well adjusted and become dominant (Bekir, 2005).

Yield of cotton was greatly reduced due to the naturally-occurring mixed weed population in which a seed cotton yield loss of 62.43 - 96.21% occurred when weeding was completely denied throughout the crop growing season (Esayas *et al*., 2013). It is estimated that losses in Arkansas, USA, due to weeds amount to approximately 34 million dollars annually (Smith, 2000). Khan and Khan (2003) reported that grassy weeds cause 15 – 40% and broad leaf weeds 15 – 30% yield losses in cotton crop. Reduction in cotton yield varied from 40-85% due to weed competition (Bhan and Mishra, 1993). Keeley and Thullen (1991) reported that losses of 16 and 26% of yield occurred when bermuda grass was permitted to compete with cotton for 12 and 20 weeks, respectively. Mofett and Mcclosky (1998) also observed that seed cotton yield was reduced up to 34% due to yellow nutsedge (*Cyperus esculentus L*.) infestation. Cotton being a wide spaced and relatively slow growing crop during its initial stages suffers from severe weed competition and causing substantial reduction in seed cotton yields up to an extent of 69 per cent (Srinivasulu and Rao, 2000). With regard to fiber quality, no significant ($p>0.05$) difference was observed for all quality parameters except for micronaire value (fiber fineness). The micronaire value was shown to have a decreasing trend as the weed infestation period increased (Esayas *et,al*., 2013).Survey conducted in Middle Awash in 2000 indicated that the infestation level was very high for most of the weed species (broad leaf, grass and sedges). Higher weed density was recorded at flowering and near harvesting growth stage of cotton resulting in reduction of yield and harvest efficiency. Similarly, a seed cotton yield loss of 35.03-88.13% and 56.45-94.44% occurred when weeding was delayed for 60 and 75 DACE, respectively. So, it could be shown that the major yield loss occurred up to 75 DACE during the cotton growth period. In Werer State Farm (WSF) and Werer Agricultural Research Center (WARC) experimental sites, the increase in seed cotton yield was observed to be consistent with advancement of weed-free period. On the other hand, the longer the weeds were allowed to grow and compete with the crop, the higher the seed cotton yield reduction would be (Esayas *et al*., 2013). Bishnoi *et al.,* (1993) reported that weed free environment from 20 days after sowing produced highest seed cotton yields (2798 kg ha^{-1}) compared to unweeded control (1614 kg ha^{-1}). Therefore, the present study was mainly designed to assess the effect of weeding frequency on the yield of cotton crop.

MATERIAL AND METHODS

Experimental Sites

The experiment was conducted at Werer Agricultural Research Center (WARC) experimental field during the main cropping season (May – October) of 2015. Werer is located at 278 km east of Addis Ababa with an altitude of 740 meters above sea level and at the coordinates of latitudes of 90° 60'N and 40° 09' E longitude. The dominant soil type of the study areas is described as chromic vertisol Sand 3.83%, Silt 61.1%, and clay 35.07 % and a bulk density of 1.17. The pH of the soil is slightly alkaline (7.5 to 8.5). The mean annual rainfall is 540 mm and the mean maximum and minimum temperatures are 34^0C and 19^0C, respectively (Esayas *et al*., 2013).

The study was designed in a Randomized Complete Block Design (RCBD) with three replications. The treatments were arranged in three weeding regimes (No-weeding, One hand weeding at 20 DACE, Two hand weeding at 20 and 34 DACE and Three hand weeding at 20, 34 and 48 DACE). The popular cotton variety in Ethiopia, Deltapine-90, was planted with a spacing of 0.20 m x 0.9 m plots each having a size of 15 m^2 for open field and 1m^2 for protected. All agronomic practices for raising a successful crop were employed as per recommendation.

