Open Access Library Journal

Weed Interference in Zero-Till Cotton (*Gossypium hirsutum* L.)

Ayyadurai Pachamuthu[1*], Poonguzhalan Ramadoos[2], Sathya Priya Ramalingam[3]

[1]Tamil Nadu Agricultural University, Paiyur, India
[2]Department of Agronomy, P. J. N. College of Agriculture and Research Institute, Karikal, India
[3]Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, India
Email: [*]ayyaagridurai@gmail.com

Received 7 July 2014; revised 10 August 2014; accepted 17 September 2014

Abstract

An investigation to study the effect of weed competition on zero-till cotton was carried out at the experimental farm of the Pandit Jawaharlal Nehru College of Agricultural and Research Institute, Karikal during the summer season (February to July) of 2007. The predominant weed species found in the experimented field were *Echinochola colanum* L., *Leptochloa chinensis* L., *Cyperus rotundus* L., *Trianthema portulacastru*, *Rotala densiflora*, *Eclipta alba*, *Phyllanthus maderaspatensis*, *Echinochloa colonum* and *Leptochloa chinensis*. Weed population increased between 20 - 60 days after sowing and decreased thereafter. Weed competition during the first 20 days after sowing resulted in an average yield loss of 12.5 percent which increased to 96.5 percent with full season competition. The seed cotton yield increased from 353 kg/ha to 2308 kg/ha as the initial weed-free period was increased from 20 days after sowing (DAS) to full season. The critical period of weed competition in zero-till cotton prevailed 20 to 60 DAS during which the crop should be kept free of weeds to prevent the potential losses in seed cotton yield.

Keywords

Weed Density, Dry Weight, Weed Index, Critical Period, Yield

Subject Areas: **Agricultural Science, Conservation Biology, Plant Science**

1. Introduction

Cotton (*Gossypium hirsutum* L.,) the "white gold" or "money spinner" enjoys a predominant position amongst all cash crops in India and cultivated since Indus valley civilization. Cotton occupies the prime in India constituting more than 70% of the total fibre consumption in the textile sector. Weed growth offers severe weed competition in the initial stages of crop growth as cotton is a wider spaced crop with slow vegetative growth during

[*]Corresponding author.

How to cite this paper: Pachamuthu, A., Ramadoos, P. and Ramalingam, S.P. (2014) Weed Interference in Zero-Till Cotton (*Gossypium hirsutum* L.). *Open Access Library Journal*, **1**: e927. http://dx.doi.org/10.4236/oalib.1100927

initial stages there by causes yield reduction to an extent of 74 percent [1]. In India, cotton is grown under varied environments and seasons. In Tamil Nadu, the zone of summer rice-fallow cotton is confined to the delta districts of Thanjavur, Thiruchirapalli, Villupuram and Vellore. Karaikal is located in the tail end of Cauvery delta zone. Of the estimated 0.5 lakh hectares under the summer cotton (2003-2004), one third of area (14,000 hectares) comes from the rice-fallows of Cauvery delta under cotton [2]. Cotton, in Karaikal region, is often grown only under rice-fallow condition. The cotton area in Karaikal region is 134 ha [3]. Rice-fallow cotton cultivation is a unique system of cultivation, wherein the cotton seeds are dibbled amidst the rice stubbles without tilling the soil to effectively utilize the residual soil moisture. Thus, in this system, cotton faces a severe competition from the early emerging weeds and weeds that are already present in rice field at the time of harvest. The problem of weed menace in rice-fallow cotton would be aggravated if the previous rice crop was not weeded adequately. Weed management during the early stages of cotton growth is more important. Hence, it is necessary to find out the critical period of crop weed competition to make weed control method more effective and economical.

