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Article

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APPLICATION OF PRE AND POST EMERGENCE HERBICIDE UNDER IMPROVED FIELD IRRIGATION SYSTEM PROVED A SUSTAINABLE WEED MANAGEMENT STRATEGY IN COTTON CROP

A Aplicação em Pré e Pós-Emergência de Herbicida sob Sistema de Irrigação Melhorado Provou ser Estratégia Sustentável no Controle de Plantas Daninhas em Cultivo de Algodão

ABSTRACT - Successful weed control in cotton crop is an imperative as weeds not only reduce the cotton production but also deteriorate the lint quality and harbor insect pest. Thus a field study was carried out to evaluate the various weed control strategies under different irrigation systems. Pendimethlin (pre-emergence), S-metolachlor (pre-emergence), glyphosate (post emergence) were used alone or in combination as chemical weedicides along with mechanical weeding under drip and furrow irrigation systems. Results showed that all the weed control treatments with drip irrigation significantly decrease weed density compared with weed control treatments where watering was practiced through furrow irrigation method. However, combined application of pendimethalin with glyphosate and S-metolachlor has significantly reduced the weed density. This combination also resulted in improved bolls per plant, boll weight, sympodial branches, seed cotton yield, ginning out turn, seed index, lint index and water use efficiency. These parameters were also improved under drip irrigation as compared to furrow irrigation system. In a nutshell it can be concluded that combination of post and pre-emergence herbicides improved the cotton lint yield and water productivity which can be further improved by adopting drip irrigation as appropriate irrigation system.

Keywords: *Gossypium hirsutum*, seed cotton, irrigation, weed density, ginning out turn and water use efficiency.

RESUMO - O controle bem sucedido de plantas daninhas na cultura do algodão é imperativo, pois elas não só reduzem a produção do algodão, como também destroem a qualidade da fibra e incentivam a praga de insetos. Portanto, um estudo de campo foi realizado para avaliar as várias estratégias de controle de plantas daninhas sob diferentes sistemas de irrigação. Pendimethalin (pré-emergência), S-metolachlor (pré-emergência) e glyphosate (pós-emergência) foram utilizados isoladamente ou em combinação com pesticidas químicos, juntamente com capina mecânica, em sistemas de irrigação de gotejamento e de sulco. Os resultados mostraram que todos os tratamentos de controle de plantas daninhas com irrigação por gotejamento diminuíram significativamente a densidade dessas plantas, em comparação com os tratamentos de controle em que a rega foi realizada através do método de irrigação por sulcos. No entanto, a aplicação combinada de pendimethalin com glyphosate e S-metolachlor reduziu significativamente a densidade de plantas daninhas. Essa combinação também resultou em melhoria

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de cápsulas por planta, peso da cápsula, ramos simpodiais, rendimento de algodão em caroço, descaroçamento, índice de sementes, índice de fiapos e eficiência do uso da água. Esses parâmetros também foram melhorados sob irrigação por gotejamento, em comparação com sulco. Em resumo, pode-se concluir que a combinação de pós e pré-emergência de herbicidas melhora o rendimento de fibra de algodão e produtividade da água, o que pode ainda ser melhorado se o sistema de irrigação por gotejamento for adotado adequadamente.

Palavras-chave: *Gossypium hirsutum*, algodão em caroço, irrigação, densidade de plantas daninhas, descaroçamento, utilização eficiente da água.

INTRODUCTION

Cotton crop is very important all over the world due to its utilities as fiber, feed, food, industrial products and demand of a huge population. Cotton crop also seems as more problematic crop due to higher pressure of insect pest compared to other crops. Although little pressure of insect attack can be reduced by the introduction of BT cotton, sustainable weed control has increasingly become a big challenge. Weed infestation in cotton seems most prominent among various yield-limiting factors, which need special attention for better crop productivity (Ali et al., 2013a; Nadeem et al., 2013; Bakhshkandi et al., 2014; Fuente et al., 2014). Crops have to compete against various narrow and broader leaf weeds during their entire growth period, while cotton is more sensitive to weeds at emergence for plants establishment (Papamichail et al., 2002; Cardoso et al., 2011; Tauseef et al., 2012). Weed population in the field not only competes for nutrition, moisture for their viability, but also affects plant roots by releasing secondary substances into the rhizosphere of the crop (Ali et al., 2005; Farooq et al., 2011).

