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MULCHING STRATEGIES FOR WEEDS CONTROL AND WATER CONSERVATION IN COTTON

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ABSTRACT

Experiment was conducted at Agronomic research area of University College of Agriculture and Environmental Sciences, The Islamia University Bahawalpur during 2013, to investigate the impact of different mulching strategies for weeds control and water conservation in cotton. Three mulch treatments (M_0 = no mulch, M_1= black plastic mulch and M_2= straw mulch) and three irrigation levels (I_0= 5days interval, I_1= 10 days interval and I_2= 15 days interval) were used in the experiment. Minimum weeds number and biomass was recorded under black plastic mulch, followed by wheat straw mulch and maximum in control (without mulch) treatment. Water related parameters like relative water content, excised leaf water loss, soil moisture percentage and yield related parameters like number of bolls, 100 bolls weight, seed cotton yield, biological yield, harvest index and water use efficiency were higher under combination of black plastic mulch with irrigation interval of five days. It was concluded that combination of black plastic mulch with irrigation interval of five days resulted in maximum weeds control, water saving and seed cotton yield than rest of the treatments used in the research.

Keywords: cotton, weeds control, drought, soil cover, moisture saving, crop competition,

INTRODUCTION

Cotton is considered as king among the various fiber crops; also called white gold is one of the most important cash crop worldwide and plays an important role in economy of many countries (Patil *et al.,* 2011*).* Among the various environmental stresses adversely affect the growth and development of plants, most damaging one is water deficit (drought) stress (Sinclair, 2005). Water deficit conditions severely restrained the growth and yield of many crops (Raza *et al.*, 2012a). Drought attacks crop plants in many regions of the world and responsible for yield losses depending upon the duration and severity of the stress. It is estimated that losses caused by drought stress is more than caused any other environmental factor (Khan *et al.,* 2010). Every aspect of plant growth and yield was affected by drought (Raza *et al*., 2015) because water is essential for every stage of plant from seed germination up to plant maturation. Water deficit stress also affects the plant by modifying the anatomy, morphology, physiology, biochemistry and finally the productivity of crop (Raza *et al.,* 2012a). Water deficit causes a severe reduction in various plant functions viz, leaf expansion, organ production (both leaves and fruit), fibre length, photosynthesis, boll retention, fiber thickening, root growth and function (Gholipoor *et al.,* 2013). With the increasing demand of more food, feed and fiber in order to fulfill the needs of increasing population of the world, threats of harmful effects of drought are also expected to be increase (Wilhite and Buchanan-Smith, 2005).

Among the various yield limiting constrains of cotton, weed is also a serious yield limiting factor. They were considered as a problem since 10,000 B.C (Avery *et al*., 2005). Weeds compete for nutrients, water, light and thus reduce the yield of cotton substantially (Iftikhar *et al.*, 2010). Weeds are responsible for losses in cotton yield to an extent of 34-61.4% (Ahmad, 2003). Although a number of methods and techniques are used for weed control, still cotton yield is reduced significantly by weeds infestation (Ashigh *et al.,* 2012).

Mulching is the practice of covering the soil surface to make favorable conditions for plant growth and development. The main objective of mulching is water saving and weed control (Lamont, 2005). Mulches when spread over the soil surface, minimize the water runoff, increase infiltration, provide shade to the soil (suppress weeds) and act as barrier to reduce water loss in form of vapors (Lamont, 2005).

It is now need of time to discover new techniques to combat with the problems of water shortage and weeds infestation. Adaptation of techniques which result in more efficient and economic use of water and weeds control is one of the best way to cope with these minaces (Nasrullah *et al.,* 2011). For drought mitigation many strategies has been developed like use of different nutrients (Raza *et al.*, 2012b), compatible solutes (Raza *et al.,* 2012c; Raza *et al.*, 2014) and management practice like mulching are used to overcome the weeds and deficit water conditions (Subhan *et al.,* 2013).