2. Materials and Methods

2.1. Experimental Site and Initial Soil Characteristics

Field experiments were laid out during summer season of 2007 in Western Block Farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T of Puducherry. The geographical location of the experimental site is 10˚55"N latitude and 79˚52"E longitude with an altitude of 4 m above MSL and the farm receives the normal total annual rainfall of 145.7 mm. A total rainfall of 79.3 mm was received during the actual cropping period (summer 2007) which was 45 percent lower than the normal. The soil of experimental site was well drained sandy clay in texture (38.15% clay, 10.85% silt, 12.25% fine sand and 38.20% coarse sand) with low in available nitrogen, high in available phosphorus and potassium. The soil analysed 172, 33 and 373 $kg \cdot ha^{-1}$ of $KMnO_4$-N, Olsen-P and NH_4OAc-K, respectively with EC of 0.28 $dS \cdot m^{-1}$, pH of 7.2.

2.2. Experimental Design, Selection of Cultivar and Sowing

The experiment was laid out in randomized complete block design (RBD) with twelve treatments and replicated thrice. The gross plot and net plot size adopted was 32.40 m^2 (7.2 m × 4.5 m) and 11.88 m^2 (3.6 m × 3.3 m). Cotton (*Gossypium hirsutum* L.) cultivar MCU 7 maturing in 135 - 145 days suitable for rice fallow cotton in coastal and cauvery deltaic region of Tamil Nadu and Karaikal used for this study. Cotton seeds, treated with cow dung slurry and dried in shade, were dibbled adopting a seed rate of 15 $kg \cdot ha^{-1}$. Two seeds $hill^{-1}$ were dibbled at a depth of 2 - 3 cm adopting a spacing of 60 cm between the rows and 30 cm between the plants in a row and covered with river sand. After sowing the seeds, immediately a light irrigation was given to the crop for uniform germination.

2.3. Treatment Details

Twelve treatments consisted of weedy periods upto 20, 40, 60, 80 and 100 DAS and at harvest and weed free periods upto 20, 40, 60, 80 and 100 DAS and at harvest. The recommended dose of 60:30:30 kg NPK ha^{-1} in the form of urea, single super phosphate and muriate of potash were applied to all plots uniformly and fifty percent of the nitrogen was applied as basal while, the remaining dose was top dressed on 41 DAS. During the course of experiment, the data were recorded on predominant weed flora, weed density and dry weight in cotton.

2.4. Observations on Weeds

2.4.1. Weed Density

The weed count was recorded species wise using 0.5 m × 0.5 m quad rat from four randomly fixed places in each plot and the weeds falling within the frames of the quad rat were counted, recorded and the mean values were expressed in number m^{-2}. The density of grasses, sedges and broad leaved weeds and the total weeds were recorded at 20, 40, 60, 80 and 100 days after sowing (DAS) and at harvest and expressed in number m^{-2}.

2.4.2. Weed Dry Weight

The weeds falling within the frames of the quad rat were collected, categorised into grasses, sedges and broad-

leaved weeds, shade dried and later dried in hot-air oven at 80˚C for 72 hrs. The dry weight of grasses, sedges and broadleaved weeds were recorded separately at 20, 40, 60, 80 and 100 days after sowing (DAS) and at harvest and expressed in kg·ha^{-1}.

2.4.3. Weed Index

Weed index (WI) was calculated as per the method [4].

$$WI = \frac{X - Y}{X} \times 100$$

where, X = yield (kg·ha^{-1}) from minimum weed competition plot; Y = yield (kg·ha^{-1}) from the treatment plot for which WI is to be worked out.

2.5. Statistical Analysis

The data collected for onion was statistically analysed by following procedure for randomised block design [5]. The data pertaining to weeds and germination were transformed to square root scale of $\sqrt{(X + 2)}$ and analysed [6]. Whenever significant difference existed, critical difference was constructed at five percent probability level.

