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Effect of different weed interference period on growth and yield performance of upland cotton varieties

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ABSTRACT

This study investigates the impact of weed interference periods on the growth and yield of cotton, emphasizing the critical weed control period (CPWC) for effective management strategies. Conducted over two growing seasons, the experiment utilized three cotton varieties (CB-15, CB-hybrid-1, and Rupali-1) under varying weed interference durations. Treatments included season-long weed-free conditions and periods of weed interference starting at different growth stages. Results indicated that all varieties exhibited the highest seed cotton yield in continuous weed-free conditions, with Rupali-1 achieving optimal yield when maintained weed-free up to 60 days after sowing (DAS). Total dry weed weight increased with prolonged interference, adversely affecting cotton growth and height. Conversely, longer weed-free periods led to significant increases in above-ground biomass and overall plant height. The findings demonstrate that effective weed management, particularly during the early growth stages, is crucial for maximizing cotton yield. The CPWC was identified as essential for optimizing herbicide use and implementing alternative weed management strategies. The study concludes that keeping the cotton field weed-free up to 60 DAS was found necessary to get highest yield which is similar to season long weed-free condition. Removing weeds after 60 DAS brings no advantage in terms of cotton yield.

INTRODUCTION

Weeds pose a significant challenge in cotton cultivation, as they interfere with crops by competing for vital resources such as light, water, nutrients, and space, and in some cases, through allelopathy. The interference from weeds during critical growth stages can lead to substantial reductions in yield and overall crop performance. Effective weed management is crucial in cotton farming to minimize competition and optimize resource use, ensuring sustainable productivity.

Monocropping systems are particularly vulnerable to weed infestations, as they often leave unused ecological resources such as moisture, nutrients, and light, which are readily exploited by weeds. In contrast, intercropping systems have demonstrated greater efficiency in suppressing weeds by more effectively utilizing these resources. Studies have shown that intercropping can either directly suppress weed growth by occupying the same ecological niche or reduce weed biomass by exploiting resources that weeds cannot access as efficiently (Saudy & El-Metwally, 2009; Altieri, 1995). For example, intercrops like corn-cassava and beans-cassava have been shown to provide better weed control compared to monocropping (Soria et al., 1975).

Intercropping can also reduce the need for chemical herbicides. Gomes et al. (2007) found that intercropping with competitive maize cultivars significantly reduced herbicide use while maintaining effective weed control. Liebman and Davis (2000) further demonstrated that intercropping can reduce weed biomass in a

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majority of field experiments, making it a viable alternative to herbicide-based weed management.

Recent studies on relay intercropping have highlighted its potential in weed control. Amossé et al. (2013) reported that forage legume relay intercropping in organic winter wheat significantly reduced the density and biomass of spring-germinating annual weeds by an average of 35.2%. Similarly, Tanveer et al. (2017) found that relay cropping reduced weed germination by over 50%, illustrating the potential of relay intercropping to suppress weeds in various cropping systems.

In upland cotton cultivation, determining the critical weed-free period is essential for effective weed management. By identifying the optimal period for maintaining a weed-free environment, farmers can achieve high yields while minimizing input costs and herbicide usage. This study aims to evaluate the effect of different weed interference periods on the growth and yield of upland cotton and estimate the critical weed-free period for sustainable and cost-effective weed management.

MATERIALS AND METHOD

The experiment

The experiment was conducted following a randomized complete block design (RCBD) with three replications. The unit plot size was 16.2 m^2maintaining row to row and plant to plant distance 90 cm and 45 cm, respectively, with 1.0 m distance between two plots and 2.0m wide space between two blocks and weeding was done manually. Two factors were involved in the experiment. Cotton varieties viz CB-15 (V1), CB-hybrid-1 (V2), Rupali-1 (V3) were selected for this experiment and considered as Factor A. Ten Weed interference period (W) viz Season long weedy (W1), Season long weed free (W2), Weed free up to 30 DAS (W3), Weed free up to 45 DAS (W4), Weed free up to 60 DAS (W5) Weed free up to 75 DAS (W6), Weed free from 15 to 30 DAS (W7), Weed free from 15 to 50 DAS (W8), Weed free from 15 to 60 DAS (W9) and Weed free from 15 to 75 DAS (W10), were considered as factor B. Weeding done 15 days interval for each treatment. Organic and inorganic fertilizers were applied as described by Harun-Or-Rashid et al. (2023).

Sowing of seeds in the field

The seeds of cotton CB-15 were defuzzed and treated with Actara @ 5 g kg^{-1} seed and were sown @ 2-3 seeds $hill^{-1}$ on 15 July, 2018 as experimental design. In furrows maintaining the row to row spacing of 90 cm and hill to hill spacing of 45 cm. Seeds were placed in pit to a depth of 4-5 cm and then covered with loose soil. The seedlings of different genotypes emerged between 3-7 DAS.

Crop management

Different necessary management practices were followed during the crop growing period. Weeding, irrigation and drainage were done properly. Protections measured were done against insects and diseases (Harun-Or-Rashid et al., 2023)

Crop sampling and data collection procedure

Five plants from each treatment plot were randomly selected and marked with sample card and data were recorded as the objectives of the experiment. Data were recorded on as describe in Manuscript one. Finally, the cotton was harvested.

Statistical Analysis

The collected data were statistically analyzed. Analysis of variance (ANOVA) for each of the parameter was performed with the help of computer packages RStudio software. The mean square at the error and phenotypic variance were estimated as per Johnson et al. (1955). Significant differences among means were adjudged using Fisher's protected Least Significant Difference (LSD) test at $P \leq 0.05$.

RESULTS

Growth parameters of cotton

Plant height

The weed interference period significantly affected in plant height at different days after sowing (Supplementary Table S1). Results revealed that the taller plant height was observed in weed free period up to 75 DAS. At 150 DAS, the tallest plant (138.25 cm) was observed in weed free period from 15 to 75 DAS followed by weed free up to 60 DAS (136.17 cm), weed free from 15 to 60 DAS (134.33 cm) and weed free up to 45 DAS (134.19 cm). On the other hand, the shortest plant (102.89 cm) was found in season long weedy condition which was statistically similar weed free up to 30 DAS (108.19 cm) (Supplementary Table S1).