Chemical weed control can be very useful against cotton weeds for their cost-effectiveness and quick action. Highest seed cotton yield was achieved with the combined use of pendimethalin and prometryne to control weeds in crop sown under ridges. Furthermore, this method was also found economically feasible when compared with other weed control strategies (Nadeem et al., 2013). Undoubtedly, chemical weed control has quick action and shows maximum results; but this technique can harm the environment. Our current scenario demands the sustainable weed control method, which has little or no destructive environmental impact. Various weed control strategies, such as the dab, mechanical, biological, chemical and allelopathic methods are practiced by farmers to fight these unwanted plants (Farooq et al., 2011; Marwat et al., 2013). Mechanical methods, such as manual or intercropping, are the most common practices of the farmers in the country. However, these practices are more expensive, difficult to conduct and laborious, thus, farmers were still in need for better weed management to enhance crop yield. Moreover, weeds cannot be fully eliminated among the crop (Irshad and Cheema, 2004; Dadari and Kuchinda, 2004; Ali et al., 2005; Papageorgiou et al., 2008; Ali et al., 2013a). Integrated weed management is an attractive environmentally friendly practice to eliminate weeds. In this system, all possible approaches as mechanical, chemical or biological are consider for successful weed management. Higher and economical cotton yield can be obtained with the integrated application of pendimethlin and mechanical methods (Ali et al., 2013b; Poddar et al., 2014).

Besides these strategies, weeds can also be controlled by proper input management i.e the use of fertilizers and irrigation, which indirectly favors weed emergence. In Pakistan, most of the farmers use conventional flood irrigation system, which causes not only water loss, but also stimulates the emergence of weeds. It is dire need of the time to examine other improved practices such as drip, sprinkler irrigation to reduce weed pressure, as well as to save a precious amount of irrigation water for sustainable crop production. Drip technology provides optimum moisture in the root of crops, which reduces the share of moisture to unwanted plants (Bükün and Uygur, 2003; Choudhary et al., 2012). Although drip irrigation requires higher initial installation cost, but its major advantages, such as high cost-benefit ratio, minimum disease, pest incidence, and lower energy and labor, compensate for its higher initial cost (Choudhary et al., 2006; Ertek et al., 2007). Keeping in view the above discussion, the present study has been planned to determine the efficacy of pre and post emergence herbicides under different irrigation systems.

MATERIALS AND METHODS

Research Area and Soil

Experiment was conducted at Central Cotton Research Institute (CCRI), Multan (Pakistan) in order to explore the impact of integrated weed management strategies under different irrigation practices. Climate of the experimental area was semi-arid with high temperature, low rainfall, and windy during the months of Jun, July (Figure 1 and 2). Field study was conducted to evaluate the best weed management practice under the drip and furrow irrigation method. Experiment was laid out in a randomized complete block design with split plot arrangement, keeping irrigation treatment in main plot and different weed control practices in sub plot with three replications with a net plot size of 7 m x 3 m. Treatments were; M_0: Weedy Check, M_1: pendimethalin (2.5 L ha^{-1} at pre-emergence), M_2: S metolachlor (2.0 L ha^{-1} as pre-emergence), M_3: glyphosate (4.7 L ha^{-1} as post-emergence), M_4: pendimethalin (2.5 L ha^{-1}) + glyphosate (4.7 L ha^{-1}), M_5: S-metolachlor (2.0 L ha^{-1}) + glyphosate (4.7 L ha^{-1}) and M_6: Manual weeding under Drip (I_1) and furrow (I_2) irrigation system.

