Critical Crop - Weed Competition Period and Yield Loss Determination in Transplanted Tomato (*Lycopersicon esculentum* M.) at Guder Ethiopia

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Abstract

A field experiment was conducted for two consecutive cropping seasons of 2013 and 2014 to determine the critical period of weed competition and yield loss in tomato at Guder, Ethiopia. Quantitative series of both increasing duration of weedy and weed free periods were compared with complete weed free and weedy check. The experiment comprised of fourteen treatments laid was in RCBD with three replications. Two years pooled data revealed that, *Amaranthus spp, Amaranthus hybridus* L., *Bidens pilosa* L., *Commelina benghalensis* L., *Datura stramonium* L., *Guizotia scabra* (Vis.) Chiov., *Galinsoga parviflora* Cav., *Ipomea cariocarpa and Nicandra physalodes* Scop were among the predominant broadleaved weeds, whereas *Digitaria abyssinica* (A. Rich.) Stapf and *Cyperus esculentus* L. were the grass and sedge weeds respectively. Significant difference in density, weed dry biomass, tomato yield and relative yield loss were observed in all the two years. Uncontrolled weed growth caused a yield reduction of 87.5, 90.8% in 2013 and 2014 respectively, in yield as compared to weed free condition. Results indicated that to prevent greater than 10% yield loss, the maximum time for which weeds could be allowed to grow after crop transplant was 30 days, and the crop must be free of weeds from 60-75 days after transplanting to prevent a predetermined level of yield loss.

Keywords: Critical period, weed control, tomato, threshold points, yield loss.

Introduction

Tomato is a popular and widely grown vegetable crop in Ethiopia, ranking 8th in terms of annual national production (Jiregna *et al*., 2011). It is produced by both small scale farmers and commercial growers for local consumption as well as for processing industries. It is used in fresh as well as processed form in a variety of dishes. It is an important cash crop for small scale formers and also provides employment in production and processing industries (Jiregna *et al*., 2011). The average yield is low, ranging from 6.5-24.0 Mg ha^{-1}compared with average yields of 51, 41, 36 and 34 Mg ha^{-1}in America, Europe, Asia and the entire world, respectively (FAOSTAT, 2010). Growers have been challenged by inconsistent production and low yields, due to a number of factors of the constraints limiting tomato production, weeds appear to have the most deleterious effect causing yield reduction (Sanok *et al.*, 1979; Usoroh, 1983, Sinha and Lagoke 1984). Adigun *et al.* (1993) reported 40 to 82% reduction in tomato fruit yield due to unchecked weed growth throughout the crop life cycle. Inorder to reduce the impact of weeds, farmers practice different weed control methods which includes cultural, mechanical, chemical methods and integrated weed management (Ashton and Monaco, 1991).

However, the pre request for designing a successful weed management strategy is to identify the critical period for weed control (Swanton and Weise 1991). Furthermore knowledge of the CPWC and the factors that affect it is essential for making decisions on the appropriate timing of weed control and in achieving the efficient use of herbicides (Van Acker *et al.,* 1993; Knezevic*et al*., 2002; Mulugeta and Boerboom, 2000). The critical period of weed control is the portion of the life cycle of a crop during which it must be kept weed-free to prevent yield loss due to weed interference (Martin *el al.,* 2001). Furthermore, the period of the crop growth when it is most susceptible to weed interference has been regarded as the critical period of weed competition The knowledge of critical period of crop-weed competition is a pre-requisite for a good harvest. (Nieto *et al.,* 1968).

Different research determined the critical crop weed competition period in different area. In Ontario, Canada, Friesen (1979) 24- 36 days, in Maryland in the United States of America, Beste (1979) up to 6 weeks, in South Western Nigeria, Usoroh (1983) between transplanting and 6 weeks later and Adigun (2005) between 3 and 6 weeks after transplanting. However, most farmers in the tropics frequently fail to control weeds at appropriate time. This could be due to lack of capital and the knowledge of the critical period of weed control and its impact on crop yield.