MATERIALS AND METHODS

A field experiment was conducted at agronomic research area of University College of Agriculture and Environmental Sciences, The Islamia University Bahawalpur. Experimental site has sandy loamy soil with 8.6 pH. Average rainfall during the experiment duration was 20mm and temperature was 32.25°C. Sowing was done during May 2013. Experiment comprised of three mulch treatments (M_0 = Control without any mulch, M_1=

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Black plastic mulch @ 40 kg ha^{-1} and M_2 = Wheat straw mulch @ 4t ha^{-1}), three irrigation levels (I_0 = 5 days interval, I_1 = 10 days interval and I_2 = 15 days interval) and laid out in randomized complete block design with split plot arrangement with three replications, keeping irrigation levels as main plot factor and mulches as sub-plot factor and a net plot size of 5m × 5m. Crop was sown with hand dibbling method on beds and mulch was spread between the beds after complete germination of cotton.

Leaf area was recorded with the help of leaf area meter, at a regular interval of fifteen days. The sampling was started 45 days after sowing (DAS) and continued up to 120 DAS. LAI was calculated by using the following formula

LAI = Leaf area /Land area

Crop growth rate (CGR) was recorded at regular interval of fifteen days. The sampling was started 45 days after sowing (DAS) and continued up to 120 DAS. After harvest, samples were weighed to determine fresh weight. Each plant sample then chaffed, thoroughly mixed and sun dried. Samples were then placed in an oven at 70°C up to constant weight. Then dry weight was recorded and crop growth rate was calculated by using the following formula

Crop growth rate (CGR) = $W_2 - W_1 / T_2 - T_1$

Where W_2 = dry weight per unit land area (g m^{-2}) at second harvest, W_1 = dry weight per unit land area (g m^{-2}) at first harvest, T_2 = time corresponding to second harvest and T_1= time corresponding to first harvest.

Counting of number of weeds per m^{-2} and weeds biomass m^{-2} was started 30 days after sowing (DAS). Further data was taken with regular interval of thirty days till 120 DAS.

Fully expanded youngest leaf was used to determine the leaf relative water content (RWC) and excised leaf water loss (ELWL). After cutting, leaves were placed in plastic bag and immediately transferred to the lab to record the fresh weight (FW). After recording the fresh weight, leaves were soaked in distilled water for 16-18 hours at room temperature to become turgid. After that leaves were dried with tissue paper to calculate turgid weight (TW). In order to record the wilted weight (WW) leaves were placed at room temperature for 6 hours. For calculating dry weight (DW) leaves were placed in oven at 70 °C for 72 hours. Relative water content and excised leaf water loss were calculated by using the following formulas

RWC (%) = FW- DW/ TW- DW X 100
ELWL (%) = FW-WW/ DW × 100
Where FW= fresh weight, WW = Wilted weight, DW= dry weight and TW= turgid weight

Soil samples from the depth of 0-15 cm and 15-30 cm soil layer were taken, 100 grams soil from each sample was separated, oven dried up to constant weight and soil moisture percentage was recorded.

Number of sympodial branches and bolls per plant was recorded by randomly selected five plants from each plot. Number of sympodial branches and bolls was counted and their average was calculated. For bolls weight, 100 bolls from each plot were taken randomly, sun dried and weighted to find the 100 boll weight. One square meter was harvested from each plot, sun dried and weighted to obtain biological yield m^{-2} and then converted into kg per hectare. After complete picking, seed cotton from each plot was weighed and then yield was calculated on hectare basis. Harvest index (HI) was calculated by using the following formula

HI = Grain yield / biological yield

Water use efficiency (WUE) was calculated by using the following formula

Water use efficiency (WUE) = Grain yield/Total water applied

Data was analyzed statistically by using Fisher's analysis of variance technique and least significant difference (LSD) test at 5% probability level was applied to compare the treatments' means (Steel *et al.*, 1997).

RESULTS

Data regarding Leaf area index is shown in the Figure-1. A steady increase in leaf area index up to 90 days after sowing (DAS) and then gradual decrease up to 120 DAS was observed. Reduced leaf area index after 90 DAS was due to shedding of cotton leaves. Maximum value of leaf area index was observed under black plastic mulch for all irrigation levels followed by wheat straw mulch and minimum in control treatment (without mulch).