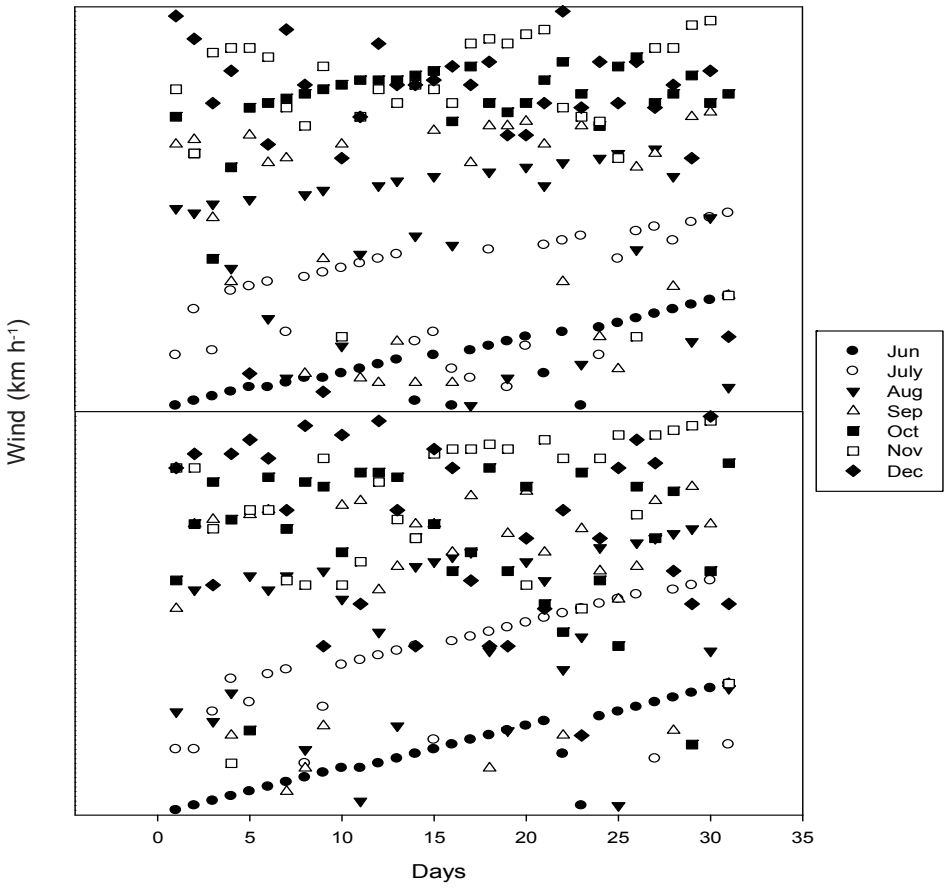

Figure 1 - Daily wind speed (km h^{-1}) during the year of 2009 and 2010.

Crop husbandry

Soil was prepared by using primary and secondary tillage implements such as chisel plough, rotator and cultivator. After ploughing, planking was done to make the soil leveled and pulverized. Cotton cultivar CIM-557 was sown on well prepared seed bed on 21st and 18th May in two successive years. Crop was sown on beds keeping row to row distance of 75 cm and plant to plant distance was maintained as 25 cm. The pre-emergence herbicide i.e., pendimethalin was sprayed by knap sack hand sprayer same day before sowing in their respective plots. The crop was planted

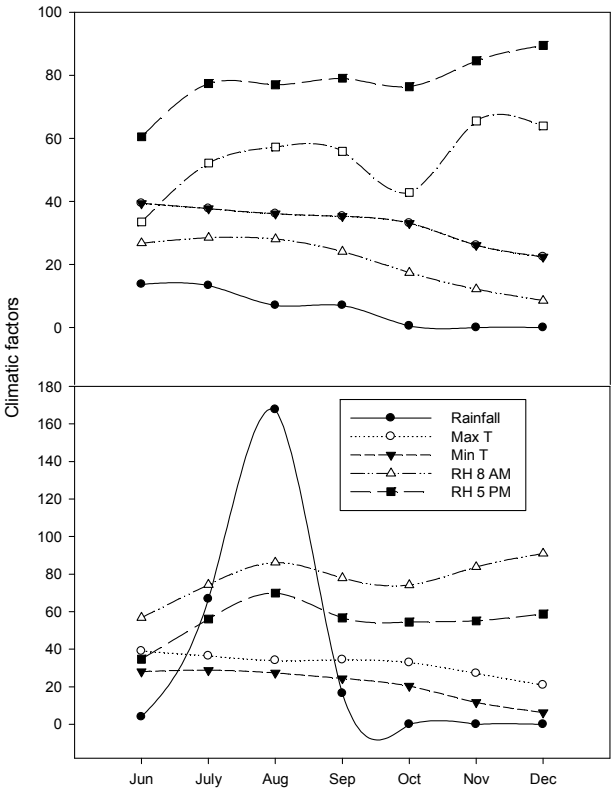

Figure 2 - Climatic factors during the year of 2009 and 2010.