The critical period of weed control values are variable depending on the location or growing season. These differences can be attributed to variations in the composition of weed species, initial density or ground cover of weeds, as well as to climatic conditions, in which crop and weeds interfere (Knezevic *et al.,* 2002). Topography, climate, crop genetics, and cultural practices, such as tillage intensity, fertilization, seeding rate, and row width, are several factors that may influence the critical period of weed control by directly affecting weed composition, weed density, time of weed emergence relative to the crop, or crop and weed growth (Mahmoodi and Rahimi, 2009). Additionally, in Ethiopia extensive weed competition studies have not been undertaken yet in vegetable crops in general and in tomato in particular. By considering climate and weed composition variability this study was to determine the critical period for weed competition on transplanted tomato and to investigate the effect of weed competition on tomato yield at Guder Ethiopia.

Materials and Methods

Description of study area

Critical weed completion period and yield loss determination on tomato (*Lycopersicon esculentum* L.) was studied under farmer's field condition in 2013 and 2014 growing season at Guder.

Treatments and experimental design

The experimental design was randomized complete block design with three replications. Fourteen treatments were included in each experiment. Two types of weed interference treatments were implemented after transplanting in naturally occurring weed populations were utilized during the study period. The first treatment was consist of keeping the crop weed free for seven period of increasing number of days from the crop transplanted onwards. Weeds emerging after each period were left on the plots. Weed removal was started immediately after transplanting and the plots were kept weed-free up to harvest, 15, 30, 45, 60, 75 and 90 days after transplanting by periodic hand hoeing. The second set of treatments was consisting of allowing the weed vegetation to grow for equivalent period of weed free. Weeds were competing with tomato for up to harvest, 15, 30, 45, 60, 75 and 90 days after transplanting. Control plots were kept free of weeds or left weedy throughout the growth period (days after transplanting).. The plot size was 3.5 m × 3 m, 70 cm between rows and 30 cm between plants. Each plot was consist of 5 tomato rows. The two outer rows of each plot was be used as buffer rows and 3 middle rows were used for weed biomass and yield assessments. 200/ kg/ha DAP and 150 kg/ha Urea, 50% of urea at time of transplanting the other 50% a 20days after transplanting.

Data collection

Weed density Count for weed flora present in the experimental field was taken from weedy check plots by placing a quadrate (0.5 m x 0.5 m) at two random locations of the plot in each replication. Data on dry weed biomass were taken after weed removal for early competition series, and at about 10 days before final harvest in the case of late competition series to avoid possible foliage and seed shedding. The harvested composite weed samples from the two quadrates per plot were oven dried at 65^0C until constant weight to measure the above ground dry matter weight.

Data analysis

The onset and the end of critical period of weed control were determined using the weed free and weed infested response curve. The onset of critical period of weed control was determined as the time at which weed interference reduces yield by 10 % while the end of critical period was the time during which the crop must be free of weed to prevent yield loss exceeding 10 %. The threshold point and duration of critical period was determined using response curve as described by Hall *et al.*, (1992).Yield loss was calculated for each year as follows:

$$Relative\ Yield\ Loss = \frac{Yield\ from\ weedfree\ plot - Yield\ from\ treated\ plot}{Yield\ from\ weed\ free\ plot} X100$$

All the data were subjected to analysis of variance using the SAS PROC GLM computer software package (SAS, 2009). Mean separation was conducted for significant treatment means using least significant differences (LSD) at 5 % probability level.

Results and Discussion

Weed flora and density

During 2013 cropping season, *Galinsoga parviflora* Cav (31.76 m^{-2}) was the dominant weed followed by *Amaranthus hybridus* L.(29.00 m^{-2}), whereas during 2014 cropping season *Amaranthus hybridus* L.(33.5 m^{-2}) was the dominant weed followed by *Galinsoga parviflora* Cav (21.53 m^{-2}) (Table1).