Table 1: Interaction effect of cotton variety and weed interference period on plant height at different days after sowing

Variety× weed interference period	Plant height (cm)				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
V_1×W_1	10.67 j	20.50 j	47.83	79.17	115.33 j-m
V_1×W_2	20.25 a-i	86.17 a	103.17	107.22	134.83 b-f
V_1×W_3	18.50 ghi	63.67 gh	93.00	98.67	132.75 b-g
V_1×W_4	19.08 c-i	73.25 def	101.08	106.67	109.83 k-n
V_1×W_5	18.75 e-i	77.58 cd	103.00	112.83	128.17 c-h
V_1×W_6	21.33 a-d	80.33 bc	105.08	111.92	126.42 e-i
V_1×W_7	18.75 e-i	62.00 h	95.08	105.75	124.08 f-j
V_1×W_8	17.92 i	62.83 h	96.75	108.50	123.67 g-j
V_1×W_9	18.42 hi	74.17 de	95.08	109.50	117.08 I-m
V_1×W_{10}	21.42 abc	77.50 cd	102.25	112.08	119.08 h-k
V_2×W_1	10.42 j	19.08 j	59.19	84.67	93.00 o
V_2×W_2	21.00 a-g	68.67 fg	93.72	110.50	137.08 b-e
V_2×W_3	19.42 b-i	64.75 gh	80.50	98.83	121.50 hij
V_2×W_4	19.08 c-i	54.08 i	88.17	96.17	108.08 lmn
V_2×W_5	20.92 a-h	64.08 gh	79.33	101.33	135.58 b-e
V_2×W_6	21.42 abc	75.17 de	97.25	105.00	142.50 ab
V_2×W_7	19.50 a-i	64.42 gh	78.50	103.50	118.67 h-l
V_2×W_8	20.75 a-h	61.17 h	82.83	98.83	134.75 b-f
V_2×W_9	19.58 a-i	73.75 def	82.50	100.50	135.92 b-e
V_2×W_{10}	21.25 a-e	74.75 de	100.42	106.50	135.25 b-e
V_3×W_1	9.08 j	16.50 j	66.92	87.33	100.33 no
V_3×W_2	21.83 ab	77.83 cd	101.17	115.83	142.83 ab
V_3×W_3	18.83 d-i	61.67h	77.50	106.83	133.25 b-g
V_3×W_4	19.25 c-i	63.67gh	80.92	109.33	106.67 mn
V_3×W_5	21.49 abc	70.83 ef	87.50	116.17	138.83 abc
V_3×W_6	22.00 a	84.25 ab	91.17	115.50	139.58 ab
V_3×W_7	19.42 b-i	61.50 h	82.75	108.33	143.50 ab
V_3×W_8	18.58 f-i	61.75 h	79.50	109.12	127.58 d-i
V_3×W_9	20.33 a-i	73.08 def	89.17	112.17	138.00 a-d
V_3×W_{10}	21.08 a-f	77.92 cd	88.08	111.17	148.67 a
Level of significance	**	**	NS	NS	**
CV (%)	8.27	4.80	11.17	10.01	5.28

Note:** indicated significant at 5% level of probability; NS = not significant; V_1=CB-15, V_2= CB-hybrid-1, V_3= Rupali-1; W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS

The effect of interaction of variety and weed interference period on plant height was also significantly different at all days after sowing except 120 DAS. At 150 DAS, the tallest plant (148.67 cm) was obtained from the variety Rupali-1 when weed free from 15 to 75 DAS followed treatment $V_3 \times W_7$ (143.50 cm), $V_3 \times W_2$ (142.83 cm) and $V_2 \times W_6$ (142.50 cm). On the other hand, the shorter plant height (93.00 cm) was found in variety CB-hybrid-1 when season long weedy condition (Table 1).

Number of leaves plant^{-1}

The number of leaves significantly different by weed interference period at different days after sowing (Supplementary Table 2). At 30DAS, the highest number of leaves plant^{-1} (8.06) was produced at weed free up to 75 DAS while the lowest one (5.44) was recorded with the weed free condition. The highest number of leaves plant^{-1} (27.11) in weed interference period of weed free up to 15 to 75 DAS at 60 DAS and the lowest one (13.31) was found in season long weedy condition. AT 90 DAS, the maximum number of leaves plant^{-1} (35.19) under weed free from 15-75 DAS whereas the minimum one (15.06) was obtained from weedy condition. At 120 DAS, the highest number of leaves plant^{-1} (40.67) was observed in weed interference period of weed free from 15 to 75 DAS. On the other hand, the lowest one (23.67) was found in season long weedy condition. At 150 DAS, the highest number of leaves plant^{-1} (54.11) was produced in weed interference period of weed free from 15-75 DAS while the lowest one (39.22) was recorded with the weedy condition (Supplementary Table 2).

The interaction effect of variety and weed interference period on number of leaves was also significant at different days after sowing. Results revealed that at 30 DAS, the highest number of leaves plant^{-1} (8.08) were observed in the treatments $V_2 \times W_6$and $V_3 \times W_6$ and the lowest one (5.17) was found in $V_1 \times W_9$ and $V_3 \times W_4$. However, at 60, 90 and 120 DAS, the highest number of leaves plant^{-1} were observed in 28.67 ($V_1 \times W_{10}$), 36.25 ($V_3 \times W_2$) and 42.33 ($V_3 \times W_{10}$), respectively and the lowest one were found in 12.83 ($V_3 \times W_1$), 14.75 ($V_1 \times W_1$)and 23.00($V_2 \times W_1$), respectively.At150 DAS, the highest number of leaves plant^{-1} (55.67) were observed in the variety CB-hybrid-1 when weed interference period of weed free from 15 to 75 DAS followed treatments $V_3 \times W_4$ (55.00), $V_3 \times W_9$ (54.67), $V_2 \times W_9$ (54.33) and $V_3 \times W_{10}$ (54.00). On the other hand, the lowest one (38.00) was found in the variety CB-hybrid-1 under weedy condition followed by treatment $V_1 \times W_1$ (38.67) (Table 2).

Table 2: Interaction effect of cotton variety and weed interference period on number of leaves plant^{-1}in cotton at different days after sowing

Variety×weed interference period	Leaves plant^{-1} (no.)				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
$V_1 \times W_1$	6.25 d-i	13.17 p	14.75 k	23.67 l	38.67 j
$V_1 \times W_2$	7.83 ab	28.17 ab	32.92 a-d	37.00 a-g	50.33 b-h
$V_1 \times W_3$	6.17 e-i	21.17 g-k	26.50 fgh	34.33 e-j	49.33 d-h
$V_1 \times W_4$	5.67 hi	22.58 e-h	30.92 b-f	39.33 a-f	49.67 c-h
$V_1 \times W_5$	6.92 b-g	25.10 cd	32.00 a-e	39.67 a-e	49.67 c-h
$V_1 \times W_6$	8.00 ab	24.58 cde	34.00 abc	41.33 abc	50.00 b-h
$V_1 \times W_7$	5.83 ghi	15.83 no	21.75 ij	25.33 kl	40.33 j
$V_1 \times W_8$	6.25 d-i	19.67 jkl	29.33 d-g	34.00 f-j	49.00 e-h
$V_1 \times W_9$	5.17 i	21.83 g-j	32.58 a-e	37.33 a-g	49.67 c-h
$V_1 \times W_{10}$	7.58 abc	28.67 a	36.17 a	41.67 ab	52.67 a-f
$V_2 \times W_1$	7.33 a-d	13.92 op	15.42 k	23.00 l	38.00 j
$V_2 \times W_2$	7.08 a-f	16.42 mn	26.58 fgh	30.67 ijk	45.67 hi
$V_2 \times W_3$	5.83 ghi	16.33 mn	20.50 j	30.00 jk	47.67 fgh
$V_2 \times W_4$	5.17 i	14.58 nop	22.83 hij	31.33 hij	46.33 gh
$V_2 \times W_5$	7.67 abc	18.33 lm	26.17 ghi	34.67 d-j	49.67 c-h
$V_2 \times W_6$	8.08 a	24.83 cde	33.67 a-d	40.67 abc	49.00 e-h
$V_2 \times W_7$	5.50 hi	20.42 h-l	28.08 efg	37.00 a-g	53.00 a-e
$V_2 \times W_8$	5.83 ghi	16.58 mn	26.75 fgh	32.00 g-j	46.33 gh

