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Evaluation of weed competitiveness of selected upland cotton varieties of Bangladesh

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ABSTRACT

This study evaluates the weed competitiveness of selected upland cotton (*Gossypium hirsutum* L.) varieties in Bangladesh, aiming to identify cultivars with superior ability to suppress weed growth and thus enhance crop yield. We evaluated the weed competitiveness of eighteen upland cotton varieties in Bangladesh, including CB-1, CB-2, CB-3, CB-4, CB-5, CB-6, CB-7, CB-8, CB-9, CB-10, CB-11, CB-12, CB-13, CB-14, CB-15, CB-hybrid-1, Rupali-1, and DM-2. The experiment was conducted under two weed regimes: season-long weed-free and season-long weedy, using a Randomized Complete Block Design (RCBD) with three replications. Results indicated significant variability in yield and weed competitiveness among the varieties, although fiber quality remained consistent across all varieties. Rupali-1 emerged as the highest-yielding variety, while CB-15 demonstrated superior weed competitiveness.. These findings highlight the importance of selecting appropriate cotton varieties as part of integrated weed management strategies to enhance sustainable cotton production in Bangladesh. The study suggests potential varietal selection strategies for optimizing cotton production in weed-prone areas of Bangladesh.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fiber crop as well as raw materials for textile industry. As a cash crop it also contributes to the economy of many cotton growing countries. The USA, India, China, Australia and the Middle East are the major countries of cotton production.

In the year 2021, Bangladesh imported 8.1 million bales raw cotton for the textile industry (BTMA, 2022) which contributes more than 12% in GDP. Backward and forward linkage industries employ more than 5 million people where 80% are female. Bangladesh has produced 0.177 million bales fibre and 700 metric tons cottonseed oil in 2020-21, which fulfilled around 3% requirement and rest was imported from East and West Africa, India, CISs, USA, Australia (BTMA, 2021; CDB, 2021). Bangladesh is the highest raw cotton importers and second fibre cotton consumer in the world (BCA, 2021). Base line survey report (Bangladesh Bank, 2020), mentions that cotton is grown in Bangladesh in around 44430 hectares of land in different districts during 2020-21.

Cotton production challenges of Bangladesh include its long duration, competition with other high value crops, high input cost, erratic rainfall, price volatility, return after long time, lack of modern ginning facilities, lack of cotton quality grading system and lack of farmers friendly marketing policy (Farid and Mortuza, 2020). In Bangladesh, present domestic requirement of raw-cotton is 11.50 million bales against the production of only 0.177 million bales from 42850 ha of land which accounts for only 3% of the annual requirement (CDB, 2021; BTMA, 2022).

Weed competition has a major effect on the production of upland cotton, which is an important crop in Bangladesh. Significant production

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decreases are caused by weed competition with cotton plants for essential resources like light, water, and nutrients (Berger et al., 2015; Nalini et al., 2015). Since weeds have historically been known to interfere with agricultural productivity, controlling them has been a problem for as long as agriculture (Ghersa et al., 2000). The co-evolution of weed management techniques and agro-ecosystems has been fueled by this (Ghersa et al., 2000). According to Nadeem et al. (2013), weed infestation is still a significant risk factor for cotton production, especially since cotton grows more slowly in its early stages and is consequently less competitive with weeds (Oad et al., 2017).

Weeds have a significant negative effect on cotton yields by competing for essential resources such as water, light, and nutrients, ultimately leading to a substantial decrease in yields (Berger et al., 2015; Nalini et al., 2015). The challenge of weed management is as old as agriculture itself, with farmers historically recognizing the detrimental impact of weeds on crop productivity (Ghersa et al., 2000). This understanding has driven the co-evolution of agro-ecosystems and weed management practices (Ghersa et al., 1994). Weed infestation remains a critical risk factor in cotton production (Nadeem et al., 2013). Cotton, which grows slowly during its early stages, is particularly vulnerable to weed competition (Oad et al., 2017).

On average, weeds can reduce seed cotton yield by 30 percent (Mushtaq and Cheema, 2008). While weed infestation does not affect cotton's qualitative attributes, it significantly impacts yield, as observed by Prabhu (2010). Muhammad et al. (2013) noted that weedy conditions reduced seed cotton weight per boll, seed index, seed cotton output, and cotton ginning outturn compared to other treatments.

The objective of this study is to recognize promising weed-competitive upland cotton varieties, assess the variation in weed competitiveness among the selected varieties, and identify specific varieties that demonstrate superior weed competitiveness. However, this study aims to evaluate the weed competitiveness of selected upland cotton varieties in Bangladesh, identifying those that can maintain higher yields despite weed pressure. This will inform strategies for optimizing cotton production in weed-prone areas through varietal selection.

MATERIALS AND METHODS

Experimental site

The experiments were conducted at Cotton Research Station (CRS), Cotton Development Board (CDB), Mahigonj, Rangpur. The experimental site is situated between latitudes $25^o25'$ N and $25^o44'$ N and longitudes $89^o16'$E and $89^o44'$E at about 32.61m above the sea level. The site is situated at the center of the Agro-Ecological Zone ‘Tista Meander Flood Plain (AEZ 3). This tract spreads over the most of greater Rangpur, eastern part of Dinajpur, northern Bogura and part of Jaipurhat, Noagoan and Rajshahi districts of Bangladesh covering an area of about 9464 km^2 (BARC, 2005).

Soil status of the experimental field

The soil of the experimental site, belongs to the Tista Meander Flood Plain, was different from the other tracts of the country due to its undulating topography. It comprises about 35% high land and 55% medium highland which stand above the normal flooding level. The soils are loamy texture at the top and porous silt loams with K-bearing minerals are medium. The soil pH ranges from 4.8 to 6.5, organic matter 1.55 to 1.82%, nitrogen 0.057 to 0.189 %, phosphorus level 4.21 to 92.55 ppm, potash level 0.09 to 0.40 meq /100g soil, sulphur level 0.64 to 68.61ppm, zinc level 1.02 to 3.62 ppm and boron level 0.001 to 1.40 ppm (SRDI, 2019).

The experiment

The experiment was conducted following a randomized complete block design (RCBD) with three replications. The unit plot size was 4.5 m × 3.6 m maintain in grow to row distance of 90 cm and plant to plant distance of 45 cm with 1.0 m distance between plots and 2.0m wide space between blocks. Thirty six treatment combinations were allocated randomly in each block. All together there were 108 plots in the experiment. Two factors were involved in the experiment. Eighteen (18) cotton varieties (V) were considered as Factor A and 2 weeding interference (W) such as season long weedy (W_1) and season long weed free (W_2) were considered as Factor B. The cotton varieties are CB-1 (V1), CB-2 (V2), CB-3 (V3), CB-4 (V4), CB-5 (V5), CB-6 (V6), CB-7 (V7), CB-8 (V8), CB-9 (V9), CB-10 (V10), CB-11 (V11), CB-12 (V12), CB-13 (V13), CB-14 (V14), CB-15 (V15), CB-hybrid-1 (V16), Rupali-1 (V17) and DM-2 (V18).