Table 1 . Weed species and mean density (m^{-2}) present in the experimental field in 2013 and 2014

S.No	2013		2014	
	Weed species	Density (m^{-2})	Weed species	Density (m^{-2})
1	*Amaranthus hybridus*L.	29.00	*Amaranthus spps*	6.47
2	*Bidens pilosa* L.	0.53	*Amaranthus hybridus* L.	33.5
3	*Chenopodium procerum* (Hochst ex.) Moq.	1.61	*Bidens pilosa* L.	4.69
4	*Commelina benghalensis* L.	5.11	*Commelina bengnalensis* L.	6.00
5	*Cyperus esculentus* L.	4.24	*Cyperus esculentus* L.	2.14
6	*Datura stramonium* L.	2.39	*Datura stramonium* L.	1.47
7	*Digitaria abyssinica* (A. Rich.) Stapf	8.32	*Digitaria abyssinica* (A. Rich.) Stapf	3.14
8	*Galinsoga parviflora* Cav.	31.76	*Galinsoga parviflora* Cav.	21.53
9	*Guizotia scabra* (Vis.) Chiov.	5.68	*Guizotia scabra* (Vis.) Chiov.	2.06
10	*Nicandra physalodes* Scop.	1.07	*Ipomea ariocarpa*	0.92
11	*Polygonum nepalense* Meisn.	16.01	*Nicandra physalodes* Scop.	3.64
			Raphanus raphanistrum L	1.75
Total		**87.31**		**105.72**

Weed dry weight

The relationship between weed dry weight and weedy /weed free days is shown in Figure 1. As weed free period increased there was reduction in weed dry weight (gm^{-2}), may be due to lower density and short period of interference between the crop and weed to accumulate biomass whereas with increased in unweeded days there was increased weed dry weight (gm^{-2}) in both cropping seasons. Similar trend was observed by Adigun (2005) and Zafar *et al.* (2010) who reported an increase in weed population and biomass with an increase in weed-crop competition period.