A quadrant with a dimension of 1 by 1 m was done within three fixed quadrant (1m^2) randomly placed in each plot of all treatments. Weed identification and density were done within three fixed quadrants (1m^2) once a week starting from 20thday to 60thday emergence of the crop to identify the dominant weed species growing in association with cotton and the identification of weed dominance was made by counting. The weeds within each quadrant were harvested at soil level, separated into species and oven dried at 70°C for 48 hours to a constant weight to determine the weed biomass. Data collection on yield and yield components of cotton included number of opened bolls, number of unopened bolls, plant population per quadrant, five ball weight, plant height and seed cotton yield. Plant height and number of plant population per quadrant were recorded after seed cotton picked. Number of balls (open and unopened) was recorded before picking. Seed cotton yield and five ball weight was taken at time of picking.

The composition of the weed flora was analyzed by calculating the relative abundance (RA) of each species within each experimental unit as follows: RA = (RD + RF) / 2, Where RD (relative density) = number of a weed species per unit area (within a quadrant) in the plot divided by the total number of weed species within the same unit area (quadrant); and RF (relative frequency) = proportion of quadrant in which the species was present per experimental unit divided by the total frequency of all species in the experimental unit (Okore *et al.,* 2001). The data were analyzed using SAS statistical analysis package 9.2. Means were separated using the Fisher's Least Significant Difference (LSD).

RESULT

Composition of Weed Species in the Study Area

A total of 15 weed species, belonging to 11 families, were identified throughout the growing season (Table 1). About 71.43 % of the weed species encountered were broadleaves, 21.43 % were grasses while sedges were about 7.14 %; and about 65 % of the entire weed species were annual in life span. In this study the most dominant weed families with the highest diversity were: *Echinocloa colana, Eriocloa fatmensis, Cyperus spp., Digera muricata, Corchorus trilocularis, Zaleya pentandra* and *Sorghum arundianaceum.* These were also the weeds which had the highest relative abundance in the field. Most of the species (81 %) were erect annual herbs and grasses, the rest were perennials that had vegetative prop gules, *viz.* rhizomes, stolen, annual prostrate herbs, annual or perennial climbers or perennial shrubs.

Weed Density and Biomass

Weed Density

The result of weed density showed that weeding frequency significantly affected the population of weeds at each time of assessment (Table 2). The un-weeded (zero-weeding) plots had a significantly higher weed density than all the plots that had been subjected to 1, 2 or 3 hand weeding in the field. The one-hand weeded plots had a significantly higher weed density than two and three hand weeded plots while no significant difference was found between weed densities in two and three-hand weeded plots. Weeding frequency had a significant effect on the population of weed. Takim and Uddin, (2010) had reported a significantly higher weed density in un-weeded plots, which is in agreement with this study finding. Weed density in growing seasons decreased with increasing duration of the weed-free period (Dragica *et al*., 2008).As it was reported in results of weed surveys on different crops in other places, field pea, faba bean, barley, wheat (Kedir *et al*., 1999 a,b) and teff (Taye and Yohannes, 1998); there was a positive and significant relationship among the weed species density, dominance and frequency. It was recognized that the dominance level of individual weed species varied across the crop growth stage.

Table 1. Relative abundance of weed species recorded on cotton field at Warer Agricultural research Center in 2015

Family	Weed species	Relative Abundance of weeds			
		A	B	C	D
Poaceae	*Echinocloacolana (L) Link*	0.51	0.538	0.574	0.505
	Eriocloafatmensis(Hochst.&Steud.) Clayton	0.654	0.656	0.622	0.494
	Sorghum arundianaceum (Desv.) Stapf	0.278	0.026	0.007	0.025
Cyperaceae	*Cyperusesculentus*	0.547	0.532	0.519	0.36
Amaranthaceae	*Digeramuricata (L.) Mart.*	0.528	0.387	0.314	0.321
Euphorbiaceae	*Phyllanthusrotundifolius Wilted*	0.237	0.192	0.136	0.112
Solanaceae	*Datura stramonium L.*	0.271	0.251	0.208	0.055
Tiliaceae	*Corchorustrilocularis L.*	0.202	0.11	0.067	0.074
Portulacaceae	*Portulacaoleracea*	0.206	0.113	0.12	0.178
Asteraceae	*Paratheniumhysterophorous*	0.028	-	-	0.014
Aizoaceae	*Zaleyapentandra (L.) Jeffrey*	0.378	0.309	0.254	0.195
Convolvulaceae	*Ipomoea sinensis (Desr.) Choisy*	0.134	0.097	0.045	0.084
Capparideae	*Gynandropsisgynandra*	0.056	-	-	-
Amaranthaceae	*Amranthushybridus*	0.001	-	-	-
Asteraceae	*Xanthium strumarium*	0.027	-	-	-