3. Results and Discussion

3.1. Effect on Weeds

The weed flora of experimental field was dominated by grasses (94.61% and 98.61% at 40 and 80 DAS, respectively). *Echinochloa colonum* (L.) was the most predominant weed species followed by *Leptochloa chinensis* (L.) Nees. The only sedge observed was *Cyperus rotundus* (L.), that too only at 40 DAS. The broad leaved weeds of the experimental field were *Trianthema portulacastrum* (L.), *Rotala densiflora* Koehne, *Eclipta alba* (L.) and *Phyllanthus maderaspatensis* constituting 3.35 percent of total weed density at 40 DAS. However, at 80 DAS, *Phyllanthus maderaspatensis* was not observed and the density of broad leaved weeds decreased. Whereas the density of grasses increased from 245.7 weeds m^{-2} at 40 DAS to 567.3 weeds m^{-2} at 80 DAS. The dominance of *Echinochloa colonum* in rice-fallow cotton was earlier reported by [7] [8] was also of similar opinion.

3.2. Weed Density

At 20 DAS, no weed was recorded in weed free for specific period treatments whereas all weedy for specific period treatments recorded significantly higher and similar weed density (222.7 to 238.0 m^{-2}). Weedy upto harvest registered the maximum density of weeds (259.7 to 575.3 m^{-2}) at all the stages followed by weedy upto 100 DAS (246.3 to 567.3 m^{-2}) (**Table 1**).

In weedy for specific period treatments, the weed density increased upto 80 DAS and then the density remained constant or decreased slightly. In weed free for specific period treatments the weed density started increasing after the weed free period and the maximum values were recorded in weed free upto 20 DAS and weed free upto 40 DAS at all stages of observation. The weed density increased with progressive increase in the duration of weed infestation and thus weedy up to harvest registered the highest weed density. All the treatments involving weed free for specific period did not register any weed population up to that specific period due to respective weeding period. But the weeds started appearing after the specific period of weed free condition. From 60 DAS onwards, weed free up to 20 DAS registered higher weed density which was on par with that in weedy up to harvest. Maintaining the field weed free up to 40 DAS or beyond reduced the weed density by 53 percent and more. This may be attributed to the faster cotton growth from 40 DAS which could suppress the weed population by shading the land area. [9] and [10] were also of similar opinion.

3.3. Weed Dry Weight

At 20 DAS, no weed dry matter production was recorded in weed free for specific period treatments whereas all weedy for specific period treatments recorded significantly higher and similar weed dry matter production (25.9 to 31.0 g·m^{-2}). The highest dry weight of weeds (31.0 to 351.4 g·m^{-2}) was recorded in weedy upto harvest at all

Table 1. Density of weeds (number m^{-2}) at different stages of crop growth.

Treatments	20 DAS		40 DAS		60 DAS		80 DAS		100 DAS		At harvest	
Weedy upto												
20 DAS	15.4	(238.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
40 DAS	15.2	(232.0)	15.8	(250.3)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
60 DAS	15.2	(231.3)	15.5	(238.3)	22.1	(490.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
80 DAS	15.1	(226.7)	15.7	(248.0)	21.9	(478.3)	23.5	(562.7)	0.7	(0.0)	0.7	(0.0)
100 DAS	14.9	(222.7)	15.7	(246.3)	21.8	(474.7)	23.8	(567.3)	23.6	(554.7)	0.7	(0.0)
Harvest	15.1	(227.3)	16.1	(259.7)	22.0	(485.0)	23.9	(575.3)	23.9	(572.0)	21.6	(467.3)
Weed free upto												
20 DAS	0.7	(0.0)	11.8	(140.0)	21.7	(472.7)	23.4	(550.7)	23.2	(538.7)	21.1	(444.0)
40 DAS	0.7	(0.0)	0.7	(0.0)	14.9	(222.7)	16.2	(262.7)	15.7	(247.3)	13.9	(191.3)
60 DAS	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	10.1	(101.3)	10.9	(119.3)	10.5	(110.7)
80 DAS	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	6.6	(42.7)	7.7	(60.0)
100 DAS	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	7.8	(60.7)
Harvest	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
C.D. (P = 0.05)	0.8		0.6		1.1		2.7		0.6		1.2	

Figures in parentheses are original values; DAS: days after sowing; observations were recorded before imposing the treatment.