A steady increase in crop growth rate was up to 105 DAS and then gradual decrease up to 120 DAS was observed (Figure-2). Decrease in crop growth rate after 105 DAS was due to crop maturity and less growth rate. Maximum value of crop growth rate was observed under black plastic mulch for all irrigation levels followed by wheat straw mulch and minimum in control treatment (without mulch).

A steady increase in number of weeds and weed biomass m^{-2} was observed up to 120 DAS (Figure-3 and Figure-4). Minimum number and biomass of weeds m^{-2} was observed under black plastic mulch for all irrigation levels followed by wheat straw mulch and maximum in control treatment (without mulch).

Relative water content (RCW) and excised leaf water loss (ELWL) are indicators of water status of leaves through their effect on cell volume (Ober *et al.*, 2005). Both treatments mulches and irrigation levels showed significant effect on RCW and ELWL (Table-1). Maximum values were recorded in M_1 (black plastic mulch) followed by M_2 (wheat straw mulch) and minimum in M_0 (control) for all irrigation intervals. Similar results were found in case of soil moisture percentage.

Number of branches, number of bolls and 100 bolls weight are important yield determinants of cotton. Treatments with more irrigation produced more number of branches and bolls per plant compared to less irrigated treatments. Maximum number of bolls and sympodial branches was recorded in M_1 followed by M_2 and minimum in M_0 for all irrigation levels.

Biological yield, seed cotton yield and harvest index was also significantly affected by mulches and irrigation levels. Among the mulch treatments, maximum yield and harvest index was recorded in M_1 followed by M_2 and minimum in M_0 for all irrigation levels.

Water use efficiency (WUE) is an important trait used to estimate drought tolerance of crops. Both treatments mulches and irrigation levels showed significant effect on WUE. Among the mulch treatment, maximum water use efficiency was recorded in M_1 followed by M_2 and minimum in M_0. For irrigation levels, maximum water use efficiency was recorded in I_1 followed by I_0 and minimum in I_2.

Table-1. Effect of mulching strategies and irrigation intervals on water related parameters of cotton.

Irrigation levels	Relative water contents (%)	Excised leaf water loss	Soil moisture percentage	
			0-15 cm	**15-30cm**
I_0(5 days interval)	74.75 A	1.84 A	8.95 A	16.14 A
I_1(10 days interval)	68.56 B	1.64 B	7.15 B	11.38 B
I_2 (15 days interval)	57.66 C	1.40 C	5.27 C	9.31 C
Mulching material				
M_0(no mulch)	64.14 C	1.40 C	3.34 C	6.31 C
M_1(Black plastic mulch)	69.33 A	1.80 A	9.71 A	18.38 A
M_2 (Wheat straw mulch)	67.50 B	1.68 B	8.32 B	12.14 B
Interaction				
M_0I_0	73.66 b	1.64 c	4.73 e	8.60 f
M_0I_1	66.60 d	1.42 e	3.26 f	6.40 g
M_0I_2	52.26 g	1.14 f	2.00 g	3.93 h
M_1I_0	75.83 a	2.04 a	11.70 a	22.40 a
M_1I_1	70.26 c	1.81 b	10.16 b	19.83 b
M_1I_2	61.90 e	1.54 d	7.26 d	12.93 d
M_2I_0	74.76 ab	1.85 b	10.41 b	17.43 c
M_2I_1	68.93 c	1.70 c	8.03 c	7.93 f
M_2I_2	58.80 f	1.50 de	6.53 d	11.00 e

Any two means not having a common letter differ significantly at $p<0.05$

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Table-2. Effect of mulching strategies and irrigation intervals on various yield parameters of cotton.