$V_2 \times W_9$	5.75 hi	21.33 g-k	33.25 a-d	38.33 a-f	54.33 a-d
$V_2 \times W_{10}$	7.92 ab	25.08 cd	34.17 abc	40.00 a-d	55.67 a
$V_3 \times W_1$	5.33 i	12.83 p	15.00 k	24.33 l	41.00 ij
$V_3 \times W_2$	5.83 ghi	24.17 c-f	36.25 a	39.33 a-f	53.33 a-e
$V_3 \times W_3$	5.83 ghi	20.00 i-l	27.17 fgh	37.33 a-g	51.00 a-g
$V_3 \times W_4$	5.50 hi	20.42 h-l	30.08 c-g	40.33 abc	55.00 ab
$V_3 \times W_5$	7.25 a-e	22.17 f-i	25.92 ghi	36.00 c-i	50.00 b-h
$V_3 \times W_6$	8.08 a	24.17 c-f	32.08 a-e	40.00 a-d	51.00 a-g
$V_3 \times W_7$	5.58 hi	19.17 kl	29.42 d-g	36.33 b-h	50.00 b-h
$V_3 \times W_8$	6.00 f-i	23.33 d-g	33.08 a-d	37.67 a-f	52.67 a-f
$V_3 \times W_9$	6.25 d-i	26.00 bc	34.83 ab	39.67 a-e	54.67 abc
$V_3 \times W_{10}$	6.58 c-h	27.58 ab	35.25 ab	42.33 a	54.00 a-e
Level of significance	*	**	**	**	**
CV (%)	10.90	6.72	9.71	9.47	6.43

Note: * indicated significant at 5% level of probability; V_1=CB-15, V_2= CB-hybrid-1 , V_3= Rupali-1; W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS

Node number of first bearing sympodial branch (NFB)

The highest NFB was significantly influenced by the weed interference period (Supplementary Table 3). Results showed that the highest node number of first fruiting branches (7.14) was found in weed interference period of weed free up to 75 DAS which was followed by conditions in season long weed free (7.11) and weed free from 15 to 75 DAS (6.92). On the other hand, the lowest NFB (5.28) was found in season long weedy condition (Table 3). The interaction effect of variety and weed interference period on NFB was not significantly different (Supplementary Table 3 and Table 4).

Monopodial branches plant^{-1}

The effect of weed interference period on monopodial branches plant^{-1} significantly different (Supplementary Table 3). Results revealed that the highest monopodial branches plant^{-1} (2.28) was found under weed free condition followed by weed free up to 75 DAS (2.19). On the other hand, the lowest one (0.97) was recorded with weed free from 15 to 45 DAS which was statistically similar to weed free up to 45 DAS and weed free from 15 to 60 DAS (1.08) (Table 3).

The interaction effect of variety and weed interference period on monopodial branches plant^{-1} was also significant (Supplementary Table 3). Results revealed that the highest monopodial branches plant^{-1} (2.42) was recorded with the variety CB-hybrid-1 under season long weed free which was statistically similar for the treatments of $V_1 \times W_6$ (2.33), $V_1 \times W_2$ and $V_3 \times W_{10}$ (2.25). On the other hand, the lowest one (0.18) was found in treatment $V_2 \times W_1$ followed by $V_1 \times W_7$ and $V_3 \times W_1$of 0.25 (Table 4).

Sympodial branches plant^{-1}

Sympodial branches plant^{-1} was significantly different for the weed interference period (Supplementary Table 3). Results revealed that the highest sympodial branches plant^{-1} (20.31) was recorded with weed interference period in season long weed free condition which was statistically similar to weed free up to 75 DAS (19.97) and weed free from 15 to 75 DAS (19.50). On the other hand, the lowest one was found in season long weedy condition (14.06) followed by weed free up to 30 DAS of 14.89 (Table 3).

The sympodial branches plant^{-1} was also significantly influenced by the interaction of variety and weed interference period (Supplementary Table 3). The highest sympodial branches plant^{-1} (20.58) was observed in the variety CB-15 when weed free up to 75 DAS condition followed by the interactions$V_1 \times W_2$ and $V_3 \times W_2$ (20.50), $V_3 \times W_6$ (20.17) and $V_3 \times W_{10}$ (20.08); and the lowest one (12.25) was recorded with the variety CB-hybrid-1 in season long weedy condition (Table 4).

Secondary fruiting branches plant^{-1}

Secondary fruiting branches plant^{-1}was significantly different for the weed interference period (Supplementary Table 3). Results revealed that significantly the highest secondary fruiting branches plant^{-1} (20.31) was found in season long weed free condition which was statistically identical to weed free up to 75 DAS (10.67). The lowest one was recorded in weed free up to 30 DAS (3.11) followed by weed free from 15 to 45 DAS of 3.50 (Table 3).

Secondary fruiting branches plant^{-1} was also significantly influenced by the interaction of variety and weed interference period (Supplementary Table 3). The highest secondary fruiting branches plant^{-1} (17.33) was observed in the variety CB-hybrid-1 in season long weed free condition followed by treatments $V_1 \times W_6$ and$V_3 \times W_6$ (11.25) whereas, the lowest one (2.50) was produced by the variety CB-15 when weed free from 15 to 45 DAS followed by the treatments $V_2 \times W_1$ and $V_3 \times W_1$ of 2.58 (Table 4).

Days to 50% flowering

Days to 50% flowering was significantly influenced by weed interference period (Supplementary Table 3). Results revealed that the lowest days for flowering (57.11 days) was required for under free up to 45 DAS condition followed by weed free up to 60 DAS (57.33 days) and weed free from 15 to 75 DAS condition (57.78 days) whereas the highest days (89.22 days) was required for season long weedy condition (Table 3).

The interaction effect of variety and weed interference period also significantly influenced by the days to 50% flowering (Supplementary Table 3). Results showed that the lowest days (54.00 days) was required by the variety CB-15 under season long weed free condition followed by the treatments of $V_1 \times W_5$ (55.00 days), $V_1 \times W_3$ and $V_1 \times W_6$ (55.33 days) while the highest one (91.33 days) was recorded with the variety CB-15 under season long weedy condition (Table 4).