Land preparation and fertilizers application

The experimental land was well prepared by deep ploughing and cross ploughing several times with a tractor drawn plough followed by harrowing and laddering to have a good tillage. The experimental land was acidic in nature. So, liming was done 25 days before planting by using Dolochun {CaMg $(CO_3)_2$} at the rate of 1ton ha^{-1}. Urea, triple super phosphate, muriate of potash (MoP), Gypsum, zinc sulphate, magnesium sulphate and borax were applied, respectively as the nutrients source of N, P_2O_5, K_2O, S, Zn, Mg and B. The whole amount of fertilizers except urea and MoP were applied excluding the final land preparation. Urea and MoP were applied in basal and also at 20, 40 and 60 DAS. Well-decomposed cowdung @10ton ha^{-1} were also applied before final land preparation. The amount of manures and fertilizers (Table 1) used in the experiment as per recommendation by Cotton Development Board (CDB, 2020).

Table 1: Fertilizers and manure applied for the experimental field

Manures and Fertilizers	Dose ha^{-1}	Application			
		Final land preparation	1st installment	2^{nd}installment	Final installment
Cow dung	10 ton	10 ton	--	--	--
Urea	260 kg	50 kg	100 kg	50 kg	60 kg
Triple super phosphate	266 kg	266 kg	--	--	--
Muriate of potash	316 kg	100 kg	100 kg	66 kg	50 kg
Gypsum	100 kg	100 kg	--	--	--
Zinc sulphate	22 kg	22 kg	--	--	--
Magnesium sulphate	22 kg	22 kg	--	--	--
Borax	22 kg	22 kg	--	--	--

Seed rate and planting

The seed of cotton varieties were defuzzed and treated by Actara @ 5 g kg^{-1}seed and then sown at 01 Agusut 2017 on @ 2-3 seeds hill $^{-1}$ using a seed rate 10 kg ha^{-1}. Seeds were placed in pits to a depth of 4-5 cm and covered with loose soil. The seedlings of different varieties emerged between 4-6 days after sowing.

Intercultural operations

Different management practices were followed during the crop growing period. Where there is no seed germinated in a pit, gap filling was done at 7 days after sowing (DAS) for getting optimum crop stand. Final thinning was done when most seedlings reached at 2-true leaf stage by retaining only one healthy seedling per pit. Three weedings were done at 20, 40 and 60 DAS. Earthing up was done at the time of last weeding (60 DAS). In case of season long weedy, irrigation was given before flowering and boll formation for optimizing the vegetative growth of cotton for the all-experimental plots equally. Proper drainage was done in excess of water from rainfall and also necessary irrigation was provided in the experimental plot.

Protection against insects and diseases

At early stage of growth, few worms (*Agrotis ipsilon*) infested the young plants and at later stage of growth, pod borer (*Maruca testulalis*) attacked the crop. Emamectin benzoates (0.5 g L^{-1}) were sprayed as alternate for two times at 15 days intervals after seedlings germination to control the insects. Imidacloropid @ 3gm kg^{-1} was applied as alternate to control Aphid/Jassid and Cypermethrin @ 1.1 L ha^{-1} was sprayed against boll worms. Five sprays were done to protect the crop from the boll worm of cotton. Fungicide Carbendazim @ 1 g L^{-1} of water was applied at early stage and boll formation stage to protect cotton plants from fungal infestation.

Seed cotton harvest

Seed cotton was harvested by three hand pickings at full maturity of bolls at 15-day intervals beginning from the last week of November. Harvested seed cotton was sun dried, weighed and yield was converted to ton ha^{-1}.

Data collection

Data were recorded on Growth parameters of cotton (plant height, number of leaves $plant^{-1}$, number of monopodial branches $plant^{-1}$, number of sympodial branches $plant^{-1}$, number of secondary fruiting branches $plant^{-1}$, aboveground biomass $plant^{-1}$) yield attributes and yield of cotton (number of bolls $plant^{-1}$, Days to 50% flowering, Days to 50% boll split, Single boll weight, Seed cotton yield, Relative yield loss due to weed influence), Ginning and lint quality parameters (Ginning out turn –GOT, Fiber length, Fiber strength, Uniformity index, Micronaire, Seed index, Lint index), Weed parameters (Weed density, Weed dry matter, Summed dominance ratio).

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 attributes of cotton

Plant height

The weeding regime significantly (P=0.05) affected the plant height of cotton at all observations except at 30 DAS. At 60, 90, 120 and 150 DAS, taller plants (60.18 cm, 69.90 cm, 111.47 cm and 128.59 cm, respectively) were observed under weed free condition and shorter one (30.58 cm, 38.52 cm, 78.23 cm and 116.43 cm, respectively) were found in season long weedy condition (Figure 1).

The effect of interaction of variety and weeding regime on plant height was significantly different only at 120 and 150 DAS (Table 2). At 120 DAS, variety CB-11 produced the tallest plant (116.03 cm) in season long weed free condition followed by CB-14 (115.22 cm), CB-hybrid-1 (114.67 cm) and DM-2 (114.42 cm), whereas the shortest plant (60.00 cm) was obtained from CB-hybrid-1 under weedy condition. At 150 DAS, the tallest plant (152.67 cm) was found in the variety CB-1 under weed free condition and the shortest one (93.33 cm) was recorded with CB-9 followed by CB-11 (94.00 cm) in season long weedy condition (Table 2).

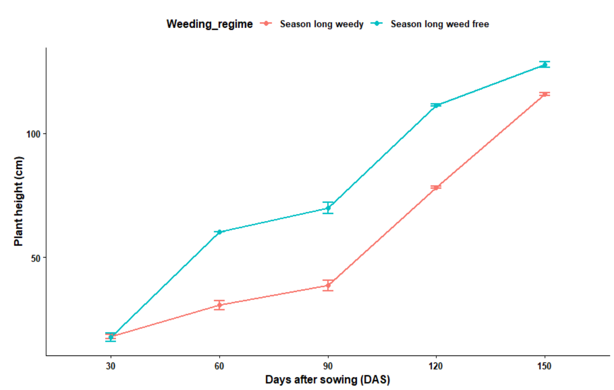

Figure 1: Plant height of cotton as influenced by weeding regime at different days after sowing. The bars indicate the values (means ± SD).

Number of leaves plant^{-1}

The weeding regime significantly (P=0.05) influenced number of leaves $plant^{-1}$ at all observations. Season long weed free condition produced significantly higher number of leaves $plant^{-1}$ than weedy condition. Higher number of leaves $plant^{-1}$ (6.52) was found in season long weed free condition at 30 DAS while the lower one (5.38) was found under weedy condition. At

60 DAS, the weed free condition resulted in the higher number of leaves plant^{-1} (12.92) than weedy condition weedy condition. Higher number of leaves plant^{-1} (22.56) was also observed in season long weed free condition at 90 DAS while the lower one (5.59) was found in the season long weedy condition. At 120 DAS, the higher number of leaves plant^{-1} (149.33) was found in season long weed free condition whereas only 49.88 leaves plant^{-1} was observed in weedy condition. Higher number of leaves plant^{-1} (155.73) was also observed in season long weed free condition at 150 DAS compared to season long weedy condition (55.80) (Figure 2).