the stages followed by weedy upto 100 DAS (27.6 to 359.2 $g \cdot m^{-2}$) except at 80 DAS, wherein weedy for 100 DAS recorded the highest DMP. In weedy for specific period treatments, the total weed dry matter production increased upto 80 DAS and then decreased slightly. The weed dry weight increased with increase in the duration of weed infestation period and decreased with increase in the duration of weed free period (**Figure 1**). The highest dry weight of weeds was observed in weedy up to harvest, throughout the crop growth period (**Table 2**). This may be attributed to the highest population of the weeds observed in this treatment which could have effectively used the resources like water, nutrients and sunlight to produce higher dry mater. The weed dry weight was proportional to the density of weeds.

This is evident from the significant positive correlation ($r = 0.846^{**}$) observed between the weed density and dry weight. The trend in weed dry weight was similar to that observed in weed density. From 40 DAS onwards, weed free up to 20 DAS recorded significantly higher weed dry weight than weedy for 20 DAS and was on par with weedy up to harvest indirecting that a weed free period of initial 20 DAS is insufficient to contain the weed growth. Maintaining the field weed free for first 40, 60, 80 and 100 days reduced the weed dry weight by 50, 72, 96 and 97 percent, respectively. This indicates that the dry matter production by weeds can be reduced to half by maintaining the field weed free initial 40 days. Similar results were earlier reported by [11]-[13].

3.4. Growth and Yield of Crop

Weed competition had significant effect on plant height and other ancillary characters, all of which decreased as the length of weedy period was increased and *vice versa* (**Table 3**). Mean plant height taken at harvest was significantly reduced from 81.5 to 34.1 cm as the weedy period was increased from 20 DAS to full crop season. Other ancillary characters like number of sympodial $plant^{-1}$, bolls $plant^{-1}$ and boll weight also followed the same trend and decreased from 16.5 to 3.3, 14.6 to 1.2 and 2.9 to 0.5 g, respectively (**Figure 2**), as the weedy period was increased from 20 DAS to full season. This corroborates the findings of [14] and [15] who have also reported reduction in plant height and other yield attributing characters with increasing weed competition. The adverse effect of weed competition on ancillary characters clearly visible in its effect on seed cotton yield (**Table 3**). Weed competition during the first 20 DAS resulted in an average yield loss of 12.5 percent which increased to 56.2, 82.7, 90.1, 95.1 and 96.5 percent as the weedy period was increased to 40, 60, 80, 100 DAS and full crop season, respectively. Similar deleterious effect of weed competition on seed cotton yield has also reported by [16]-[19]. On the other hand, increasing the weed-free period resulted in significant improvement in both the ancillary characters and the seed cotton yield (**Table 2**). On rice fallow conditions weed seeds germinate

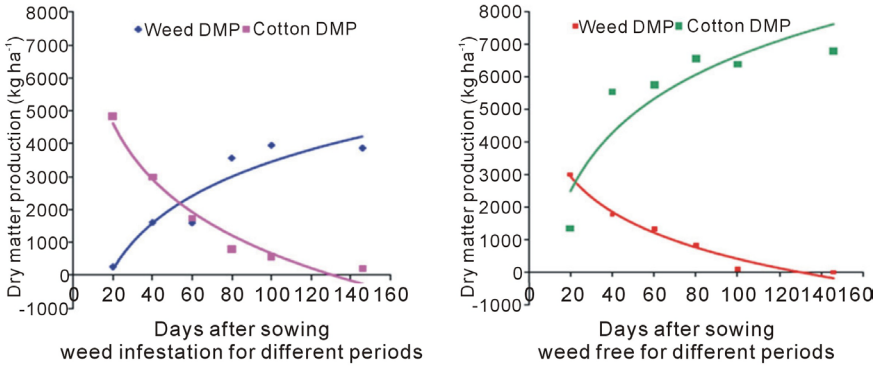

Figure 1. Dry matter production (DMP) by cotton and weeds as influenced by different periods of weed competition.