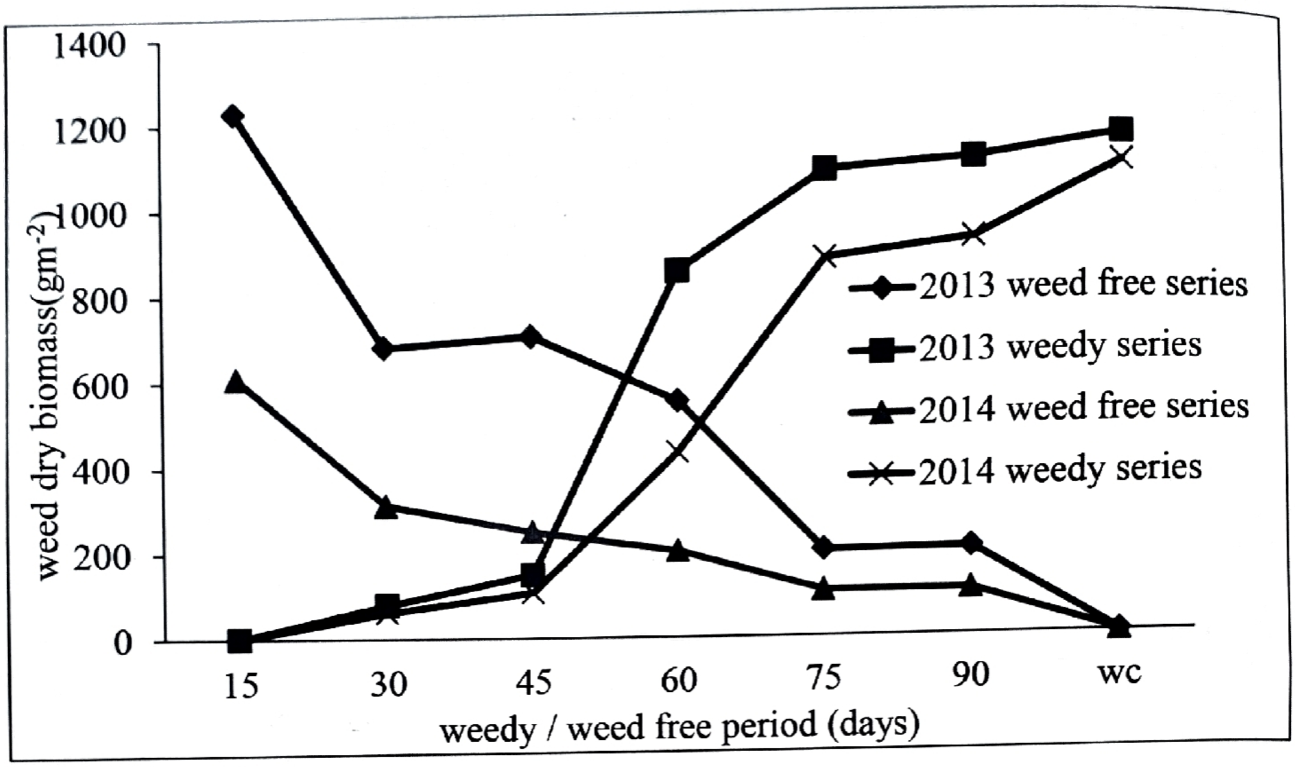


Figure 1. Weed dry weight as affected by increasing duration of weed free and/or unweeded condition after transplanting of tomato.

Relative yield loss

Data on the relative yield loss (%) presented in Table 2 indicated that in late competition, the highest relative yield loss (71.5%, 74.9 %) was recorded from weed free up to 15 days after transplanting whereas the lowest was recorded from weed free condition up to harvest (0.00%, 0.00%) which was not statistically significant from weed free up to 90 days after transplanting whereas (1.4%, 3.2%) in 2013 and 2014 cropping season respectively. This may be due to higher weed crop competition for the growth and development factor (nutrient, water and space) and higher density and dry biomass in weed free up to 15 days after transplanting whereas.

In early competition, also the relative yield loss was significantly affected, where the lowest relative yield losses (6.6, 6.4 %) were observed from 15 days after transplanting which was not statically significant from 30 days after transplanting, whereas the highest loss was recorded from unweeded condition up to harvest (87.5, 90.8%) in 2013 and 2014 cropping season respectively. This may be due to lower weed crop competition for the growth and development factor (nutrient, water and space) and lowered density and dry biomass of weeds in unweeded free up to 15 days after transplanting whereas. Early competition also caused higher yield loss as compared to late competition. This implied that early competition is more significant that the late competition in causing deleterious effect on productivity of tomato.

Generally, the yield loss in early competition increased with increased time of weed interference whereas in late competition the increased weed free period the yield loss decreased. This indicated that the competitive ability of a given density of weeds which emerged with the crop and their dry matter production was strongly dependent on the length of the period they remained in the field along with tomato. Thus early period of crop- weed competition is more important that late competition in terms of yield reduction in crops.