Table 2: Interaction effect of variety and weeding regime on plant height of cotton at different days after sowing

Variety× weeding regime	Plant height (cm)				
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**150 DAS**
CB-1×Weedy	17.42	28.58	36.58	82.40 j	124.00 hi
CB-1×Weed free	17.33	57.92	71.50	110.67 f	152.67 a
CB-2×Weedy	21.50	28.58	37.25	75.92 l	113.00 l
CB-2×Weed free	18.25	62.08	74.50	110.33 f	121.00 ij
CB-3×Weedy	17.75	31.83	41.83	75.87 l	121.00 ij
CB-3×Weed free	14.42	58.08	66.17	110.58 f	139.67 b
CB-4×Weedy	18.17	26.83	37.08	89.53 h	121.33 hij
CB-4×Weed free	19.42	48.25	69.08	112.11 c-f	134.00 cde
CB-5×Weedy	20.00	32.75	39.17	71.55 mn	112.00 l
CB-5×Weed free	17.00	68.25	74.25	113.55 a-e	132.00 def
CB-6×Weedy	18.92	34.25	38.50	79.87 k	118.00 jk
CB-6×Weed free	16.67	63.83	67.83	110.67 f	129.00 fg
CB-7×Weedy	16.17	24.33	34.25	84.70 ij	110.00 lm
CB-7×Weed free	16.67	54.08	58.75	105.08 g	121.00 ij
CB-8×Weedy	16.17	25.75	34.92	85.13 i	129.00 fg
CB-8×Weed free	17.58	62.25	70.92	111.78 def	105.00 n
CB-9×Weedy	18.50	33.17	39.67	89.58 h	93.33 p
CB-9×Weed free	19.58	63.33	72.00	110.58 f	106.00 mn
CB-10×Weedy	15.75	25.42	33.58	70.53 n	114.00 kl
CB-10×Weed free	15.17	61.25	69.25	102.88 g	124.00 hi
CB-11×Weedy	18.08	25.17	34.42	90.15 h	94.00 p
CB-11×Weed free	18.75	56.50	66.83	116.03 a	105.00 n
CB-12×Weedy	15.83	32.92	40.17	64.95 o	122.00 hij
CB-12×Weed free	16.92	60.67	68.25	110.17 f	137.33 bc
CB-13×Weedy	17.00	30.50	39.25	66.17 o	118.00 jk
CB-13×Weed free	16.42	65.50	73.83	113.50 a-e	135.33 cd
CB-14×Weedy	19.42	32.75	40.75	70.08 n	132.00 def
CB-14×Weed free	18.25	59.17	69.42	115.22 ab	140.33 b
CB-15×Weedy	17.33	32.17	38.83	73.33 lm	130.00 ef
CB-15×Weed free	18.58	67.42	72.25	111.28 ef	129.00 fg
CB-hybid-1×Weedy	18.33	36.08	43.67	60.00 p	132.00 def
CB-hyb-1×Weed free	16.75	64.42	72.25	114.67 abc	125.00 ghi
Rupali-1×Weedy	17.00	34.17	43.00	90.17 h	112.00 l
Rupali-1×Weed free	20.83	56.67	71.17	112.98 b-f	125.33 gh
DM-2×Weedy	18.75	35.25	40.50	88.25 h	100.00 o
DM-2×Weed free	17.17	53.75	70.00	114.42 a-d	137.33 bc
Level of significance	**NS**	**NS**	**NS**	**	**
CV (%)	**14.81**	**10.81**	**13.24**	**1.61**	**2.09**

NS=Not significant; **= Significant at 5% level of probability and within a column, means sharing same alphabets are not significantly different at P=0.05 probability level according to least significant difference test

The interaction effect of variety and weeding regime on number of leaves plant^{-1} was also significant at different days after sowing except at 30 DAS (Table 3). At 60 DAS, variety CB-4 produced the highest number of leaves plant^{-1} (20.75) in season long weed free condition whereas, the lowest one was recorded with the variety CB-1 (3.83) under weedy condition followed by CB-6 (4.25), CB-hybrid-1 (4.33) and CB-7 (4.42). Under weed free condition at 90 DAS, the maximum number of leaves plant^{-1} (32.25) was recorded with CB-5 while the lowest one (4.25) was observed in the variety CB-11 under weedy condition followed by CB-1, CB-7and CB-15 produced similar number of leaves (4.58). At 120 DAS, the highest number of leaves plant^{-1} (154.50) was obtained from the variety CB-1 under weed free condition while the lowest one (46.50) was found in CB-12 followed by CB-6 (47.42) and CB-7 (47.62) under weedy condition. Under season long weed free condition, variety CB-4 produced the maximum number of leaves plant^{-1} (157.78) at 150 DAS followed by CB-12 (156.98) and the lowest one (53.87) was recorded with CB-6 under weedy condition (Table 3).

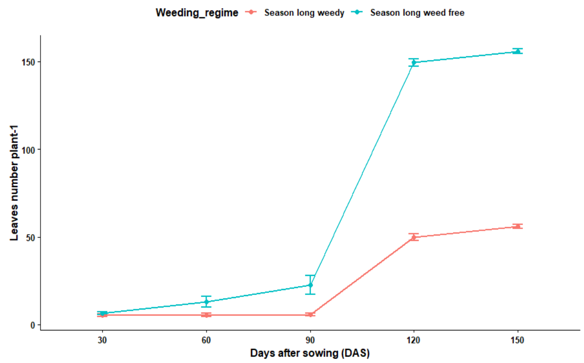

Figure 2: Number of leaves plant^{-1}of cotton as influenced by weeding regime at different days after sowing

Table 3: Interaction effect of variety and weeding regime on number of leaves plant^{-1} of cotton at different days after sowing

Variety×weeding regime	Leaves plant^{-1}(no.)				
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**150 DAS**
CB-1×Weedy	5.33	3.83 n	4.58 h	51.50 hi	55.67 jkl
CB-1×Weed free	7.08	10.00 i	24.58 cd	154.50 a	156.72 a-d
CB-2×Weedy	6.25	5.50 klm	5.58 h	51.83 hi	55.87 jkl
CB-2×Weed free	7.25	13.75 e	23.25 de	148.50 de	156.91 abc
CB-3×Weedy	5.17	5.58 klm	6.08 h	49.92 jk	56.02 i-l
CB-3×Weed free	5.67	10.50 ghi	22.50 def	150.57 c	156.95 abc
CB-4×Weedy	5.92	6.00 jkl	6.17 h	52.50 h	55.75 jkl
CB-4×Weed free	6.75	20.75 a	20.42 f	152.48 b	157.78 a
CB-5×Weedy	6.33	7.17 j	5.33 h	50.72 ij	57.02 ij
CB-5×Weed free	6.17	12.08 f	32.25 a	148.58 de	152.85 h
CB-6×Weedy	5.75	4.25 mn	5.33 h	47.42 mn	53.87 m
CB-6×Weed free	6.17	10.67 f-i	28.33 b	146.83 fg	154.87 efg
CB-7×Weedy	4.33	4.42 mn	4.58 h	47.62 mn	55.22 klm
CB-7×Weed free	6.08	11.83 fg	14.83 g	150.42 c	154.70 fg
CB-8×Weedy	5.50	5.08 k-n	5.25 h	51.48 hi	56.45 ijk
CB-8×Weed free	6.75	10.33 ghi	24.58 cd	150.48 c	155.09 efg
CB-9×Weedy	5.50	6.42 jk	6.50 h	48.75 klm	55.42 j-m
CB-9×Weed free	7.42	17.25 b	22.83 de	147.50 efg	155.85 b-f
CB-10×Weedy	5.00	5.00 k-n	5.33 h	49.33 jkl	56.13 ijk
CB-10×Weed free	6.67	13.50 e	26.17 bc	148.17 ef	155.82 b-f
CB-11×Weedy	5.33	5.33 k-n	4.25 h	51.48 hi	55.92 ijkl
CB-11×Weed free	6.17	11.08 f-i	21.33 ef	147.62 efg	155.41 b-g
CB-12×Weedy	4.92	5.42 klm	6.58 h	46.50 n	55.39 j-m
CB-12×Weed free	6.83	11.75 fgh	21.75 ef	148.58 de	156.98 ab
CB-13×Weedy	4.83	5.58 klm	6.25 h	51.55 hi	57.52 i
CB-13×Weed free	6.08	14.42 de	24.67 cd	147.83 efg	156.35 a-e