Irrigation levels	Plant height (cm)	No. of sympodial branches per Plant	No. of bolls per plant	100 bolls weight (g)	Seed cotton yield (kg ha $^{-1}$)	Biological yield (kg ha^{-1})	Harvest index (%)	Water use efficiency (kg ha $^{-1}$ mm^{-1})
I_0(5 days interval)	157.00 A	22.77 A	43.00 A	348.22 A	3424 A	8341 A	39.99 A	3.11 A
I_1(10 days interval)	128.56 B	19.11 B	34.22 B	315.33 B	2503 B	7203 B	34.75 B	3.62 B
I_2 (15 days interval)	105.46 C	13.56 C	24.44 C	266.56 C	1220 C	4491 C	24.67 C	3.39 C
Mulching material								
M_0(no mulch)	117.44 C	16.56 C	27.55 C	289.56 C	1673 C	5121 C	30.82 C	2.15 C
M_1(Black plastic mulch)	142.33 A	21.22 A	39.88 A	328.44 A	3246 A	8267 A	37.99 A	4.20 A
M_2 (Wheat straw mulch)	131.22 B	18.56 B	34.22 B	312.11 B	2227 B	6648 B	32.60 B	2.85 B
Interaction								
M_0I_0	140.33 b	19.33 cd	36.00cd	330.67 c	2428 d	6465 e	35.89 d	2.20 f
M_0I_1	119.67 cd	17.33 de	27.33 f	304.33 ef	1724 f	5189 f	33.22 e	2. 34e
M_0I_2	92.33 e	10.33 g	19.33 g	233.67 h	869 h	3711 h	23.37 h	1.70 g
M_1I_0	170.33 a	26.33 a	48.66 a	366.33 a	4558 a	10391 a	43.83 a	4.13 b
M_1I_1	138.33 b	21.00 bc	39.66 c	327.00 cd	3514 b	9173 b	38.29 c	5.19 a
M_1I_2	118.33 cd	16.33 e	31.33 e	292.00 f	1668 f	5237 f	31.82 f	3.27 c
M_2I_0	160.33 a	22.66 b	44.33 b	347.67 b	3286 c	8170 c	40.23 b	2.99 d
M_2I_1	127.67 bc	19.00 d	35.67 d	314.67 de	2273 e	7247 d	32.74 e	3.35 c
M_2I_2	105.67 d	14.00 f	22.66 g	274.00 g	1123 g	4527 g	24.83 g	2.20 f