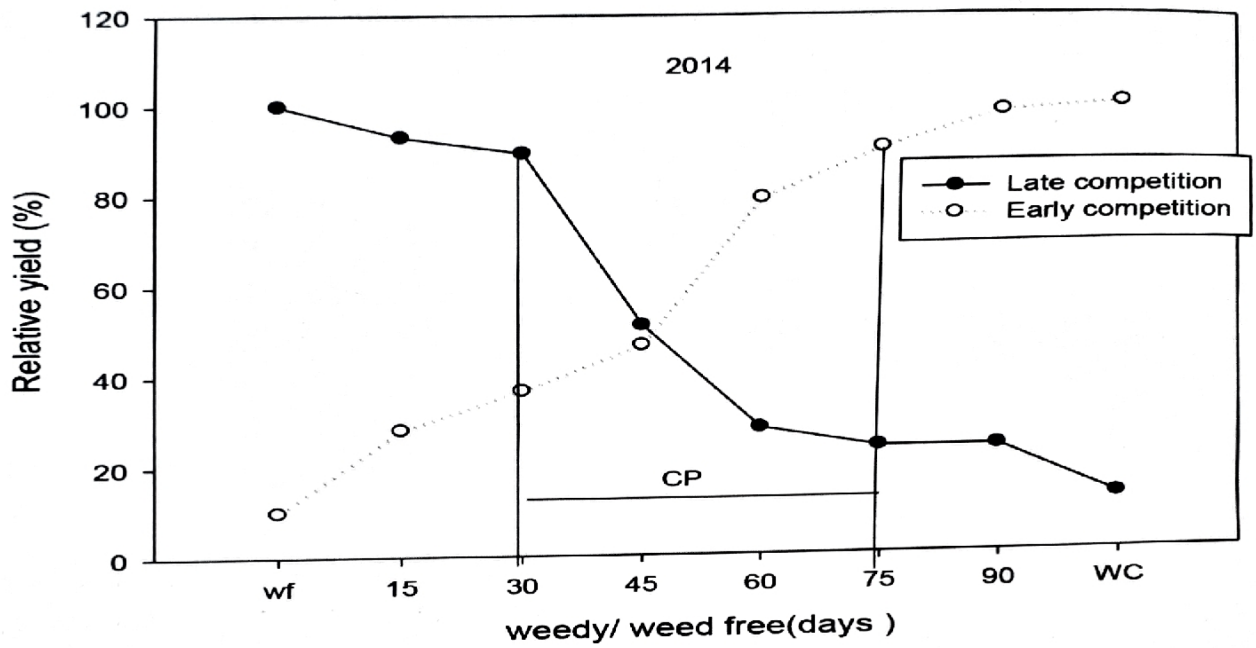
Table 2. Relative yield loss in late and early competition as compared to complete weed free plot

Late competition (weed free up to)	Relative yield loss 2013	Relative yield loss 2014	Early competition (weedy up to)	Relative yield loss 2013	Relative yield loss 2014
15 DAT	71.5a	74.9a	15 DAT	6.6d	6.4d
30 DAT	60.3b	54.4b	30 DAT	8.8d	11.2d
45 DAT	52.4c	17.7c	45 DAT	60.8c	51.9bc
60 DAT	30.2d	13.3cd	60 DAT	71.3bc	74.9ab
75 DAT	12.5e	4.4cd	75 DAT	75.9ab	79.7ab
90 DAT	1.4f	3.2d	90 DAT	75.9ab	82.3a
Complete weed free	0.0f	0.0d	weedy check	87.5a	90.8a
LSD (0.05)	7.58	13.53	LSD (0.05)	12.56	29.91
CV	13.05	31.71	CV	11.59	27.99

LSD= least significant difference, CV= coefficient of variation, DAT= Days after transplanting

Critical period of weed control

Results of this study indicated that to prevent greater than 10% yield loss, the maximum time for which weeds could be allowed to grow after crop transplant time was 30 days and the crop must be free of weeds up to 60-75 day after transplanting to prevent a predetermined level of yield loss. The critical period for weed competition for tomato crop in Guder area was found to be approximately 30- to 60/75 DAT with duration of 30-45 days (Fig. 2). Removing weeds between these two points is usually adequate to prevent the tomato plants from damage due to weeds. Critical period at this location was later than that reported by different authors from different locations. Adigun (2005) concluded that the crop was most critically affected by weed interference between 3 and 6 WAT. Probably the differences could be explained partially due to the differences in the physiographic, edaphic, biotic and competitive effects that determined the occurrence and establishment of weeds (Evans *et al.*, 2003; Norsworthy and Oliveira, 2004; Mahmoodi and Rahimi, 2009). Moreover, weeds were similar to crop in morphology which might have also offered more competition due to same type of root system thereby compete for the same resources from the same soil depth. Also at the study area the weather was cold which probably allowed the weeds to emerge and grow slowly. Knezevic et al. (2002) reported that the critical period of weed interference for a given crop can vary with the relative time of weed emergence, because later weed emergence can lead to the later beginning of the critical period. Weed control under these conditions should be based on post emergence cultivation.