CB-14×Weedy	5.42	4.75 lmn	6.00 h	48.95 klm	56.15 ijk
CB-14×Weed free	6.75	15.58 cd	27.92 b	150.75 c	156.02 b-f
CB-15×Weedy	5.58	6.50 jk	4.58 h	49.25 jkl	55.99 i-l
CB-15×Weed free	7.08	10.42 ghi	26.25 bc	150.42 c	155.34 c-g
CB-hyb.-1×Weedy	5.00	4.33 mn	5.50 h	49.32 jkl	56.49 ijk
CB-hyb.-1×Weed free	5.50	12.08 f	15.50 g	146.42 g	156.17 b-f
Rupali-1×Weedy	5.58	5.50 klm	6.33 h	48.17 lm	54.46 lm
Rupali-1×Weed free	6.17	16.25 bc	14.17 g	148.50 de	154.15 gh
DM-2×Weedy	5.17	5.75 j-m	6.42 h	51.50 hi	55.07 klm
DM-2×Weed free	6.75	10.25 hi	14.67 g	149.75 cd	155.15 d-g
Level of significance	**NS**	**	**	**	**
CV (%)	**14.78**	**8.80**	**9.06**	**0.9778**	**0.80**

NS=Not significant,*= Significant at 5% level of probability and within a column, means sharing same alphabets are not significantly different at P=0.05 probability level according to least significant difference test

Number of monopodial branches plant^{-1}

The weeding regime significantly (p=0.05) affected the number of monopodial branches plant^{-1} (Table 4). Higher number of monopodial branches plant^{-1} (1.76) was found in season long weed free condition while lower one (1.20) was recorded under weedy condition (Table 4)

The interaction effect of variety and weeding regime on number of monopodial branches plant^{-1} was also significant (Table 6). The highest number of monopodial branches plant^{-1} (2.77) was obtained from the variety CB-6 under weed free condition whereas the lowest one (0.53) was found in CB-2 under weedy condition (Table 5).

Number of sympodial branches plant^{-1}

The weeding regime significantly (p=0.05) influenced the number of sympodial branches plant^{-1} (Table 6). Results showed that higher number of sympodial branches plant^{-1} (19.75) was observed in the season long weed free condition than weedy condition (Table 4).

The number of sympodial branches plant^{-1} was significantly influenced by the interaction of variety and weeding regime (Table 4). The highest number of sympodial branches plant^{-1}(23.33) produced the variety CB-14 under weed free condition followed by Rupali-1 (22.07) and CB-1 (21.73) in season long weed free condition while the lowest one (15.80) was found in CB-6 under weedy condition (Table 5).

Days to 50% flowering

Days to 50% flowering was significantly (p=0.05) influenced by weeding regime (Table 6). Results showed that lower days for 50% flowering (55.61 days) was observed in season long weed free condition whereas the higher one (87.76 days) was found in weedy condition (Table 4).

The effect of interaction of variety and weeding regime on days to 50% flowering was also significantly different (Table 4).

Table 4: Number of monopodial branches plant^{-1}, number of sympodial branches plant^{-1}, days to 50% flowering and days to 50% boll split of cotton as influenced by weeding regime

Weeding regime	Monopodial branches plant^{-1}(no.)	Sympodial branches plant^{-1} (no.)	Days to 50% flowering	Days to 50% boll split
Season long weedy	1.20 b	17.12 b	87.76 a	135.43 a
Season long weed free	1.76 a	19.75 a	55.61 b	133.09 b
Level of significance	**	**	**	**
CV (%)	**12.57**	**8.59**	**7.84**	**2.30**

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

Table 5: Interaction effect of variety and weeding regime on number of monopodial branches plant^{-1}, number of sympodial branches plant^{-1}, days to 50% flowering and days to 50% boll split of cotton

Variety×weeding Regime	Monopodial branches plant^{-1} (no.)	Sympodial branches plant^{-1} (no.)	Days to 50% flowering	Days to 50% boll split
CB-1×Weedy	0.73 j	17.60	89.67 a	126.67
CB-1×Weed free	1.33 f-i	21.73	58.00 d-h	127.67
CB-2×Weedy	0.53 j	16.80	91.33 a	130.00
CB-2×Weed free	2.33 c	18.33	61.33 de	127.33
CB-3×Weedy	0.67 j	17.47	86.33 a	141.00
CB-3×Weed free	1.47 fgh	19.93	49.33 f-i	139.67
CB-4×Weedy	1.87 e	17.00	93.33 a	130.33
CB-4×Weed free	2.20 cd	19.60	64.00 cd	129.00
CB-5×Weedy	2.20 cd	16.87	88.00 a	129.00
CB-5×Weed free	2.40 bc	19.33	53.00 e-i	126.67
CB-6×Weedy	1.27 ghi	15.80	91.00 a	130.33
CB-6×Weed free	2.77 a	19.00	61.00 de	127.67
CB-7×Weedy	1.40 f-i	17.27	90.00 a	131.33
CB-7×Weed free	1.07 i	20.60	60.00 def	126.00
CB-8×Weedy	2.47 abc	16.60	88.00 a	127.67
CB-8×Weed free	2.73 ab	17.53	64.00 cd	126.67
CB-9×Weedy	1.47 fgh	16.47	90.33 a	129.00
CB-9×Weed free	2.53 abc	18.40	60.33 de	125.33
CB-10×Weedy	1.27 ghi	15.93	72.67 bc	141.33
CB-10×Weed free	1.53 fg	20.40	46.00 i	138.33
CB-11×Weedy	1.33 f-i	18.13	89.00 a	142.67
CB-11×Weed free	2.47 abc	20.07	48.00 hi	139.67
CB-12×Weedy	0.47 j	17.00	88.00 a	140.67
CB-12×Weed free	1.67 ef	19.20	49.00 ghi	138.00
CB-13×Weedy	1.07 i	17.67	88.33 a	142.67
CB-13×Weed free	1.33 f-i	18.33	51.00 e-i	139.67
CB-14×Weedy	1.93 de	19.20	90.33 a	139.33
CB-14×Weed free	1.33 f-i	23.33	51.00 e-i	139.00
CB-15×Weedy	1.47 fgh	17.40	85.67 a	130.67
CB-15×Weed free	0.53 j	19.20	54.00 d-i	127.67
CB-hyb.-1×Weedy	0.47 j	16.93	91.00 a	142.33
CB-hyb.-1×Weed free	1.47 fgh	19.33	51.00 e-i	139.00
Rupali-1×Weedy	0.53 j	16.53	75.67 b	141.67
Rupali-1×Weed free	1.13 hi	19.07	59.00 d-g	139.67
DM-2×Weedy	0.47 j	17.47	91.00 a	141.00
DM-2×Weed free	1.47 fgh	22.07	61.00 de	138.67
Level of significance	**	**NS**	*	**NS**
CV (%)	**12.57**	**8.59**	**7.84**	**2.30**