by dibbling of seeds manually. The other pre-emergence herbicides i.e., S-metolachlor were sprayed 24 hours after sowing in their respective plots. The post emergence herbicide i.e. glyphosate at the rate of 4.7 liters per hectare was sprayed by knap sack hand sprayer with shield at nozzle to protect the crop at appropriate time. Two manual weeding were carried out at 25 and 45 days after sowing in respective plots. Drip irrigation system was installed in their respective plots. However, the remaining plots were irrigated by furrow irrigation system for this study. The recommended dose (115 kg ha^{-1}) of nitrogen fertilizer was applied in the form of Urea (46% N) and basal dose of phosphorus was applied at the rate of 57 kg P_2O_5 ha^{-1} in the form of triple super phosphate (46% P_2O_5). Nitrogen was applied in three splits to reduce the volatilization losses. First dose was applied at the time of crop sowing while other amount of nitrogen was applied at first and second irrigation. After 60 days of crop sowing, the weed density (m^{-2}) was measured randomly from every plot. Weeds were uprooted and fresh weight was calculated. Furthermore, collected weeds were air dried and oven dried at 70 °C for about 24 hours for calculating dry weight. Cultural practices like protection measures were made out accordingly as and when required by the plant.

Yield parameters

Plant height of four plants (free of mechanical or terminal damage or without obvious defects) was measured with scalar from cotyledon node to the top of the terminal bud. The total number of bolls (either open or closed) per plant was recorded randomly from four selected plants of each treatment. Furthermore, fully opened one hundred bolls were randomly picked from each treatment. The boll weight (g) was recorded at maturity stage and results were presented on average boll weight basis. At the time of harvesting, seed cotton yield was calculated on the basis of plot size and then converted into kg ha^{-1} by using the following formula

$$\text{Seed cotton yield (kg ha}^{-1}\text{)} = \frac{\text{Seed cotton weight (kg) plot}^{-1} \times 43560\ \text{ft}^2 \times 2.471}{\text{Plot size (ft}^2\text{)}}$$

Quality parameters

The seed cotton obtained from net plot area was mixed thoroughly (treatment wise) and 100 g sample was drawn from all treatments for quality test. The seed cotton was ginned separately treatment wise with a hand gin. Ginning out turn percentage was calculated by using the following formula.

$$Ginning\ percentage = \frac{Weight\ of\ lint\ (g)}{Weight\ of\ seed\ cotton\ (g)} \times 100$$

After ginning, 100 seeds were randomly taken from each treatment. Seed index was calculated by weighing 100 seeds. Moreover water use efficiency was measured by following equation:

$$WUE\ (kg\ mm^{-1}) = \frac{Seed\ cotton\ yield\ (kg\ ha^{-1})}{Total\ quantity\ of\ water\ applied\ (mm)}$$

Statistical analysis

The collected data at different growth phases was enumerated and analyzed by using appropriate advanced statistical technique "MSTAT-C" in order to check the effectiveness of treatments at probability level of 5 and 1% through LSD test. Correlation and regression analyses methods were used to test statistical significance of association between yield and yield components (Steel et al., 1997).

RESULTS AND DISCUSSION

Weed density (m^{-2}), weed dry weight (g m^{-2}) at 60 DAS and plant height

All treatments of drip irrigation practices tended to a significant decrease (19-24%) of total weed density in all the treatments as compared to treatments where watering was conducted through the furrow irrigation method at 60 days after sowing (DAS). Regarding weed management practices, application of glyphosate alone or in combination with pendimethalin or S-metolachlor had given the significant control up to 90-95% as compared to manual weeding showing weed control of 88%, S-metolachlor (57%) and pendimethalin (49%) during study period of 2009.

Drip and furrow irrigation maintained up to 69.9 and 101.3 g m^{-2} for weeds dry weight during 2009. Drip and furrow irrigation also maintained similarly up to 84.7 and 114.0 g m^{-2} for weeds dry weight during period of 2010, respectively. In addition to this, all the treatments associating glyphosate use had given maximum weed control. However, minimum total weeds dry matter (8.1 and 12.3 g m^{-2}) was achieved in the treatments where glyphosate was applied after spraying of S-metolachlor during both years. Hence, spraying of pendimethalin, S-metolachlor, glyphosate (alone or combined with S-metolachlor or pendimethalin) and adoption of manual weeding had efficiently suppressed weeds at up to 42-46%, 45-49%, 94-96% and 90-92% over control treatment, respectively (Table 1).