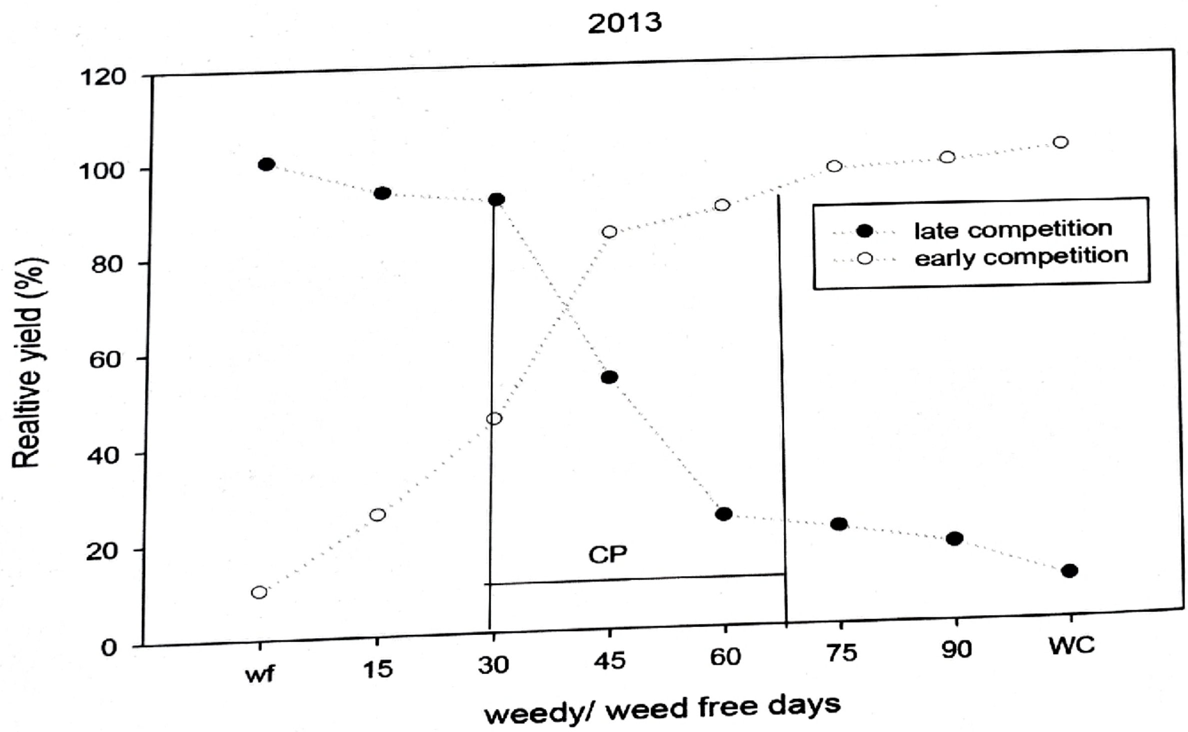


Figure 2. Tomato fruit yield response to increasing length of weed free (late competition) or duration of weed interference (early competition) periods: CP (critical period), wc = weed check, wf= weed free

Conclusion

Weeds are the major biotic constraints that limit the production in the tomato producing areas of Guder. Farmers usually weed their fields late in the season, and as a result severe yield reduction was caused every year due to weeds. Therefore, weeds should be removed at early tomato growth stage up to 4 weeks after emergence. Based on the results of this study, tomato producers are advised to keep their field from weeds from 30 to 68 days after transplanting.

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