Table 2. Dry matter of weeds ($g \cdot m^{-2}$) at different stages of crop growth.

Treatments	20 DAS		40 DAS		60 DAS		80 DAS		100 DAS		At harvest	
Weedy upto												
20 DAS	5.2	(26.4)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
40 DAS	5.1	(25.9)	12.7	(160.6)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
60 DAS	5.2	(26.6)	12.5	(158.2)	12.6	(159.4)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
80 DAS	5.3	(28.3)	12.6	(159.3)	12.5	(155.4)	18.9	(356.2)	0.7	(0.0)	0.7	(0.0)
100 DAS	5.3	(27.6)	12.6	(157.9)	12.3	(151.7)	19.0	(359.2)	18.1	(327.5)	0.7	(0.0)
Harvest	5.6	(31.0)	12.7	(161.1)	12.8	(162.6)	18.7	(351.4)	17.9	(330.5)	17.3	(299.1)
Weed free upto												
20 DAS	0.7	(0.0)	9.7	(93.7)	10.3	(105.3)	14.7	(216.1)	17.3	(300.4)	16.7	(278.2)
40 DAS	0.7	(0.0)	0.7	(0.0)	5.3	(27.3)	11.7	(136.0)	12.5	(155.7)	13.3	(177.2)
60 DAS	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	7.2	(52.6)	11.5	(131.8)	9.8	(100.9)
80 DAS	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	9.2	(84.3)	3.6	(12.2)
100 DAS	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	3.1	(9.0)
Harvest	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)	0.7	(0.0)
C.D. (P = 0.05)	0.6		0.8		0.8		1.2		2.1		1.7	

Figures in parentheses are original values; DAS: days after sowing; observations were recorded before imposing the treatment.

Table 3. Effect of crop-weed competition on the ancilliary characters and yield of zero-till cottton.

Treatments	Final height (cm)	Sympodial branches $plant^{-1}$	Bolls $plant^{-1}$	Boll weight (g)	Boll setting percentage	Seed cotton yield ($kg \cdot ha^{-1}$)	Weed index (%)*
Weedy upto							
20 DAS	81.5	16.5	14.6	2.9	67.3	2342	12.5
40 DAS	64.5	11.4	10.9	2.3	67.8	1173	56.2
60 DAS	59.1	11.4	8.1	1.2	72.7	462	82.7
80 DAS	44.8	6.1	5.9	0.9	100.0	266	90.1
100 DAS	38.7	5.7	2.6	0.3	100.0	131	95.1
Harvest	34.1	3.3	1.2	0.5	100.0	94	96.5
Weed free upto							
20 DAS	59.0	7.1	4.5	1.5	69.3	353	86.8
40 DAS	85.9	21.5	13.9	2.5	73.4	2058	23.1
60 DAS	89.5	23.9	17.1	2.4	87.0	2336	12.7
80 DAS	90.9	23.4	21.8	2.5	94.4	2676	0.0
100 DAS	94.7	24.5	17.5	2.6	80.5	2393	10.6
Harvest	96.7	24.1	17.3	2.4	74.9	2308	13.7
C.D. (P = 0.05)	6.7	3.3	1.6	0.8	19.9	352	-

DAS: days after sowing; *Data not statistically analysed.