Table 1 - Effect of different chemical and mechanical weed management practices under different irrigation methods on weeds density, weed dry matter and plant height

Treatment	Weed density (60 DAS)		Weed Dry Matter (60 DAS)		Plant Height (150 DAS)	
	2009	2010	2009	2010	2009	2010
Irrigation systems						
I_1	77.9 b	87.5 b	69.9 b	84.7 b	93.2 a	83.0 a
I_2	102.7 a	108.4 a	101.3 a	114.0 a	81.4 b	75.4 b
LSD	10.39	3.06	13.86	12.49	8.46	7.17
Weed management						
M_0	284.8 a	286.3 a	257.9 a	308.7 a	74.2 d	68.6 d
M_1	145.0 b	149.7 b	148.1 b	166.5 b	89.0 bc	78.9 bc
M_2	121.3 c	123.8 c	140.9 b	155.5 c	89.6 bc	80.8 b
M_3	17.8 e	31.3 d	11.0 d	15.8 e	79.7 c	74.8 c
M_4	16.2 e	28.7 d	9.4 d	13.6 e	91.7 ab	82.3 ab
M_5	14.2 e	26.2 d	8.1 d	12.3 e	92.4 ab	83.7 ab
M_6	32.8 d	39.7 d	24.0 c	23.2 d	94.6 a	85.5 a
LSD	12.94	14.74	9.75	9.81	4.70	4.63

I_1: Drip irrigation, I_2: Furrow irrigation, M_0: Untreated, M_1: Pendimethalin (2.5 L ha^{-1}), M_2: S-metolachlor (2 L ha^{-1}), M_3: Glyphosate (4.7 L ha^{-1}), M_4: Pendimethalin + glyphosate, M_5: S-metolachlor + glyphosate, M_6: Manual weeding.

Results proved that the drip irrigation method has produced taller plants as compared to the furrow irrigation method throughout the entire plant growth period during both crop seasons (2009-10). In weeds management practices, significantly taller plants were achieved by manual weeding, which is statistically at par with the treatments where S-metolachlor and pendimethalin were applied in combination with glyphosate. However, glyphosate applied alone produced the shortest plants (Table 1).

Number of bolls per plant

It was noted that the drip irrigation method has significantly produced (P≤0.05) higher number of bolls per plant as compared to the furrow irrigation method throughout crop growth during both crop seasons. In addition, all weed management practices have significantly (P≤0.01 and 0.05) produced higher number of bolls than control treatments during both seasons throughout crop growth. During both years, manual weeding produced greater number of bolls per plant than all other weed management practices, which is followed by the combination of S-metolachlor and glyphosate. Hence, among all weed management practices, glyphosate alone gave significantly minimum numbers of bolls per plant as compared to other weed eradication techniques (Table 2).

Chlorophyll content (SPAD value)

It was noted that the drip irrigation method significantly produced (P≤0.05) higher chlorophyll contents as compared to the furrow irrigation method. In addition, all weed management practices significantly (P≤0.01 and 0.05) showed higher chlorophyll contents than control treatments during both seasons at each sampling stage. During both years, manual weeding produced leaves with greater chlorophyll rate than all other weed management practices which is followed by the S-metolachlor + glyphosate and pendimethalin + glyphosate at 150 DAS (Table 2).

Boll weight (g)

Among irrigation systems, drip irrigation significantly improved the boll weight in both cropping seasons. Morever, manual weeding gave significantly highest boll weight (3.10 g) which remained

Table 2 - Effect of different chemical and mechanical weed management practices under different Irrigation systems on Number of bolls per plant, SPAD value and Sympodial branches

Treatment	No. of bolls per plant (150 DAS)		SPAD value (150 DAS)		Sympodial branches	
	2009	2010	2009	2010	2009	2010
Irrigation systems						
I_1	25.1a	23.4a	46.8a	46.4	24.1a	23.3a
I_2	21.7b	20.7b	40.7b	42.0	21.5b	20.3b
LSD	3.03	2.61	5.39	NS	2.36	2.68
Weed management						
M_0	16.0e	15.3i	38.4bc	39.2b	19.6b	18.5c
M_1	22.2cd	20.6e	42.6ab	44.4ab	22.8ab	21.4ab
M_2	23.8cd	22.2d	44.7ab	46.0a	23.6a	22.2a
M_3	21.8d	18.5f	42.3ab	42.6b	21.5b	20.0bc
M_4	24.8bc	24.3bc	45.6ab	44.2ab	24.3a	23.1a
M_5	26.8ab	25.5b	46.2a	45.8ab	25.5a	23.5a
M_6	28.4a	27.8a	46.6a	47.2a	25.6a	23.9a
LSD	2.60	1.71	4.69	4.83	2.44	1.98