Any two means not having a common letter differ significantly at $p<0.05$

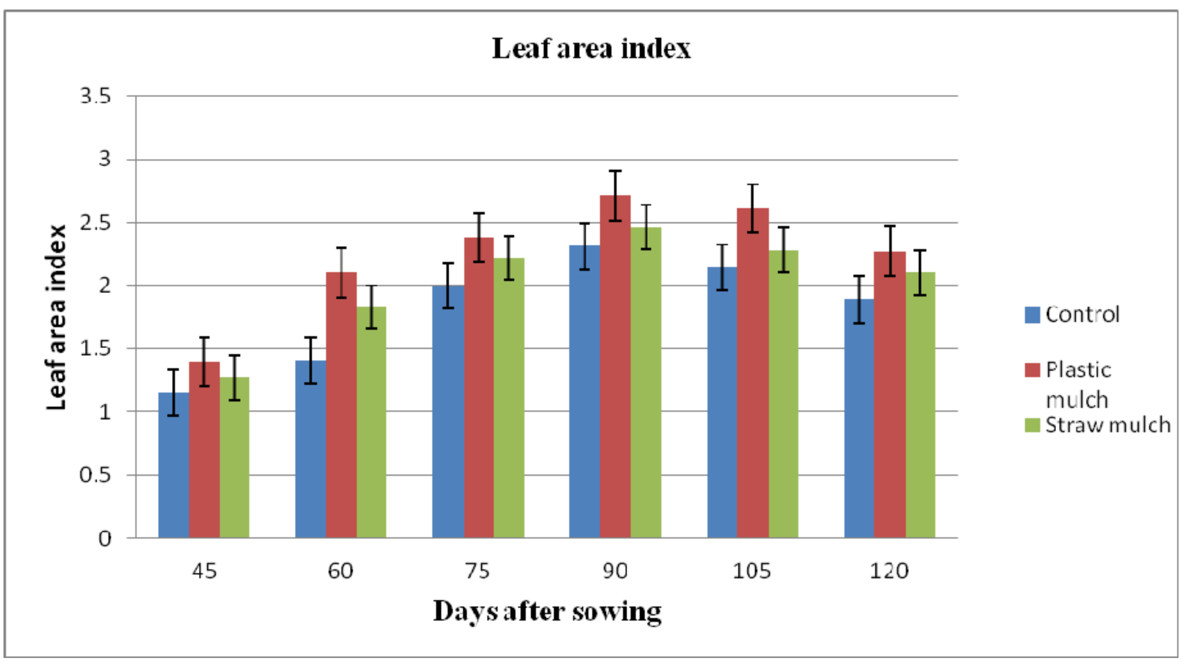

Figure-1. Effect of mulches strategies and irrigation intervals on leaf area index of cotton.

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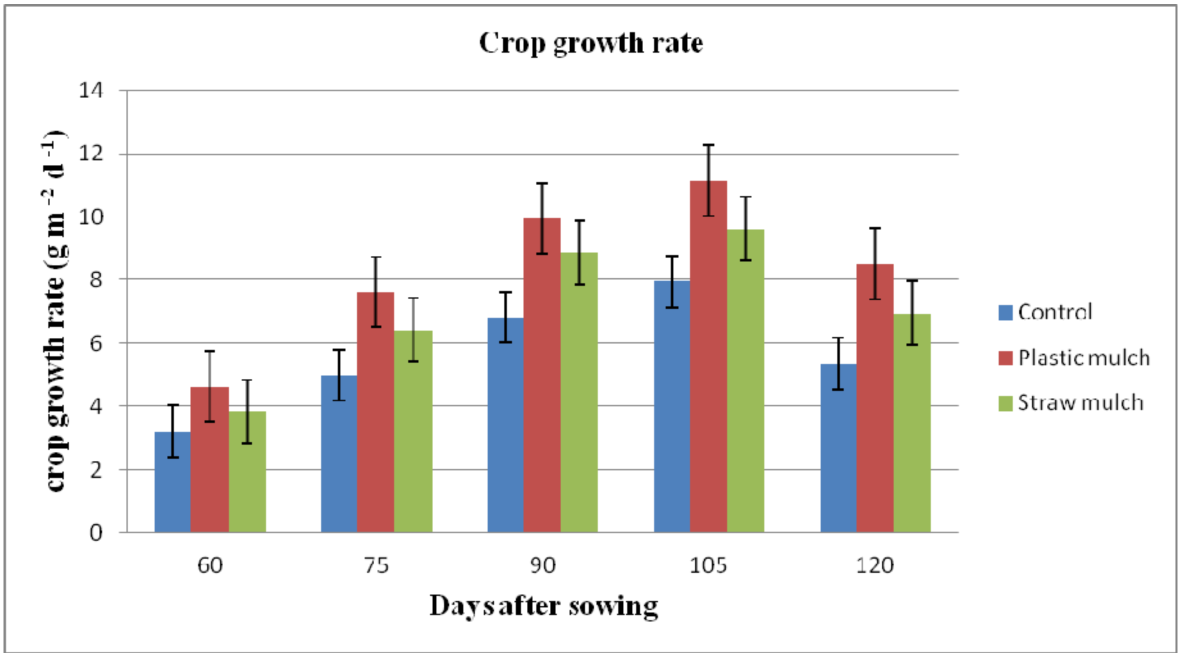

Figure-2. Effect of mulching stragegies and irrigation intervals on crop growth rate of cotton.