NS=Not significant; * = Significant at 5% level of probability, respectively and Within a column, means sharing same alphabets are not significantly different at P=0.05 probability level according to least significant difference test

Results showed that highest days (93.33 days) required for 50% flowering was recorded with the variety CB-4 in season long weedy condition while the lowest one (46.00 days) was found in CB-10 under weed free condition (Table 5).

Days to 50% boll split

Days require for 50% boll split was significantly affected by the weeding regime (Table 4). Results showed that least number of days required for 50% boll split (133.09 days) was observed in season long weed free condition compared to season long weedy condition (135.43 days) (Table 4). The interaction effect of variety and weeding regime for days required for 50% boll split was also significantly different. Results revealed that the lowest number of days (125.33) for 50% boll split was required in the variety CB-9 under weed free condition while the highest value (142.67 days) was calculated with the varieties CB-11 and CB-13 in season long weedy condition (Table 5).

Yield contributing characters and biomass of cotton

Number of bolls plant^{-1}

The weeding regime significantly (p=0.05) affected the number of bolls plant^{-1}Results showed that higher number of bolls plant^{-1} (55.00) was produced in season long weed free condition than weedy condition (34.50) (Table 6). Number of bolls plant^{-1} was significantly affected by the interaction of variety and weeding regime. The highest number of bolls plant^{-1} (72.00) was obtained from the variety Rupali-1 which was statistically identical with DM-2 (70.33) in season long weed free condition and the lowest one (22.00) was found in Rupali-1 followed by CB-10 (22.67) and CB-15 (26.00) under weedy condition (Table 7).

Single boll weight

Weeding regime significantly (p=0.05) affected single boll weight. Weed free condition resulted in higher boll weight (5.72 g) than weedy condition (4.67 g) (Table 6).

Boll weight was significantly affected by the interaction of variety and weeding regime (Table 7). The highest boll weight (6.40 g) was obtained from the variety CB-15 under weed free condition which was statistically similar with the varieties CB-hybrid-1 (6.30g), CB-9 and Rupali-1 (6.10 g) in season long weed free condition; and the lowest one (4.00 g) was found in the varieties CB-10 and CB-11 under weedy condition followed by CB-12 (4.20 g) (Table 7).

Seed cotton yield

A significant (p=0.05) difference in seed cotton yield was also observed for weeding regime. Higher seed cotton yield (3.15t ha^{-1}) was recorded under the season long weed free condition than weedy condition (1.87 t ha^{-1}) (Table 7). The seed cotton yield was significantly influenced by the interaction of variety and weeding regime. Results revealed that variety Rupali-1 produced the highest seed cotton yield (4.07 t ha^{-1}) under weed free condition followed by CB-12 (3.90 t ha^{-1}). On the other hand, the lowest one (1.17 t ha^{-1}) was observed in the variety CB-14 in season long weedy condition followed by the varieties CB-10 (1.19 t ha^{-1}) and DM-2 (1.25 t ha^{-1}) under weedy condition (Table 7).

Aboveground biomass plant^{-1}

Weeding regime significantly (p=0.05) differed for the aboveground plant biomass of cotton. Results showed that higher plant biomass (27.09 g plant^{-1}) was obtained from season long weed free condition and the lower one (13.85 g plant^{-1}) was found under weedy condition (Table 6). The interaction effect of variety and weeding regime also significantly affected the aboveground plant biomass. Results revealed that the highest aboveground biomass plant^{-1} (35.00 g) was recorded with the variety CB-2 under weed free condition followed by the varieties CB-1, CB-15 and DM-2 of 34.33g, 32.67g and 32.00 g, respectively in season long weed free Condition. The lowest one (11.33 g plant^{-1}) was found in the varieties CB-11 and CB-14 followed by the varieties CB-3 and CB-4 (11.67 g plant^{-1}) under weedy condition (Table 7).

Aboveground biomass plant^{-1}

Weeding regime significantly (p=0.05) differed for the aboveground plant biomass of cotton. Results showed that higher plant biomass (27.09 g plant^{-1}) was obtained from season long weed free condition and the lower one (13.85 g plant^{-1}) was found under weedy condition (Table 6). The interaction effect of variety and weeding regime also significantly affected the aboveground plant biomass. Results revealed that the highest aboveground biomass plant^{-1} (35.00 g) was recorded with the variety CB-2 under weed free condition followed by the varieties CB-1, CB-15 and DM-2 of 34.33g, 32.67g and 32.00 g, respectively in season long weed free Condition. The lowest one (11.33 g plant^{-1}) was found in the varieties CB-11 and CB-14 followed by the varieties CB-3 and CB-4 (11.67 g plant^{-1}) under weedy condition (Table 7).

Table 6: Above ground biomass, number of Boll, boll weight, seed cotton yield, ginning out turn (GOT), seed index and lint index as influenced by weeding regime of cotton

Weeding regime	Biomass plant^{-1} (g)	Boll plant^{-1} (no.)	Single boll weight (g)	Yield (t ha^{-1})	GOT (%)	Seed index (g)	Lint index
Season long weedy	13.85 b	34.39 b	4.67 b	1.87 b	36.30 b	9.35 b	3.36 b
Season long weed free	27.09 a	55.00 a	5.72 a	3.15 a	38.24 a	10.26 a	3.85 a
Level of significance	**	**	**	**	**	**	**
CV (%)	13.92	3.71	5.23	5.62	4.80	8.60	10.86

** = 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 7: Interaction effect of variety and weeding regime on number of bolls plant^{-1}, single boll weight, seed cotton yield and aboveground plant biomass of cotton