NB. A= Weedy check, B = One hand weeding, C = Two hand weeding, D = Three hand weeding in open field and E = Weedy check, F = One hand weeding, G = Two hand weeding and H = Three hand weeding in controlled field

Weed Biomass

Moreover, weed biomass at cotton maturity was significantly affected by weeding frequency and un-weeded plots had higher weed biomass than all the other plots (Table 2). The control plots (weedy check) utilized the environmental resources for a longer period of time and ultimately produced more weed dry mass than plots that were weeded once, twice or thrice. One hand weeding had a significantly higher weed biomass than two and three hand weeding while two and three hand weeding showed no significant difference. Weeding frequency significantly affected weed biomass. Mandumbu and Karavina, (2012) reported that the increases in weeding intensity decreases the competitiveness of weeds as the crop will have established and hence outcompetes weeds. Weed biomass in growing seasons decreased with increasing duration of the weed-free period (Dragica *et al*., 2008). Ali *et al*., (2013) reported that weeds in non-controlled plots utilized the environmental resources for a longer period of time and ultimately produced more weed dry mass than plots where weeds were controlled by different chemical and mechanical methods. Different management practices significantly reduced the weed dry biomass of both broad and narrow leaf weeds. Hand-weeding reduced the maximum dry mass of weeds (Ali *et al*., 2013).

Table 2. Effects of weed removal on Weed density and Weed biomass on cotton field at Werer Agricultural Research Center in 2015.

Weed Removal Treatments	Weed Density	Weed Biomass
Weedy check	7.538a	835.450a
One hand Weeding at 20 DACE	5.744b	403.950b
Two hand weeding at 34 DACE	3.978c	126.670c
Three hand weeding at 48DACE	3.855c	49.230c
C.V.	11.285	32.369
S. D	0.596	114.528
$LSD_{(0.05)}$	1.19	228.81

NB. CV= Coefficient of variation, SD= Standard deviation, LSD= Least significance difference at ($P \leq 0.05$), the mean values with different letters represent significant variation and the mean values with the same letters are not significantly different.

Effect of Weed Removal on Seed Cotton Yield and yield component

Different yield attributes, such as number of bolls per square meter and ball weight were affected by weed removal (Table 3). Exceptionally the plant height was not significantly affected by weeding frequency. According to Solaiappan *et al*., (1992), the dry matter production of cotton crop per unit area was the lowest under un-weeded condition. However, the plant height was not affected even when the crop was left un-weeded. Decrease in plant height was however observed due to weed competition (Singh, 1983 and Rushing *et al*., 1984). Plant height and stem diameter reduced by weed competition was also reported by (Snipes and Byrd, 1994). Cotton stem diameter and height also decreased with increasing weed competition (Keeley and Thullen, 1991b).

Weedy cheek has lower number of balls, plant population and ball weight. The yield components except plant height were increased as the weed-free period increased and showed decreasing trend as the weed infestation period increased from 20 DACE onwards. Velayutham *et al*., (2002) and Srinivasan (2003) reported that un-weeded check reduced the boll number per plant and boll weight of cotton. Mohamed and Bhanumurthy (1985) reported significant reduction in fruiting points due to uncontrolled weed growth in the field. Weed removal treatments resulted in significantly higher plant height, a greater number of open bolls, higher boll weight, and leaf area index and seed cotton yield than weedy check. Weed removal might have resulted in optimum utilization of environmental resources by the crop which enhanced the yield components and finally seed cotton yield. These results are also supported by other findings elsewhere Douti, (1997), Sadras (1997) and Lamm *et al*., (2002).

Table 3. Effects of weed removal on yield and yield components of cotton at Werer Agricultural Research Centerin2015.