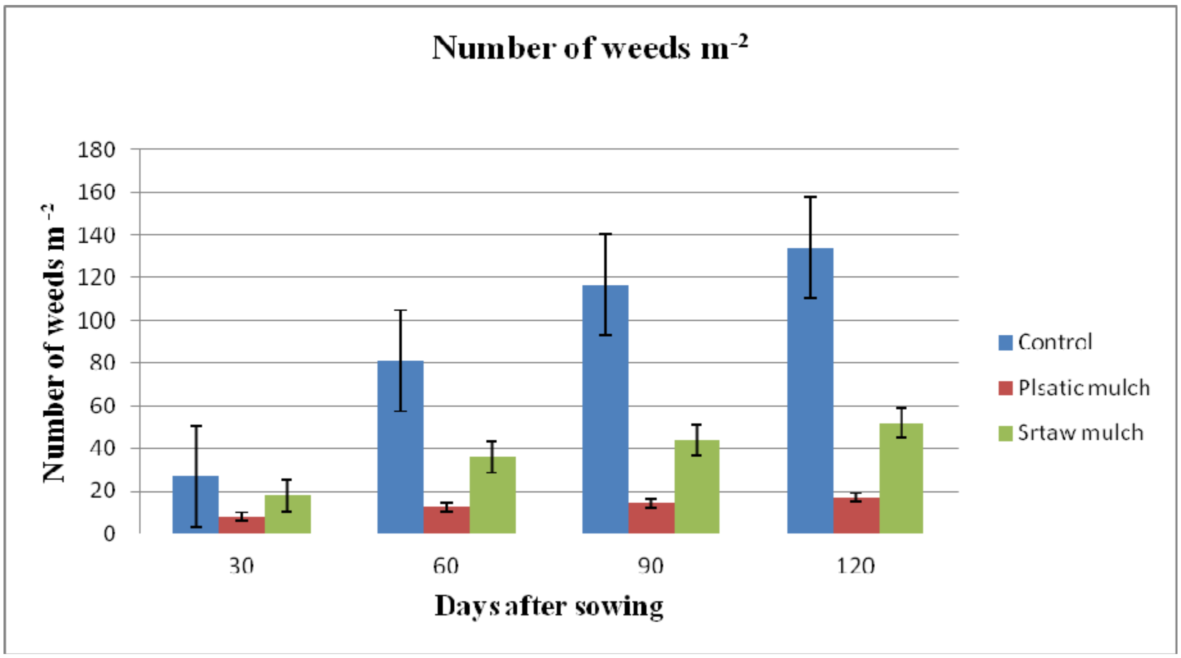

Figure-3. Effect of mulching stragegies and irrigation intervals on number of weeds m^{-2} of cotton.