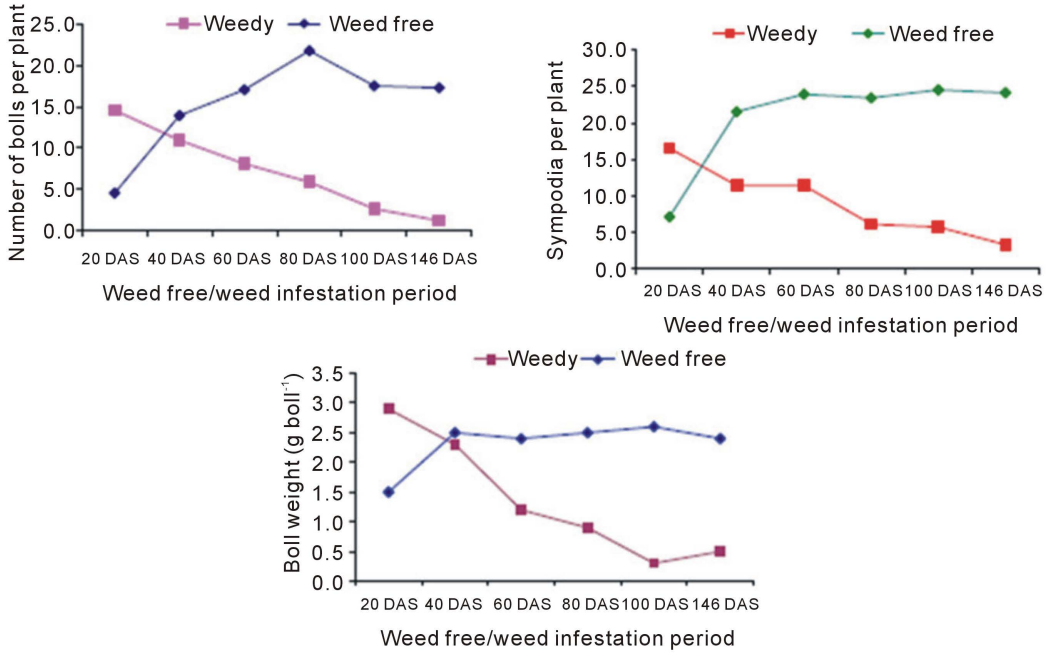

Figure 2. Effect of weed competition on yield components of cotton.

earlier than cotton and there will also be grown up weeds of previous season rice. Slow growth of cotton during early stage further aggregate the problem and make more susceptible to the weed competition when left unchecked reduced the seed cotton yield by 96.5%. The loss in the yield decreased with increase in the duration of weed free condition during the initial period of crop growth. [20]-[22] and [8] also reported that weeds reduced the cotton yield upto 85%.

Seed cotton yield was adversely affected in plots maintained weed free only for 20, 40 and 60 days after sowing as compared to 80 DAS and weed infestation for 20 days after sowing or weed free treatments. This was because of re-emergence of large number of weeds under these plots. Weed free check treatment recorded maximum yield, followed by weed free upto 60 DAS and weedy upto 20 DAS.

3.5. Critical Period

Weed interference for only first 20 days caused no significant loss in seed cotton yield (**Figure 3**). When weeds were allowed to remain beyond 20 days or longer, the yield was reduced significantly. The LSD (P = 0.05) for seed cotton yield was 3.52 q or 13% of weed free check. By using this LSD = 13% we can see that the seed cotton yield was statistically at par with weed free check when weedy period last only upto initial 20 days and weed free period onward upto 60 days or more weed competition worked out to be between 20 and 60 DAS in rice fallow cotton. [23] and [24] also used LSD (P = 0.05) to find out the critical period of weed competition. [25] observed that the critical period of rainfed cotton was 30 to 60 DAS. [26] observed that the critical period for weed competition in irrigated cotton to be from 40 to 60 DAS. However, maintaining the field weed free beyond 80 DAS considerably reduced the seed cotton yield due to lower boll setting percentage. Season-long weed competition the seed cotton yield by 96.5 percent. The yield was found to decline at the rate of 6.019 kg·ha^{-1} for every kg of weed dry matter produced. The presence of weeds for the first 40 days caused 50.9% reduction in yield indicating that initial weed infestation was harmful to the crop. In contrast, crop initially weeds free for 40 days recorded only 14.0% reduction probably because weeds emerged after days did not pose any adverse effects on crop yield.