Variety×weeding regime	Bolls plant^{-1}(no.)	Single boll weight (g)	Seed cotton yield (t ha^{-1})	Biomass plant^{-1}(g)
CB-1×Weedy	27.00 n	5.30 e-i	1.64 o	15.67 ijk
CB-1×Weed free	56.00 d	5.83 bcd	3.32 c	34.33 a
CB-2×Weedy	30.00 m	4.87 i-l	1.70 no	14.00 jk
CB-2×Weed free	46.00 f	5.63 c-f	3.09 def	35.00 a
CB-3×Weedy	38.33 hij	4.43 lmn	1.87 mno	11.67 k
CB-3×Weed free	62.00 b	5.47 d-h	3.32 b	25.67 def
CB-4×Weedy	36.33 jk	4.73 jkl	2.22 jk	11.67 k
CB-4×Weed free	50.00 e	5.53 d-g	2.85 fg	23.67 d-h
CB-5×Weedy	31.00 m	5.07 g-j	2.10 jkl	13.00 k
CB-5×Weed free	47.00 f	5.50 d-h	2.87 fg	27.00 cde
CB-6×Weedy	40.00 hi	4.50 klm	2.00 lm	13.00 k
CB-6×Weed free	53.00 e	5.67 cde	2.93 f	23.00 d-h
CB-7×Weedy	31.00 m	4.70 j-m	1.84 mno	13.33 k
CB-7×Weed free	61.00 b	5.57 d-g	3.16 cde	27.33 cde
CB-8×Weedy	31.33 lm	4.63 j-m	1.73 no	14.33 jk
CB-8×Weed free	46.00 f	5.60 c-f	2.60 gh	33.00 ab
CB-9×Weedy	34.00 kl	4.90 i-l	1.73 no	21.33 fgh
CB-9×Weed free	52.33 e	6.10 abc	3.28 cd	25.33 d-g
CB-10×Weedy	22.67 o	4.00 n	1.19 p	12.00 k
CB-10×Weed free	57.67 cd	4.77 jkl	3.20 cd	25.00 d-g
CB-11×Weedy	46.67 f	4.00 n	2.45 hi	11.33 k
CB-11×Weed free	62.00 b	5.13 f-j	3.23 c	22.67 e-h
CB-12×Weedy	38.00 ij	4.20 mn	2.01 klm	12.33 k
CB-12×Weed free	52.67 e	5.80 b-e	3.90 ab	24.67 d-g
CB-13×Weedy	50.33 e	5.00 h-k	2.29 jk	12.67 k
CB-13×Weed free	59.00 bc	5.80 b-e	3.30 c	24.00 d-h
CB-14×Weedy	32.00 lm	4.53 klm	1.17 p	11.33 k
CB-14×Weed free	39.00 hij	5.90 bcd	2.18 jkl	24.00 d-h
CB-15×Weedy	26.00 n	4.80 ijkl	2.76 gh	19.00 hij
CB-15×Weed free	43.00 g	6.40 a	3.42 c	32.67 ab
CB-hyb.-1×Weedy	41.00 ghi	5.13 f-j	1.91 lmn	13.67 k
CB-hyb.-1×Weed free	61.00 b	6.30 ab	3.26 cd	28.33 bcd
Rupali-1×Weedy	41.33 gh	4.20 mn	2.30 ij	13.67 k
Rupali-1×Weed free	72.00 a	6.10 abc	4.07 a	20.00 ghi
DM-2×Weedy	22.00 o	5.00 h-k	1.25 p	15.33 ijk
DM-2×Weed free	70.33 a	5.90 bcd	3.03 def	32.00 abc
Level of significance	**	**	**	**
CV (%)	**3.71**	**5.23**	**5.62**	**13.92**

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

Ginning and lint quality parameters

Ginning out turn

The weeding regime significantly (p=0.05) influenced the GOT%. Season long weed free condition showed higher GOT (38.24%) whereas, lower one (36.30%) was found in season long weedy condition (Table 6). The ginning out turn was not significantly affected by the interaction of variety and weeding regime (Table 8).

Seed index

A significantly difference in seed index was found due to weeding regime. Higher seed index (10.26 g) was recorded with the weed free condition and lower one (9.35 g) was observed in season long weedy condition. Seed index was not significantly affected by the interaction of variety and weeding regime (Table 8).

Lint index

The weeding regime was significantly (p=0.05) affected the lint index. Higher lint index (3.85%) was found in season long weed free condition and the lower one (3.36%) was recorded with the weedy condition. The lint index was not significantly affected by the interaction of variety and weeding regime (Table 8).

Fiber length

The weeding regime was significantly influenced the fiber length. Higher fiber length (31.36 mm) was found in season long weed free condition; and lower one (33.19 mm) was recorded with under weedy condition (Table 7). The fiber length was not significantly affected by the interaction of variety and weeding regime (Table 8).

Fiber strength

The weeding regime did not significantly influenced for the fiber strength. The fiber strength was not significantly affected by the interaction of variety and weeding regime (Table 10).

Uniformity index

Weeding regime significantly (p=0.05) affected the uniformity index of cotton. Higher uniformity index (85.97%) was found in season long weed free condition while lower one (84.46%) was recorded under weedy condition. The uniformity index was not significantly affected by the interaction of variety and weeding regime (Table 9).

Micronaire

Weeding regime significantly influenced the micronaire. Higher value of micronaire (4.2.7µg inch^{-1}) was found in season long weed free condition whereas lower one (3.59 µg inch) was recorded with the weedy condition. The micronaire was not significantly affected by the interaction of variety and weeding regime (Table 10).

Weed parameters

Weed composition of the experimental field

Nine weed species from six different families were identified in weedy plots comprising five broad-leaved, three grasses and one sedge. Based on the summed dominance ratio (SDR) values, grass weed *Digitaria songuilaris (Retz.) keol* was the most dominant species (SDR 58.86); *Cyperus rotundus* L. emerged as second dominant sedge weed species (SDR 11.78). Another grass weed species *Cynodon dactylon (L) Pers* the ranked third (SDR 8.71). Among the species, *Euphorbia hirta L.* appeared as the fourth dominant sedge weed (SDR 4.16). Broad leaf weed species *Amaranthus viridis L.* occupied the fifth position (Table 11).

Weed density

Weed density was significantly differed by cotton variety. Results revealed that the highest weed density (470 m^{-2}) was recorded with the variety DM-2 followed by the varieties Rupali-1 (447 m^{-2}), CB-10 (462 m^{-2}), CB-9 (431 m^{-2}) and CB-14 (428 m^{-2}), whereas the lowest one (321 m^{-2}) was observed in the variety CB-12 followed by CB-15 (339 m^{-2}) (Figure 3).