Weed Removal Treatments	Yield	NoB	H.ball	Un. OB	PP	PH	BW
Weedy check	4.57c	3.52c	3.03d	1.73c	3.56b	114.49a	1.69b
One hand Weeding at 20 DACE	18.10b	6.42b	5.02c	3.87b	4.22ab	61.73c	2.26b
Two hand weeding at 34 DACE	23.08a	7.81a	6.12b	4.82ab	4.67a	82.11bc	3.02a
Three hand weeding at 48 DACE	24.28a	8.87a	6.81a	5.65a	4.89a	107.78ab	3.20a
C.V. (%)	13.82	8.46	4.12	18.09	11.76	14.59	12.95
S. D	2.42	0.563	0.22	0.73	0.51	13.35	0.33
$LSD_{(0.05)}$	4.835	1.125	0.432	1.45	1.02	26.68	0.66

NB. NoB = Number of ball, H.ball = harvested ball, Un.OP. =Number of unopened ball, PP = Plant Population, PH = Plant height, BW = Ball weight, CV= Coefficient of variation, SD= Standard deviation, LSD= Least significance difference at ($P \leq 0.05$), the mean values with different letters represent significant variation and the mean values with the same letters are not significantly different

Effect of weed removal on seed cotton yield

Result analysis showed that cotton seed yield was significantly affected by weeding frequency. Weedy check (zero weeding) recorded a significantly lower yield than one, two and three hand weeding (Table 3). However, no significant yield difference between two and three hand weeding in terms of yield. A yield loss of 80% in seed cotton was recorded when weeding was completely denied throughout the crop growing season. One and two hand weeding at 20 and 34 DACE decreased the seed cotton yield loss by 57 and 74 percent respectively. This result agrees with Esayas, *et al*., (2012) who reported seed cotton yield loss of 62.43 - 96.21% when weeding was completely denied throughout the crop growing season, and attributed it to the presence of naturally-occurring mixed weed population. Bishnoi *et al.,* (1993) weed free environment from 20 days after sowing produced highest seed cotton yields (2798 kg ha^{-1}) compared to unweeded control (1614 kg ha^{-1}).

There was 93% reduction in seed cotton yield as a result of unchecked weed competition. This was due to early weed management which decreased weed competition and damage resulted from competition (small ball number, small ball size and weight and small plant population).The vigor of competition from *Cyperus spp*. is illustrated well in work by Keeley and Thullen (1983) who showed that hoeing cotton from 4 to 12 weeks after emergence reduced the population of *C. esculentus* present at harvest by 67 - 87%. Over six locations, a *C. esculentus* free period of 4 to 12 weeks was required to avoid cotton yield reduction. *Echinochloa spp.* that competed for 6, 9, 12 or 25 weeks after cotton emergence reduced cotton yield 21, 59, 90, or 97%. A weed-free period of 9 weeks after crop emergence was required to prevent cotton yield reduction. If cotton was kept weed free for 3 or 6 weeks after emergence, it yielded 13 and 87% as much as cotton that was weed free for the whole season (Keeley and Thullen, 1991a).

CONCLUSION

The degree of damage of cotton from weed competition is related to the weed species composition (type of weeds), weed densities, and the duration of weed-cotton competition as related to the lifecycle of the cotton plants. Weeds that are allowed to grow with the cotton throughout the cotton growing period has high density and dry mass of weeds and long duration of interference with cotton which results in high competition. As the density and duration of weeds in the field increases the weed dry mass increases and the damage on yield and yield component was found to also increase. This study showed that weedy check has high weed density and weed dry mass than one, two and three hand weeding which resulted in a damage of small number and size of bolls and small boll weight of cotton.

RECOMMENDATION

For effective weed management in cotton, growers should concentrate efforts on weed management at early time of the growing season. Weeding two times at 20 and 34 DACE results in better cotton yield and yield components than others. Therefore, cotton growers should align weeding time to these schedules. This study also advocated the need for appropriate weed management, which is resulted in high crop yield by reducing weed competition and minimizing insect pest damage by denying alternative host.

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