4. Conclusion

From the present investigation, the critical period of crop-weed competition in rice-fallow cotton was found to be between 20 and 60 DAS. Maintaining the field weed free upto 80 DAS resulted in the highest seed cotton

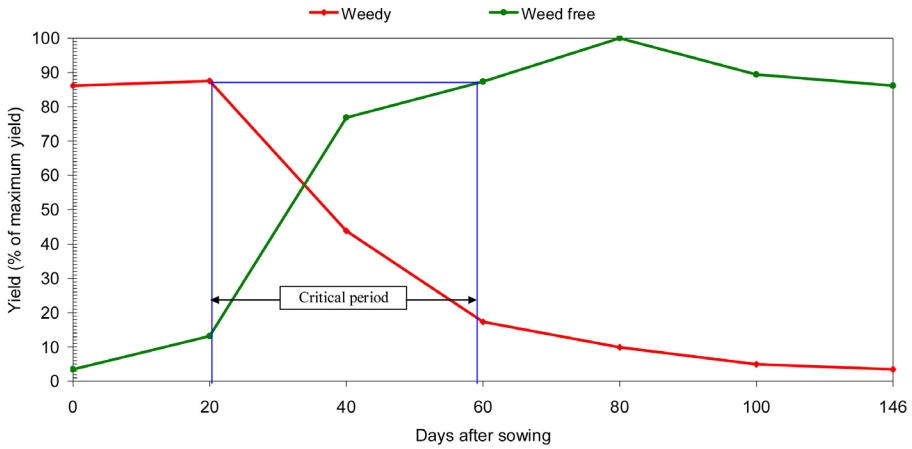

Figure 3. Critical period of crop-weed competition in rice-fallow cotton.

yield and maximum profit. However, maintaining the field weed free beyond 80 DAS resulted in significantly lower yield due to lower boll setting percentage.

References

[1] Shelke, D.K. and Bhosle, R.H. (1990) Emergence of Summer Groundnut Influenced by Herbicides Applied to Kharif Cotton. *Journal of Maharastra Agricultural University*, **15**, 265-266.

[2] Gurumurthy, G. (2004) Drought, Cauvery Crisis Push Tamil Nadu Cotton Growers to Newer Areas. *Business Line*, July 02.

[3] SCR (2006) Season and Crop Report. Directorate of Economics and Statistics. Government of Puducherry.

[4] Gill, G.S. and Vijaya Kumar, K. (1969) Weed Index—A New Method of Reporting Weed Control Trials. *Indian Journal of Agronomy*, **14**, 96-98.

[5] Gomez, K.A. and Gomez, A.A. (2010) Statistical Procedures for Agricultural Research. Wiley India Pvt. Ltd., New Delhi.

[6] Snedecor, G.W. and Cochran, W.G. (1967) Statistical Methods. Oxford and IBH Publ. Co., New Delhi, 593.

[7] Chandrasekaran, B., Chinnuswami, K.N. and Sankaran, S. (1989) Effect of Nitrogen and Weed Management in Rice-Fallow Cotton. *Indian Journal of Agronomy*, **34**, 264-265.

[8] Latha (2005) Evaluation of Chemical Weed Control Methods in Rice-Fallow Cotton (*Gossypium hirsutum* L.) in the Coastal Region of Karaikal. M.Sc (Ag.) Thesis, Submitted to Tamil Nadu Agricultural University, Coimbatore.

[9] Wu, J.R., Han, J., Shen, J.M., Mao, Y.X. and Zhang, X.Y. (1999) A Study on Critical Period of Combination between Crab Grass and Transplanted Cotton Interplanting with Wheat. *Jiangsu Journal of Agricultural Science*, **15**, 87-92.

[10] Sivakumar, C. and Subbian, P. (2002) Growth and Yield of Irrigated Cotton (*Gossypium hirsutum* L.) as Influenced by Different Chemical and Non-Chemical Weed Management Practices. *Indian Journal of Agronomy*, **47**, 123-129.

[11] Cia, E., Deuber, R., Ferraz, C.A.A., Sabino, N.P., Aranhe, C., Leitao, H.F., Forstar, R. and Veiga, A.A. (1978) Effect of Weed Competition on Cotton. *Cotton and Tropical Fibres Abstracts*, **5**, 176.