Table 3: Number of first fruiting branches plant^{-1} (NFB), number of monopodial branchesplant^{-1}, number of sympodial branches plant^{-1}, number of secondary fruiting branches plant^{-1}, days to 50% flowering and days to 50%boll split of cotton as influenced by weed interference period

Weed interference period	NFB plant^{-1} (no.)	Monopodial branches plant^{-1}(no.)	Sympodial branches plant^{-1} (no.)	Secondary fruiting branches plant^{-1}(no.)	Days to 50% first flowering	Days to 50% boll split
W_1	5.28 d	0.36f	14.06 c	3.42 fg	89.22 a	139.78 a
W_2	7.11 a	2.28 a	20.31 a	11.25 a	56.22 e	111.78 d
W_3	6.22 c	0.64 e	14.89 c	3.11 g	58.22 c	136.67 ab
W_4	6.56 bc	1.08 d	15.75 c	5.22 e	57.11 d	134.78 abc
W_5	6.42 bc	1.82 c	17.89 b	4.86 e	57.33 D	132.67 abc
W_6	7.14 a	2.19 ab	19.97 ab	10.67 b	57.78 cd	131.33 abc
W_7	6.06 c	0.78 e	15.47 c	3.78 f	60.44 b	130.33 abc
W_8	6.25 c	0.97 d	15.47 c	3.50 fg	60.11 b	127.33 bc
W_9	6.31 c	1.08 d	15.64 c	6.11 d	58.33 c	125.22 c
W_{10}	6.92 ab	2.08 b	19.50 ab	9.22 c	57.78 cd	124.00 c
Level of significance	**	**	**	**	**	**
CV (%)	9.12	10.65	13.39	17.84	1.35	8.97

Note:** indicated significant at 5% level of probability;W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS, NFB=Node number of first fruiting branch

Table 4: Interaction effect of variety and weed interference period on number of first fruiting branches plant^{-1}(NFB), number of monopodial branches, number of sympodial branches, number of secondary fruiting branches, days to 50% first flowering and days to 50% boll split of cotton

Variety×weed interference period	NFB plant^{-1} (no.)	Monopodial branches plant^{-1} (no.)	Sympodial branches plant^{-1} (no.)	Secondary fruiting branches plant^{-1}(no.)	Days to 50% first flowering	Days to 50% boll split
V_1×W_1	5.25	0.67 klm	16.33	5.08 gh	89.00 b	138.00
V_1×W_2	6.92	2.25 abc	20.50	8.00 f	54.00 m	128.00
V_1×W_3	6.25	0.50 m	13.92j	3.25 lm	55.33 lm	134.00
V_1×W_4	7.00	1.25 gh	15.25j	7.83 f	56.00 kl	135.00
V_1×W_5	6.58	2.07 cd	19.17	5.25 g	55.00 lm	131.67
V_1×W_6	7.00	2.33 ab	20.58	11.25 b	55.33 lm	131.00
V_1×W_7	6.00	0.25 n	14.33	3.67 jkl	61.00 de	130.00
V_1×W_8	6.17	0.82 jkl	15.00j	2.50 m	59.00 fgh	131.67
V_1×W_9	6.25	0.93 ij	15.08	5.00 ghi	57.33 ijk	129.33
V_1×W_{10}	7.00	1.68 e	19.67	7.83 f	57.00 jk	128.00
V_2×W_1	5.33	0.18 n	12.25	2.58 m	91.33 a	141.00
V_2×W_2	7.08	2.42 a	19.92	17.33 a	57.33 ijk	122.00
V_2×W_3	6.00	0.83 jk	15.33	3.17 lm	60.33 ef	139.00
V_2×W_4	6.25	1.00 ij	15.92	3.67 jkl	58.00 g-j	135.00
V_2×W_5	6.58	1.93 d	17.33	4.17 ijk	58.33 g-j	136.33
V_2×W_6	7.00	2.17 bc	20.17	9.50 cd	60.33 ef	132.33
V_2×W_7	6.17	1.08 hi	18.17	4.33 hij	61.67 de	130.00
V_2×W_8	6.25	0.83 jk	15.67	3.25 lm	59.33 fg	125.00
V_2×W_9	6.58	1.65 ef	16.42	9.17 de	57.33 ijk	122.67
V_2×W_{10}	6.83	2.32 ab	18.75	10.17 c	57.00 jk	122.00
V_3×W_1	5.25	0.25 n	13.58	2.58 m	87.33 c	140.33
V_3×W_2	7.33	2.17 bc	20.50	8.42 ef	57.33 ijk	85.33
V_3×W_3	6.42	0.60 lm	15.42	2.92 lm	59.00 fgh	137.00
V_3×W_4	6.42	1.00 ij	16.08	4.17 ijk	57.33 ijk	134.33
V_3×W_5	6.08	1.45 fg	17.17	5.17 gh	58.67 ghi	130.00
V_3×W_6	7.42	2.07 cd	19.17	11.25 b	57.67 hij	130.67
V_3×W_7	6.00	1.00 ij	13.92	3.33 klm	58.67 ghi	131.00
V_3×W_8	6.33	1.25 gh	15.75	4.75 ghi	62.00 d	125.33
V_3×W_9	6.08	0.67 klm	15.42	4.17 ijk	60.33 ef	123.67
V_3×W_{10}	6.92	2.25 abc	20.08	9.67 cd	59.33 fg	122.00
Level of significance	NS	**	NS	**	**	NS
CV (%)	9.12	10.65	13.39	17.84	1.35	8.97

Notes: * indicates significant at 5% level of significance; NS = not significant; **V_1**=CB-15, **V_2**=CB-hybrid-1 ,**V_3**= Rupali-1; W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS ,NFB=Node number of first fruiting branch

Days to 50% boll split

Days to 50% first boll split was significantly different by the weed interference period (Supplementary Table 3). Results revealed that the lowest days required for first boll split (111.78 days) was observed in season long weed free condition whereas the highest one (139.79 days) was found in season long weedy condition which was statistically similar to weed free up to 30 DAS (136.67 days), weed free up to 45 DAS (134.78 days), weed free up to 60 DAS (132.67

days), weed free up to 75 DAS (131.33 days) and weed free from 15 to 30 DAS (130.33 days) (Table 3). The interaction effect of variety and weed interference period on days to 50% first boll split was not significant (Supplementary Table 3 and Table 4).

Yield contributing characters, yield and biomass of cotton

Aboveground crop biomass of cotton

Weed interference period significantly influenced for aboveground crop biomass of cotton (Supplementary Table 4). Results showed that the highest biomass (19.64 g plant^{-1}) was found under season long weed free condition which was followed by weed free up to 75 DAS (18.79 gplant^{-1}). On the other hand, the lowest one (14.93 g plant^{-1}) was found in weed free from 15 to 30 DAS followed by weed interference period of weed free up to 30 DAS (15.62 gplant^{-1}) (Supplementary Table 4). The aboveground crop biomass of cotton was not significantly affected by the interaction between variety and weed interference period (Supplementary Table 3 and Table 5).