Table 8: Interaction effect of variety and weeding regime on ginning out turn, seed index and lint index of cotton

Variety×weeding regime	Ginning out turn (%)	Seed index (g)	Lint index
CB-1×Weedy	35.00	9.00	3.07
CB-1×Weed free	37.33	9.67	3.60
CB-2×Weedy	35.33	9.33	3.27
CB-2×Weed free	36.67	10.33	3.77
CB-3×Weedy	36.67	9.67	3.50
CB-3×Weed free	39.33	10.50	4.03
CB-4×Weedy	35.33	9.17	3.20
CB-4×Weed free	37.00	9.83	3.60
CB-5×Weedy	36.33	9.17	3.30
CB-5×Weed free	37.33	9.33	3.47
CB-6×Weedy	35.00	9.83	3.40
CB-6×Weed free	36.67	11.33	4.07
CB-7×Weedy	35.33	10.00	3.50
CB-7×Weed free	37.67	10.17	3.77
CB-8×Weedy	36.33	9.00	3.23
CB-8×Weed free	37.67	9.83	3.70
CB-9×Weedy	35.00	9.33	3.23
CB-9×Weed free	36.67	10.17	3.70
CB-10×Weedy	35.33	9.50	3.30
CB-10×Weed free	37.33	10.67	3.60
CB-11×Weedy	35.00	9.50	3.27
CB-11×Weed free	35.67	10.00	3.50
CB-12×Weedy	36.33	9.33	3.40
CB-12×Weed free	38.67	10.33	4.07
CB-13×Weedy	37.67	9.33	3.50
CB-13×Weed free	39.00	10.83	4.20
CB-14×Weedy	37.67	9.17	3.43
CB-14×Weed free	39.33	10.33	4.07
CB-15×Weedy	36.33	10.00	3.63
CB-15×Weed free	37.33	11.00	4.03
CB-hyb-1×Weedy	39.67	10.00	3.97
CB-hyb.-1×Weed free	42.00	10.50	4.03
Rupali-1×Weedy	37.33	8.67	3.20
Rupali-1×Weed free	41.00	10.33	4.23
DM-2×Weedy	37.67	8.33	3.07
DM-2×Weed free	41.67	9.50	3.90
Level of significance	NS	NS	NS
CV (%)	4.80	8.60	10.86

NS=Not significant

Table 9: Fiber length, strength, uniformity index and micronaire value of cotton fibers influenced by weed interference

Weed interfrence period	Length (mm)	Strength (g tex^{-1})	Uniformity index (%)	Lint index
Season long weedy	30.19 b	34.12	84.46 b	3.59 b
Season long weed free	31.36 a	34.27	85.97 a	4.27 a
Level of significance	*	NS	**	**
CV (%)	8.32	5.59	1.31	9.00

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

Table 10: Interaction effect of variety and weeding regime on fibre length, strength, uniformity index and micronaire value of cotton

Variety×weeding regime	Length(mm)	Strength (g tex^{-1})	Uniformity index (%)	Micronaire (μg $inch^{-1}$)
CB-1×Weedy	30.37	34.65	83.35	3.68
CB-1×Weed free	31.72	32.88	84.73	4.42
CB-2×Weedy	29.92	34.27	84.67	3.56
CB-2×Weed free	30.67	32.53	86.38	4.43
CB-3×Weedy	30.40	32.41	84.17	3.62
CB-3×Weed free	30.75	34.18	85.45	3.63
CB-4×Weedy	30.38	34.84	85.00	3.63
CB-4×Weed free	31.42	33.50	85.67	4.29
CB-5×Weedy	30.25	35.69	85.25	4.06
CB-5×Weed free	31.08	34.79	85.92	4.10
CB-6×Weedy	30.45	33.83	83.92	3.46
CB-6×Weed free	30.98	35.45	86.25	4.44
CB-7×Weedy	29.73	34.17	84.08	3.60
CB-7×Weed free	30.45	33.08	86.17	4.35
CB-8×Weedy	29.43	31.80	83.58	3.29
CB-8×Weed free	29.87	34.29	85.92	4.37
CB-9×Weedy	29.42	33.89	83.83	3.70
CB-9×Weed free	30.00	34.25	85.50	4.38
CB-10×Weedy	29.75	35.24	84.83	3.64
CB-10×Weed free	30.25	34.56	86.08	4.52
CB-11×Weedy	30.45	35.23	84.75	3.48
CB-11×Weed free	30.90	34.76	85.83	4.41
CB-12×Weedy	30.57	34.79	84.50	3.72
CB-12×Weed free	33.33	34.55	86.17	4.38
CB-13×Weedy	29.87	34.63	83.92	3.76
CB-13×Weed free	30.05	36.12	85.83	3.98
CB-14×Weedy	29.67	35.20	84.00	3.19
CB-14×Weed free	36.83	34.86	86.25	3.63
CB-15×Weedy	32.92	34.27	86.92	3.54
CB-15×Weed free	33.42	33.36	87.92	4.49
CB-hyb.-1×Weedy	29.33	32.23	84.25	3.65
CB-hyb.-1×Weed free	32.33	32.72	86.00	4.38
Rupali-1×Weedy	30.28	35.18	84.33	3.45
Rupali-1×Weed free	30.47	34.32	85.75	4.60
DM-2×Weedy	30.17	34.53	85.00	3.51
DM-2×Weed free	29.92	34.02	85.67	4.03
Level of significance	NS	NS	NS	NS
CV (%)	8.32	5.59	1.31	9.00

NS=Not significant

Table 11: 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	*Digitaria sangguinalis* (Retz.) koel	Poaceae	Grass	60.03	57.70	58.86
2	Durba	*Cynodon dactylon* (L.) Pers	Poaceae	Grass	12.30	5.13	8.71
3	Shama	*Echinochloa crus-galli* (L.) Link	Poaceae	Grass	3.86	4.02	3.94
4	Mutha	*Cyperus rotundus* L.	Cyperaceae	Sedge	14.37	9.19	11.78
5	Shaknote	*Amaranthus viridis* L.	Amaranthaceae	Broadleaf	2.44	5.70	4.07
6	Katanote	*Amaranthus spinosus* L.	Amaranthaceae	Broadleaf	1.21	4.04	2.63
7	Foska begun	*Physalis heterophylla* Nees	Solanace	Broadleaf	1.34	5.04	3.19
8	Asthma	*Euphorbia hirta* L.	Euphorbiaceae	Broadleaf	3.41	4.91	4.16
9	Helencha	*Jussiaea repens* Vahi	Onagraceae	Broadleaf	1.00	4.22	2.61

Weed dry matter

Weed dry matter was significantly affected the cotton variety (Appendix 39). The analytical data showed that the highest weed dry matter (272.50 g. m^{-2}) was found in the varieties CB-5 and CB-9 followed by the varieties CB-14 (272.14g.m^{-2}), CB-1 (272 g. m^{-2}) and DM-2 (267.14 g. m^{-2}) whereas, the lowest one (179.64 g. m^{-2}) was recorded with the variety CB-12followed by the varieties CB-3 (184.25 g. m^{-2}), Rupali-1 (188.64 g. m^{-2}), CB-11 (201.14 g. m^{-2}), CB-2 (205.75 g.m^{-2}) and CB-15 (209.64 g. m^{-2}), respectively (Figure 3).

Seed cotton yield under weed free condition

Seed cotton yield under weed free condition was significantly different among the cotton varieties (Table 11). Results revealed that the highest seed cotton yield (4.07 t ha^{-1}) was produced by the variety Rupali-1 followed by the varieties CB-12 (3.90 t ha^{-1}) and CB-15 (3.42 t ha-^{1}, while the lowest one CB-14 (2.18 t ha^{-1}) followed by CB-8 (2.60 t ha^{-1}), CB-4 (2.85 t ha^{-1}), CB-5 (2.87 t ha^{-1}), and CB-6 (2.93 t ha^{-1}) which were statistically similar (Figure 4).