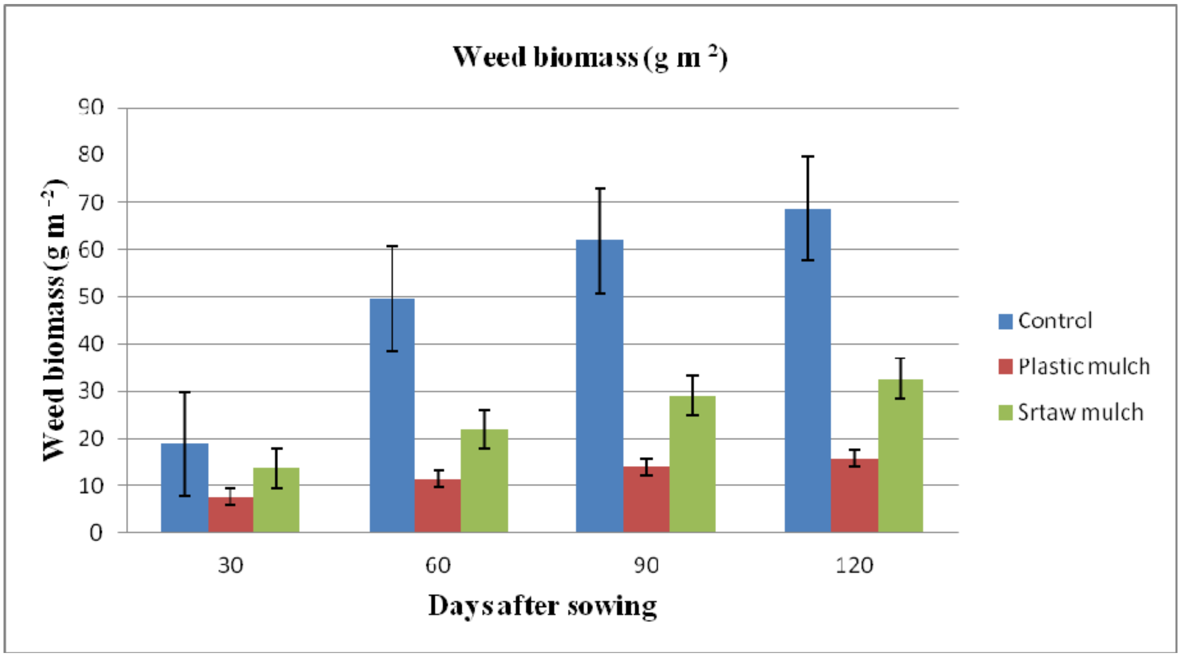

Figure-4. Effect of mulching stragegies and irrigation intervals on weed biomass m^{-2} of cotton.

DISCUSSIONS

Drought causes reduction in almost all growth and yield related parameters of plant. Among various management practices, an important strategy is mulching. Reduction in leaf area under water deficit conditions was due to leaf area adjustment process (Alves and Setter, 2004). This result is in line with the findings of Noreen *et al.* (2013) they reported that water deficit stress reduced the leaf area index (LAI) of cotton. Higher values of leaf area index under mulch was due to more water conservation and minimum number of weeds, which results in more number of leaves and good leaf growth. Similar results were reported by Hugar *et al.* (2009). Crop growth rate decreased under drought stress mainly due to less cell division and expansion. Higher values of CGR under mulch were due to more water conservation and minimum number of weeds, which results in good plant growth. This result is in line with the findings of Nasrullah *et al.* (2011).

Karlen *et al.* (2002) reported that if weed control measures are delayed by 30-40 days after the germination of cotton, yield may fall up to 20-40 percent and if left uncontrolled, the weeds in many fields are capable of reducing yields by more than 80%. Mulches suppress the weeds growth mainly by restricting the light penetration into the soil. These results are in line with the findings of Ather *et al.* (2013).

Higher values of RWC and ELWL under mulch treatments were due to less evapotational water loss and more water conservation. Similar findings were reported by Ihsanullah (2009). Lower values of RWC and ELWL under drought stress were due to disturbance in leaf water status. These results are in line with the findings of Patil *et al.* (2011) and Faizanullah *et al.* (2012). Optimum soil moisture results in good plant growth, development and subsequently higher yield. More soil moisture percentage under mulch treatments was due to less evaporational water loss and less number of weeds.

Less number of branches and bolls under drought stress was due to less plant height and less number of nodes. These results are in line with the findings of Ghaderi-Fara (2012). As mulch provides favorable condition for plant growth so higher number and bolls were recorded in mulched treatment as compared to un-mulch treatment. These results are in accordance with the findings of Nasrullah *et al.* (2011). Higher weight of bolls, seed yield and harvest index under mulch treatments was due to more production of photosynthates. Similar results were reported by Hugar *et al.* (2009). Smaller values under drought stress were mainly due to smaller leaf area and less production of photosynthates. These results are in line with the findings of Basal *et al.* (2009). Higher values of WUE under mulch treatments were due to less water loss and more water conservation. These results are in line with the findings of Snowden *et al.* (2013) and Jing *et al*. (2004).

CONCLUSIONS

a) Mulching with different materials significantly controlled the weeds and conserve soil moisture.
b) Under mulched treatments, crop growth and yield is significantly better than un-mulched treatment.
c) Polyethylene plastic mulch proved to be better than straw mulch and un-mulched treatments.
d) Black plastic mulch with irrigation interval of five days performed better than rest of the treatments used in the experiment.

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