Number of bolls plant^{-1}

The weed interference period was significantly different for bolls plant^{-1} (Supplementary Table 4). Results revealed that the highest number of bolls plant^{-1} (40.28) was recorded with weed free up to 75 DAS condition followed by season long weed free condition (39.00) whereas the lowest one (20.33) was found in weed free up to 30 DAS condition (22.28) followed by weed free from 15 to 45 DAS condition (23.28) (Supplementary Table 4).

Number of bolls plant^{-1}was significantly influenced by the interaction of variety and weed interference period (Supplementary Table 3). Results revealed that the highest number of bolls plant^{-1} (42.08) was found in variety CB-15 under weed free up to 75 DAS condition followed by the treatment of $V_2 \times W_2$ (41.25) whereas the lowest one (10.42) was found in the variety CB-hybrid-1 in season long weed free condition which was statistically similar to Rupali-1 under weedy condition (Table 5).

Single boll weight

The weed interference period significantly affected single boll weight (Supplementary Table 4). The season long weed free condition produced the highest boll weight (5.61 g) which was statistically similar (5.17 g) to weed free from 15 to 75 DAS whereas the lowest one (4.61 g) was found in season long weed free from 15 to 30 DAS followed by season long weedy condition (4.67 g). Boll weight was not significantly different for the interaction of variety and weed interference period (Supplementary Table 4 and Table 5).

Seed cotton yield

Significant difference was observed for weed interference period regarding seed cotton yield (Supplementary Table 3). The highest seed cotton yield (3.83t ha^{-1}) was recorded with under season long weed free condition which was statistically similar to weed free up to 75 DAS (3.81 t ha^{-1}); and the lowest one (0.58t ha^{-1}) was observed in season long weedy condition (Supplementary Table 3).

The interaction effect of cotton variety and weed interference period was also significantly influenced the seed cotton yield (Supplementary Table 4). Results revealed that the highest seed cotton yield (4.00 t ha^{-1}) was found in the varietiesCB-15 and Rupali-1 under season long weed free condition and weed free up to 75 DAS, respectively followed by the variety CB-hybrid-1 (3.99 t ha^{-1}) and CB-15 (3.75 t ha^{-1}) in season long weed free and weed free up to 60 DAS conditions, respectively. On the other hand, the lowest yield (0.49 t ha^{-1}) was observed in Rupali-1 under season long weedy condition which was statistically similar to CB-hybrid-1 (0.57 t ha^{-1}) and CB-15 (0.67 t ha^{-1}) under season long weedy condition (Table 5).

Table 5: Interaction effect of variety and weed interference period on aboveground plant biomass plant^{-1}, number of bolls plant^{-1}, single boll weight and seed cotton yield of cotton

Variety ×weed interference period	Biomass plant^{-1} (g)	Bollsplant^{-1}(no.)	Single boll weight (g)	Seed cotton yield (t ha^{-1})
$V_1 \times W_1$	1.75	14.15 lm	4.67	0.67 l
$V_1 \times W_2$	18.82	39.67 abc	5.83	4.00 a
$V_1 \times W_3$	19.93	18.67 kl	5.00	1.75 j
$V_1 \times W_4$	15.64	26.25 fgh	5.17	1.11 k
$V_1 \times W_5$	16.67	37.00 bcd	4.92	3.75 ab
$V_1 \times W_6$	17.88	42.08 a	4.50	4.00 a
$V_1 \times W_7$	18.55	27.75 fg	4.67	2.50 fg
$V_1 \times W_8$	14.88	24.83 f-i	4.83	2.17 g-j
$V_1 \times W_9$	15.38	26.00 fgh	5.08	2.37 fgh
$V_1 \times W_{10}$	16.42	34.00 d	5.08	3.42 bcd
$V_2 \times W_1$	2.13	10.42 m	4.83	0.57 l
$V_2 \times W_2$	17.72	41.25 ab	5.33	3.99 a
$V_2 \times W_3$	18.75	28.17 ef	5.00	1.83 ij
$V_2 \times W_4$	15.32	36.67 bcd	4.67	3.17 cd
$V_2 \times W_5$	16.42	37.50 a-d	4.58	3.00 de
$V_2 \times W_6$	18.08	39.08 abc	4.92	3.42 bcd
$V_2 \times W_7$	18.75	27.83 f	4.42	2.33 fgh
$V_2 \times W_8$	14.82	22.17 h-k	4.50	2.49 fg
$V_2 \times W_9$	15.50	28.17 ef	4.67	2.67 ef
$V_2 \times W_{10}$	16.33	35.58 cd	4.83	3.50 bc
$V_3 \times W_1$	1.58	10.50 m	4.50	0.49 l
$V_3 \times W_2$	19.56	36.08 cd	5.67	3.50 bc
$V_3 \times W_3$	20.25	20.00 jk	4.75	1.17 k
$V_3 \times W_4$	15.92	32.92 de	4.92	2.20 ghi
$V_3 \times W_5$	16.67	34.17 d	5.08	3.17 cd
$V_3 \times W_6$	17.88	39.67 abc	5.25	4.00 a
$V_3 \times W_7$	19.08	20.50 ijk	4.75	2.00 hij
$V_3 \times W_8$	15.08	22.83 h-k	5.25	2.00 hij
$V_3 \times W_9$	16.83	23.00 g-k	5.08	2.42 fgh
$V_3 \times W_{10}$	17.07	24.33 f-j	5.58	2.57 fg
Level of significance	**NS**	**	**NS**	**
CV (%)	**5.98**	**10.20**	**10.59**	**10.19**

Notes: ** indicates significant at 5% level of significance; NS = not significant; $\mathbf{V_1}$=CB-15, $\mathbf{V_2}$=CB-hybrid-1,$\mathbf{V_3}$= Rupali-1; W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS

Ginning out turn and lint quality parameters

Ginning out turn

The weed interference period significantly affected the GOT% of cotton. Season long weed free condition resulted showed the highest GOT (39.79%) followed by weed free from 15 to 75 DAS (38.05%) and the lowest one (38.00%) was recorded under weedy condition (34.48%) (Figure 10). The ginning out turn was not significantly affected by the interaction of variety and weed interference period (Supplementary Table 5 and Table 6).

Seed index

Significantly variation in seed index of cotton was found among the weed interference periods (Supplementary Table 4). The highest seed index (11.11 g) was found in season long weed free condition which was followed by weed free up to 75 DAS (10.67 g), weed free from 15 to 60 DAS and weed free from 15 to 75 DAS (10.78 g). On the other hand, the lowest one (9.44 g) was observed in season long weedy condition followed by weed free from 15 to 30 DAS (9.89 g) (Supplementary Table 4). Seed index was not significantly affected by the interaction of variety and weed interference period (Table 6 and Supplementary Table 5).

Lint index

The weed interference period significantly influenced for the lint index (Supplementary Table 4). Season long weed free condition resulted the highest lint index (4.31) followed by weed free from 15 to 75 DAS (4.09) while the lowest one (3.25) was found in season long weedy condition (Supplementary Table 4). The lint index was not significantly affected by the interaction of variety and weed interference period (Table 6 and Supplementary Table 5).