Seed cotton yield under weedy condition

Seed cotton yield under weedy condition was significantly different among the cotton variety (Appendix 39). Results showed that the highest seed cotton yield (2.76 t ha^{-1}) was produced by the variety CB-15 followed by the varieties CB-11 (2.45 t ha^{-1}), Rupali-1 (2.30 t ha^{-1}) and CB-4 (2.22 t ha^{-1}). On the other hand, the lowest one (1.17 t ha^{-1}) was produced by the variety CB-14 followed by the varieties CB-10 (1.19 t ha^{-1}) and DM-2 (1.25 t ha^{-1}) which was statistically similar (Figure 4).

Relative yield loss due to weed interference

Weed inflected relative yield loss (%) of crop is an important indicator to recognize the weed tolerance of a variety. Lower the relative yield loss higher the weed tolerance, since in the presence of competition for weeds, weed tolerance refers to the ability to maintain high yields. The cotton varieties demonstrated a broad diversity in relative loss ranged from 19.30 to 62.85%. Variety CB-15 (19.30%) enjoyed the least relative yield loss followed by the varieties CB-4 (22.15%), CB-11 (24.15%) and CB-5 (26.83%) and thus appeared as more weed competitive variety. Variety CB-10 (62.85%) allowed the higher relative yield loss followed by DM-2 (58.75%) and CB-1 (50.60%) and the less weed competitive variety. Variety CB-10 allowed higher relative yield loss (62.85%) followed by the varieties DM-2(58.75%) and CB-1 (50.60%) and appeared as less weed competitive variety. Among the best yield performers, only Rupali-1 (47.32%) appeared as moderately weed competitive variety while the varieties like CB-12 (30.19%) and CB-3 (9.93%) appeared as very weak competitive against weeds (Figure 5).

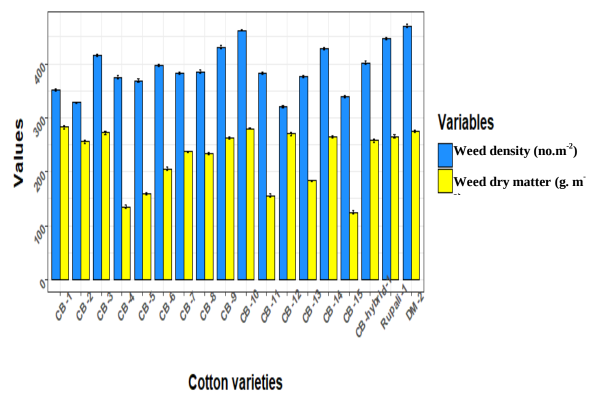

Figure 3: Effect of variety on weed density and weed dry matter of cotton

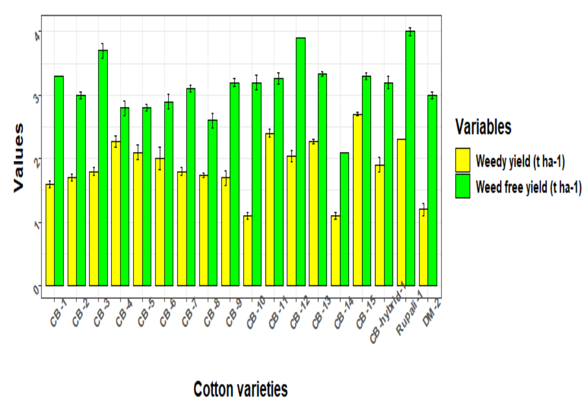

Figure 4: Effect of variety on weedy yield and weed free yield of cotton

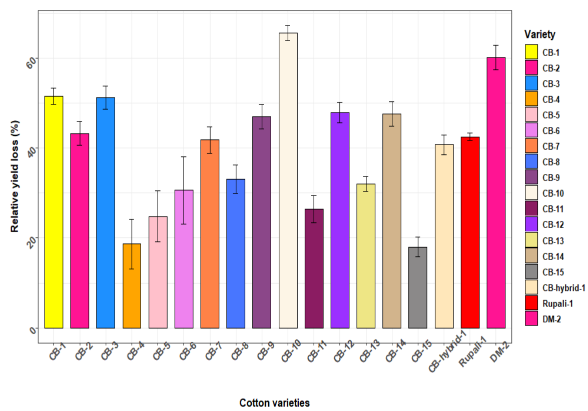

Figure 5: Relative yield loss of different cotton varieties due to weed interference

DISCUSSION

Weed competitiveness of upland cotton varieties

Weed competitiveness (WC) includes two components: the ability to reduce weed growth by competitive means, weed suppressor ability (WSA) and the ability to maintain potential output in the presence of weeds competitiveness (Jannink et al., 2000). For long-term weed management, WSA should be emphasized more than weed tolerance (WT). However, the roles of WSA, WT and yield potential are generally ambiguous under weedy conditions and strong WSA will not guarantee a high yield of a low yield variety under weedy conditions (Zhao, 2006). Therefore, high yield potential and strong WSA should be pooled to ensure economically acceptable returns under competition for weed. Anwar *et al*. (2010) reported that weed competitive cultivars are a critical tool for sustainable weed management, and suggest propose weed suppressive aerobic rice by combining traits associated with weed competitiveness.

Crops differ in the competitiveness of their capacity to suppress weeds (Mahajan et al., 2011 and Eslami, 2015). Comprehensive cultivars would reduce the use of herbicides, as well as overall weed management costs in crop systems. In general, the weed competitiveness of cultivars is correlated with plant height, seedling vigor, early canopy closure, leaf orientation, leaf area development, and branching (Eslami, 2015). The cotton plants will branch and extend their canopy during the growth process to complete canopy closure (Jost and Cothren, 2001). If the canopy is closed, it would be easier to penetrate the inter-row spaces, and in the cultivation period, weeds cannot compete with cotton (Jost and Cothren, 2001). However, weed competition in the early phase could be slow to decrease significantly in plant growth and yield if growing in 1meter row spacing (Ortiz and Bourland, 1999; Papamichail et al.,2002). Therefore, it would be highly desirable for weed management to eliminate cultivars with increased planting strength, as this would ensure that weed is eliminated during first cultivation phases (Bertholdsson, 2005; Liu et al., 2015).

Results of this study are encouraging as there are cotton varieties that could be employed to enhance the yield of fiber. The variety Rupali-1 was the highest seed cotton yield (4.07 tha^{-1}) followed by CB-12 (3.90 t ha^{-1}) and CB-15 (3.74 tha^{-1}) under weed-free conditions. On the other hand, the variety CB-15 has produced the highest seed cotton yield (2.76 t ha^{-1}) under the weedy condition which was followed by CB-11 (2.45 t ha^{-1}), hybrid Rupali-1 (2.30 t ha^{-1}) and CB-13 (2.29 t ha^{-1}). Because of the variety of CB-15 has superior for suppressive ability and Rupali-1 and CB-13 have also suppressive ability. The cotton variety CB-15 was a promising weed competitive variety and it was also enjoyed the least relative yield loss. Results were similar (Oerke, 2006) in which cotton is reported as among those crops that hundreds of pests have been attacked by viruses, pathogens, insect pests and weeds that together can cause a return loss of over 80% in this crop.

CONCLUSION

Upland cotton varieties under study varied widely in their yielding ability and weed competitiveness, but not in fiber quality. Although Rupali-1 appeared as the highest yielder, CB-15 was found as the most weed competitive one.

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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