[12] Singh, T., Brar, L.S., Sandhu, B.S. and Singh, H. (1992) Chemical Weed Control in Upland Cotton (*Gossypium hirsutum* L.). *Indian Journal of Agronomy*, **37**, 874-876.

[13] Vencil, W.K., Giraudo, L.J. and Langdale, G.W. (1993) Soil Moisture Relations and Critical Periods of *Cynodon dactylon* (L.) Pers. (Coastal Bermudagrass) Competition in Conservation-Tillage Cotton (*Gossypium hirsutum* L.). *Weed Research*, **33**, 89-96. http://dx.doi.org/10.1111/j.1365-3180.1993.tb01921.x

[14] Brar, H.S. (1975) Chemical Weed Control and Crop Weed Competition in Cotton (*Gossypium hirsutum* L.). Ph.D. Dissertation, Punjab Agricultural University, Ludhiana.

[15] Snipes, C.E., Buchanan, G.A., Street, J.E. and McQuire, J.A. (1982) Competition of Common Cocklebur (*Xanthium pensylexmium*) with Cotton (*Gossypium hirsutum* L.). *Weed Science*, **30**, 553-556.

[16] Rushing, D.W., Murray, D.S. and Varhalen, L.S. (1985) Weed Interference with Cotton. I. Buffalobur (*Solanum rostratum*). *Weed Science*, **33**, 810-814.

[17] Bryson, C.T. (1987) Interference of Hemp Sesbania (*Sesbania exaltata*) with Cotton (*Gossypium hirsutum*). *Weed*

Science, **35**, 314-318.

[18] Green, J.D., Murray, D.S. and Varhalen, L.M. (1987) Full Season Interference of Silver Nightshade (*Solanum elaeagnifolium*) Interference with Cotton (*Gossypium hirsutum*). *Weed Science*, **35**, 813-818.

[19] Keeley, P.E. and Thullen, R.J. (1989) Growth and Competition of Black Nightshade (*Solanum nigrum*) and Palmer Amaranth (*Amaranthus palmer*) with Cotton (*Gossypium hirsutum*). *Weed Science*, **37**, 326-334.

[20] Srinivasalu, G. and Rao, A.S. (2000) Effect of Sequential Application of Herbicides on Weed Management in Cotton. *Proceedings of Symposium on Challenges in Agronomic Crop Management in Early* 21*st Century*, Hydrabad, 24-25 May 2000, 71-74.

[21] Virk, J., Singh, S.D. and Tripathi, H.P. (1982) Growth and Yield of Cotton as Influenced by Herbicides Alone or in Combination with Interculture. *Pesticides*, **16**, 21-25.

[22] Bryson, C.T., Reddy, K.N. and Molin, W.T. (2003) Purple Nutsedge (*Cyperus rotundus*) Population Dynamics in Narrow Row Transgenic Cotton (*Gossypium hirsutum* L.) and Soybean (*Glycine max*) Rotation. *Weed Technology*, **17**, 805-810. http://dx.doi.org/10.1614/WT02-177

[23] Chhokar, R.S., Balyan, R.S. and Pahuja, S.S. (1995) The Critical Period of Weed Competition in Soybean [*Glysine max* (L.) Merrill]. *Indian Journal of Weed Science*, **27**, 197-200.

[24] Wanjari, R.H., Yaduraju, N.T. and Ahuja, K.N. (2001) Critical Period of Crop-Weed Competition in Rainy-Season Sunflower (*Helianthus annus*). *Indian Journal of Agronomy*, **46**, 309-313.

[25] Muthusankaranarayanan, A., Chellamuthu, V., Rajamannar, A. and Rajapandian, J.S.S. (1998) Effect of Herbicides on the Weed Control in Rainfed Cotton/Blackgram Intercropping System. *Indian Journal of Weed Science*, **20**, 91-93.

[26] Zeman, E. (1985) The Critical Period for Weed Competition in Irrigated Cotton. *Cotton and Tropical Fibres Abstracts*, **10**, 740.