Table 6: Interaction effect of variety and weed interference period on ginning out turn, seed index and lint index of cotton

Variety×weed interference period	Ginning out turn (%)	Seed index (g)	Lint index
$V_1 \times W_1$	34.12	9.67	3.29
$V_1 \times W_2$	37.98	11.67	4.43
$V_1 \times W_3$	35.60	10.33	3.67
$V_1 \times W_4$	35.78	10.67	3.82
$V_1 \times W_5$	36.55	10.67	3.89
$V_1 \times W_6$	37.25	11.00	4.09
$V_1 \times W_7$	35.98	10.00	3.59
$V_1 \times W_8$	36.42	11.00	4.01
$V_1 \times W_9$	37.18	11.00	4.09
$V_1 \times W_{10}$	37.90	10.67	4.04
$V_2 \times W_1$	34.20	9.67	3.30
$V_2 \times W_2$	39.23	10.67	4.18
$V_2 \times W_3$	35.15	10.33	3.63
$V_2 \times W_4$	35.92	10.00	3.59
$V_2 \times W_5$	36.05	10.67	3.84
$V_2 \times W_6$	37.10	10.67	3.95
$V_2 \times W_7$	35.02	10.00	3.50
$V_2 \times W_8$	37.12	10.67	3.96
$V_2 \times W_9$	36.38	10.67	3.89
$V_2 \times W_{10}$	37.72	11.00	4.15
$V_3 \times W_1$	35.12	9.00	3.15
$V_3 \times W_2$	39.17	11.00	4.30
$V_3 \times W_3$	36.60	9.33	3.41
$V_3 \times W_4$	37.13	9.33	3.46
$V_3 \times W_5$	37.33	10.00	3.74
$V_3 \times W_6$	36.98	10.33	3.82
$V_3 \times W_7$	37.29	9.67	3.60
$V_3 \times W_8$	37.27	10.00	3.72
$V_3 \times W_9$	37.25	10.67	3.97
$V_3 \times W_{10}$	38.53	10.67	4.11
Level of significance	NS	NS	NS
CV (%)	2.14	6.13	6.42

Notes: NS = not significant; $\mathbf{V_1}$=CB-15, $\mathbf{V_2}$=CB-hybrid-1 and $\mathbf{V_3}$= Rupali-1; W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS

Weed parameters

Weed composition of the experimental field

Nine weed species from five different families were identified in weedy plots comprising four grasses and five broad-leaved. Based on the summed dominance ratio (SDR) values, grass weed *Digitarias onguilaris (Retz.) keol* was the most predominant species (SDR 47.37); *Cynodon dactylon* (L.) Perse merged as second dominant grass weed species (SDR 25.50). Another broad-leaf weed species *Amaranthus spinosus L.* ranked third (SDR 8.71). Among the species, *Euphorbia hirta L.* appeared as the fourth dominant broad-leaved weed (SDR 4.16). Broad leaf weed species *Jussiaea hirta L.* occupied the fifth position (Table 7).

Table 7: Dominant weed species with their relative density (RD), relative dry matter (RDM) and summed dominance ratio (SDR) in the experimental field

No.	Weed name	Scientific name	Family name	Type	RD%	RDM%	SDR
1	Anguli ghas	*Digitaria sanguinalis* (Retz.) koel	Poaceae	Grass	50.96	43.78	47.37
2	Durba	*Cynodondactylon* (L.) Pers	Poaceae	Grass	32.63	18.37	25.50
3	Shama	*Echinochloa crus-galli* (L.) Link	Poaceae	Grass	0.48	1.49	0.98
4	Chagolgasa	*Ageratum conozaides*L.	Poaceae	Grass	1.36	1.11	1.24
5	Shaknote	*Amaranthus viridis* L.	Amaranthaceae	Broadleaf	1.60	3.99	2.80
6	Foska begun	*Physalis heterophylla* Nees	Solanace	Broadleaf	3.69	2.30	3.00
7	Katanote	*Amaranthus spinosus* L.	Amaranthaceae	Broadleaf	2.97	11.77	7.37
8	Asthma	*Euphorbia hirta* L.	Euphorbiaceae	Broadleaf	4.66	9.36	7.01
9	Helencha	*Jussiaea repens* Vahi	Onagraceae	Broadleaf	1.60	7.78	4.69

Weed density

The weed interference period significantly affected the GOT% by the weed density (Supplementary Table 6). Results showed the highest weed density (558.00 m^{-2}) observed in season long weedy condition whereas the weed was absent in season long weed free condition but the lowest one (199.22 m^{-2}) was found in weed free from 25 to 75 DAS (Figure 12). The interaction effect of variety and weed interference period on weed density was not significant (Supplementary Table 5 and Table 8).

Weed dry matter

The weed interference period significantly affected the weed dry matter (Supplementary Table 6). Results revealed that the highest weed dry matter (354.56 g m^{-2}) was found in season long weedy condition whereas, the lowest one (98.44 g m^{-2}) was found in weed free from 15 to 30 DAS condition (Supplementary Table 5).

The interaction effect of variety and weed interference period on weed dry matter was significant (Supplementary Table 5). Results showed that the highest weed dry matter (368.67 g m^{-2}) was recorded with the variety Rupali-1 under season long weedy condition followed by CB-15 in season long weedy condition. On the other hand, the lowest one (97.33 g m^{-2}) was found in the variety CB-15 under weed free condition from 15 to 30 DAS followed by Rupali-1 under weed free condition from 15 to 30 DAS of 99.67 g m^{-2} (Table 8).

Table 8: Interaction effect of cotton variety and weed interference period on weed density and weed dry matter in cotton

Variety ×weed interference period	Weed density(no.m^{-2})	Weed dry matter (g m^{-2})
$V_1 \times W_1$	561.33	361.67 a
$V_1 \times W_2$	0.0000	0.0000 k
$V_1 \times W_3$	192.67	127.00 gh
$V_1 \times W_4$	235.33	135.33 efg

$V_1 \times W_5$	177.00	142.00 ef
$V_1 \times W_6$	208.67	147.67 de
$V_1 \times W_7$	226.67	97.333 j
$V_1 \times W_8$	217.00	110.67 ij
$V_1 \times W_9$	217.33	119.00 hi
$V_1 \times W_{10}$	199.33	125.00 gh
$V_2 \times W_1$	570.67	333.33 b
$V_2 \times W_2$	0.0000	0.0000 k
$V_2 \times W_3$	246.67	125.33 gh
$V_2 \times W_4$	238.00	134.67 efg
$V_2 \times W_5$	226.00	156.33 d
$V_2 \times W_6$	213.00	160.67 cd
$V_2 \times W_7$	235.33	98.333 j
$V_2 \times W_8$	224.00	114.33 hi
$V_2 \times W_9$	223.67	122.67 ghi
$V_2 \times W_{10}$	200.67	127.33 gh
$V_3 \times W_1$	542.00	368.67 a
$V_3 \times W_2$	0.0000	0.0000 k
$V_3 \times W_3$	265.33	135.33 efg
$V_3 \times W_4$	245.00	148.67 de
$V_3 \times W_5$	228.33	161.33 cd
$V_3 \times W_6$	217.00	173.00 c
$V_3 \times W_7$	237.33	99.667 j
$V_3 \times W_8$	235.33	118.00 hi
$V_3 \times W_9$	223.67	122.33 ghi
$V_3 \times W_{10}$	197.67	128.00 fgh
Level of significance	NS	*
CV (%)	10.27	6.26

Note:* indicates significant at 5% level of significance; NS = not significant; $\mathbf{V_1}$=CB-15, $\mathbf{V_2}$=CB-hybrid-1 and $\mathbf{V_3}$= Rupali-1; W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS

DISCUSSION

Effect of weed interference period on growth and yield of cotton

The concept of a critical weed control period (CPWC) can be used to make herbicide use more efficient and to improve the efficiency other weed control procedures. Different researchers have defined CPWC in several ways. It was defined as a time interval between the seed period and the emergence of weed competition, where the crop yield is not reduced and the time after which weed competition will not reduce crop yield (Zimdahl, 1993 and 1988). Therefore, the crop should be free of weeds to prevent crop yield loss during the lowest possible period. Knezevic et al. (2002) described CPWC as a "window" for the cultivar growth cycle, in order to avoid unacceptable losses of yield weed must be monitored. In developing alternative weed management strategies the CPWC is a major concern (Swanton and Weise, 1991). The critical period indicates the timing of the management of weeds and helps to understand the impact of weed populations on the crop. The duration of the weeds' presence and the time of the cultivation in relation to the crop affect both the weed/crop competition (Hall et al., 1992). Critical research during the period is normally done by keeping weed-free crops up before a predetermined time and allowing the weeds for the emergence of weeds and alternatively, by growing with crops for a predetermined time (Nieto et al., 1968). Results from these experiments showed that all the varieties CB-15, CB-hybrid-1 and Rupali-1 produced the highest seed cotton yield in season-long weed-free conditions but this variety produced the highest seed cotton yield as weed interference period of weed-free up to 75 DAS. This line is marked by Papamichail et al. (2002) who said that the critical competition from the cotton mixed weeds began at 3–5 WAE and continued until the 11 WAE, with the aim of preventing a decrease in cotton growth and yield.

The total dry weight of weeds increased as the duration of the weed-infested period increased. The highest total dry weed weight was recorded in variety Rupali-1 when weed-free up to 75 days after sowing. Results may be attributed to the increased weed density and differences in weed species proportions. Total weed dry weight in all growing seasons decreased with the increasing duration of the weed-free period. High cotton plants produced with weeds have been reduced in all treatments, with prolonged weed disposal delays. Conversely with the increasing duration of the weed-free period in all treatments, cotton plants grew in height. Similar results were found in Bukun (2004). Total dry weed weight increased with time before weed removal.

Above-ground biomass is a very important growth character. An ideal range of plant density can effectively sustain individual growth and improve the canopy structure (CRI, 2013). In the present study, the biological yield (above-ground biomass) increased with increasing plant density in cotton crops. These results were consistent with previous findings that high plant density increased total biomass yield, while the final reproductive allocation was usually stable with increasing plant density; thus, the total biological yield from low to high density was the determinant of seed cotton yield formation (Ali et al., 2009; Boquet, 2005; Dai et al., 2015). A high harvest index means more reproductive photosynthesis, usually leading to high yields, but the weed competition was reduced because of excessive vegetative growing and reduced lint yield due to increased plant densities (Ali et al., 2009). Dong et al. (2010) achieved higher lint yield with the ratio of seed cotton to stalk increasing within a given range of plant densities. Present findings suggested that the weedy plot resulted the low plant density was inversely related to the final seed cotton yield, and it was significantly higher than that at medium to super-high plant densities. Since a similar seed cotton yield was achieved and plant biomass increased at medium to super-high density in full-season cotton, or at high to super-high plant density in short-season cotton, seed cotton yield stability was mainly determined by the ratio of biomass allocation to reproductive tissues under adequate biomass production. Results confirmed previous reports that economic yield is dependent on biomass accumulation, and effective partitioning of assimilates to the reproductive organs is the key factor for increasing seed cotton yield (Bange and Milroy, 2004; Dai et al., 2015).

Results of weed interference agree that cotton production has a positive correlation with the weed-free period following crop emergence, as seen in (Snipes et al., 1987; Keely and Thullen, 1993; Vencill et al., 1993; Oliver and Klingman, 1994; Papamichail et al., 2002). The critical period of *S. halepense* has been reported by Bridges and Chandler (1987) for up to 6 weeks following the formation of cotton. Cotton has proved to require 6 or 9 weeks weed-free to maximize outputs for a mixed population of weeds (Buchanan et al., 1980; Bryson, 1987; Vencill et al., 1993). Similarly higher plant height and height growth rates were observed at the weed-free conditions as compared to the weedy conditions which might be the outcome of higher inter-specific interference in presence of weeds. Present findings revealed that all the yield components were positively influenced by herbicide application and severely reduced due to season-long weed free interference. Our results are well consistent with those of Hasanuzzaman et al. (2008) and Mamun et al. (2011) who partly agreed and noticed that herbicide treatments had a significant effect on all yield components with the exception of a thousand seed weights. Thus reactions to herbicide treatments are different for the rice yield components. Pacanoski and Glatkova (2009) were of the opinion that improved weed control has led to increased participation of rice yields, resulting in increased yields of grain.

CONCLUSION

Weed interference period showed remarkable effect on plant growth, yield attributes and yield of upland cotton. Keeping the cotton field weed-free up to 60 days after sowing (DAS) was found necessary to get the highest yield which is similar to season long weed-free condition. Removing weeds after 60 DAS brings no advantage in terms of cotton yield.

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Table S1: Plant height of cotton as influenced by weed interference period at different days after sowing

Weed interference period	Plant height (cm)				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
Season long weedy	10.06 c	18.69 e	57.98 d	83.72 c	102.89 d
Season long weed free	21.03 a	77.56 ab	99.35 a	111.19 a	129.17 c
Weed free up to 30 DAS	18.92 b	63.36 d	83.67 c	101.44 b	108.19 d
Weed free up to 45 DAS	19.14 b	63.67 d	90.06 bc	104.06 ab	134.19 abc
Weed free up to 60 DAS	20.39 ab	70.83 c	89.94 bc	110.11 ab	136.17 ab
Weed free up to 75 DAS	21.58 a	79.92 a	97.83 ab	110.81 a	128.75 c
Weed free from 15 to 30 DAS	19.22 b	62.64 d	85.44 c	105.86 ab	128.67 c
Weed free from 15 to 45 DAS	19.08 b	61.92 d	86.36 c	105.48 ab	130.33 bc
Weed free from 15 to 60 DAS	19.44 b	73.67 c	88.92 bc	107.39 ab	134.33 abc
Weed free from 15 to 75 DAS	21.25 a	76.72 b	96.92 ab	109.92 ab	138.25 a
Level of significance	**	**	**	**	**
CV (%)	8.27	4.80	11.17	10.01	5.28

Note: ** = Significant at 5% level of probability. Within a column, means sharing same alphabets are not significantly different at P=0.05 probability level according to least significant difference test

Table S2: Number of leaves per plant of cotton as influenced by weed interference period at different days after sowing

Weed interference period	**Leaves plant^{-1}(no.)**				
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**150 DAS**
Season long weedy	6.31 cd	13.31 f	15.06 g	23.67 e	39.22 d
Season long weed free	6.92 bc	22.92 c	31.91 bc	35.67 bcd	49.78 c
Weed free up to 30 DAS	5.94 de	19.17 de	24.72 f	33.89 cd	49.33 c
Weed free up to 45 DAS	5.44 e	19.19 de	27.94 de	37.00 bc	50.33 bc
Weed free up to 60 DAS	7.28 b	21.87 c	28.03 de	36.78 bc	49.78 c
Weed free up to 75 DAS	8.06 a	24.53 b	33.25 ab	40.67 a	50.00 bc
Weed free from 15 to 30 DAS	5.64 e	18.47 e	26.42 ef	32.89 d	47.78 c
Weed free from 15 to 45 DAS	6.03 de	19.86 d	29.72 cd	34.56 cd	49.33 c
Weed free from 15 to 60 DAS	5.72 de	23.06 c	33.56 ab	38.44 ab	52.89 ab
Weed free from 15 to 75 DAS	7.36 b	27.11 a	35.19 a	41.33 a	54.11 a
Level of significance	**	**	**	**	**
CV (%)					

Note: ** = Significant at 5% level of probability. Within a column, means sharing same alphabets are not significantly different at P=0.05 probability level according to least significant difference test

Table S3: Analysis of variance (mean square) of the data for growth parameters and yield component traits of cotton

Source of variation	DF	NFB plant^{-1} (no.)	Monopodial branches plant^{-1}(no.)	Sympodial branches plant^{-1}(no.)	Secondary fruiting branches plant^{-1}(no.)	Days to 50% flowering	Days to 50% boll split	Number of bolls plant^{-1}(no.)	Boll weight (g)	Seed cotton yield (t ha^{-1})	Biomass plant^{-1} (g)
Replication	2	0.089	0.033	3.936	3.534	0.578	163.511	35.753	0.929	0.020	0.118
Varieties (V)	2	0.008^{NS}	0.285**	0.779^{NS}	13.817**	42.178**	273.144^{NS}	140.085**	0.734^{NS}	0.926**	2.885*
Weed interferen	9	2.778**	4.402**	47.899**	87.136**	883.927**	566.130**	694.072**	0.701**	9.333**	234.005**

ce period (W)											
V×W	18	0.157^NS	0.272**	4.487^NS	16.111**	7.264**	167.441^NS	29.458**	0.171^NS	0.551**	0.543^NS
Error	58	0.34318	0.020	5.116	1.238	0.681	134.569	8.567	0.274	0.067	0.876

Table S4: Effect of weed interference period on aboveground crop biomass, number of Bolls, single boll weight, seed cotton yield, ginning out turn (GOT), seed index and lint index of cotton

Weed interference period	**Biomass plant^{-1}(g)**	**Bolls plant^{-1}(no.)**	**Single boll weight (g)**	**Yield (t ha^{-1})**	**GOT (%)**	**Seed index (g)**	**Lint index**
W_1	1.82 f	11.69 f	4.67 c	0.58 f	34.48 g	9.44 e	3.25 f
W_2	19.64 a	39.00 a	5.61 a	3.83 a	38.79 a	11.11 a	4.31 a
W_3	15.62 de	22.28 e	4.92 bc	1.59 e	35.78 f	10.00 cde	3.57 e
W_4	16.59 c	31.94 c	4.92 bc	2.16 d	36.28 def	10.00 cde	3.62 de
W_5	17.95 b	36.22 b	4.86 bc	3.31 b	36.64 cde	10.44 bcd	3.83 cd
W_6	18.79 ab	40.28 a	4.89 bc	3.81 a	37.11 c	10.67 ab	3.96 bc
W_7	14.93 e	25.36 d	4.61 c	2.28 cd	36.09 ef	9.89 de	3.57 e
W_8	15.91 cd	23.28 de	4.86 bc	2.22 d	36.93 cd	10.56 abc	3.89 bc
W_9	16.61 c	25.72 d	4.94 bc	2.49 c	36.94 cd	10.78 ab	3.98 bc
W_{10}	18.69 b	31.31 c	5.17 ab	3.16 b	38.05 b	10.78 ab	4.09 ab
Level of significance	**	**	**	**	**	**	**
CV (%)	**5.98**	**10.20**	**10.59**	**10.19**	**2.14**	**6.13**	**6.42**

Note: ** = Significant at 5% level of probability. Within a column, means sharing same alphabets are not significantly different at P=0.05 probability level according to least significant difference test;
W_1= Season long weedy, W_2= Season long weed free, W_3= Weed free up to 30 DAS, W_4= Weed free up to 45 DAS, W_5= Weed free up to 60 DAS, W_6= Weed free up to 75 DAS, W_7= Weed free from 15 to 30 DAS, W_8= Weed free from 15 to 45 DAS, W_9= Weed free from 15 to 60 DAS and W_{10}= Weed free from 15 to 75 DAS

Table S5: Analysis of variance (mean square) of the data for lint qualities and weed parameters of cotton

Source of variation	DF	Ginning out turn (%)	Seed index (g)	Lint index	Weed density (no. m^{-2})	Weed dry matter (g m^{-2})
Replication	2	11.031	1.633	0.045	506.00	11.70
Varieties (V)	2	7.025**	3.433**	0.206*	2249.00*	737.90**
Spacing (S)	9	12.813**	2.372**	0.851**	162199.00**	69251.70**
Varieties ×Spacing (V×S)	18	0.642^NS	0.223^NS	0.024^NS	635.00^NS	159.20*
Error	58	0.619	0.403	0.059	575.00	76.70

Table S6: Effect of weed interference period on weed density and weed dry matter

Weed interference period	Weed density (no. m^{-2})	Weed dry matter (g. m^{-2})
Season long weedy	558.00 a	354.56 a
Season long weed free	0.0000 f	0.0000 g
Weed free up to 30 DAS	234.89 bc	129.22 d
Weed free up to 45 DAS	239.44 b	139.56 c
Weed free up to 60 DAS	210.44 de	153.22 b
Weed free up to 75 DAS	212.89 cde	160.44 b
Weed free from 15 to 30 DAS	233.11 bc	98.444 f
Weed free from 15 to 45 DAS	225.44 bcd	114.33 e
Weed free from 15 to 60 DAS	221.56 b-e	121.33 de
Weed free from 15 to 75 DAS	199.22 e	126.78 d
Level of significance	**	**
CV (%)	10.27	6.26

Note: ** = Significant at 5% level of probability. Within a column, means sharing same alphabets are not significantly different at P=0.05 probability level according to least significant difference test