I_1: Drip irrigation, I_2: Furrow irrigation, M_0: Untreated, M_1: Pendimethalin (2.5 L ha^{-1}), M_2: S-metolachlor (2 L ha^{-1}), M_3: Glyphosate (4.7 L ha^{-1}), M_4: Pendimethalin + glyphosate, M_4: Pendimethalin + glyphosate, M_5: S-metolachlor + glyphosate, M_6: Manual weeding.

at par level with S-metolachlor + glyphosate (3.09 g), pendimethalin + glyphosate (3.06), glyphosate (3.01 g), S-metolachlor (3.06 g) and pendimethalin (3.04 g) as compared to untreated check (2.87 g). It was equidistantly noted during 2010 that all treatments including pendimethalin (2.99 g), S-metolachlor (3.04 g), glyphosate (2.96 g), pendimethalin + glyphosate (3.03 g), S-metolachlor + glyphosate (3.06 g) and manual weeding (3.07 g) produced significantly similar boll weight. However, it was amazingly noticed from the results that glyphosate applied alone treatments showed higher boll weight than control but results were non-significant (Table 3).

Seed cotton yield kg ha^{-1}

Maximum seed Cotton yields (1842.8 and 1537.4 kg ha^{-1}) were obtained by the drip irrigation method that was approximately 10 and 16 percent higher as compared to the furrow irrigation method (1686.5 and 1333.8 kg ha^{-1}) during 2009 and 2010, respectively.

All chemical and mechanical weed management methods gave significantly (P≤0.01 and 0.05) higher yield than control treatments. Maximum yield (2254.7 and 1799.5 kg ha^{-1}) was produced by the manual weeding which were at par with the application of S-metolachlor + glyphosate (2146.7 kg ha^{-1}) during 2009. While S-metolachlor + glyphosate (1714.8 kg ha^{-1}) and pendimethalin + glyphosate (1662.5 kg ha^{-1}) were differer non-significantly with each other. However, pendimethalin and S-metolachlor alone gave significantly similar values i.e., 1888.5 and 1751.8 kg ha^{-1} during 2009 and 1425.2 and 1477.3 kg ha^{-1} during 2010, respectively. During both years, separate application of glyphosate produced significantly minimum yield (1317.3 and 1200.2 kg ha^{-1}) than other weed management practices. Hence, lowest yield was obtained in control treatments (Table 3).

Ginning out turn percentage (GOT %)

Data showed that drip irrigation significantly (P≤0.05) yielded higher GOT % than furrow irrigation method. Similar to weed management practices, manual weeding significantly improved GOT percentage (43.2 and 42.3%) than other weed control treatments followed by S-metolachlor + glyphosate (40.8 and 40.7%) and pendimethalin + glyphosate (40.3 and 40.4%). All other treatments gave non-significantly higher percentages of ginning out turn than control treatment.

Table 3 - Effect of different chemical and mechanical weed management practices under different Irrigation systems, on boll weight, seed cotton yield and GOT

Treatment	Boll weight (g)		Seed Cotton yield (kg ha^{-1})		GOT (%)	
	2009	2010	2009	2010	2009	2010
Irrigation systems						
I_1	3.13a	3.07a	1842.8a	1537.4a	40.8a	40.8a
I_2	2.93b	2.92b	1686.5b	1333.8b	39.3b	39.3b
LSD	0.16	0.14	152.63	168.93	1.39	1.17
Weed management						
M_0	2.87b	2.81b	936.0d	769.7d	38.0c	38.7c
M_1	3.04a	2.99ab	1751.8b	1425.2b	39.7b	39.7bc
M_2	3.06a	3.04a	1888.5ab	1477.3b	39.5b	39.3bc
M_3	3.01a	2.96ab	1317.3c	1200.2c	38.6bc	39.2c
M_4	3.06a	3.03a	2057.5a	1662.5a	40.3b	40.4b
M_5	3.09a	3.06a	2146.7a	1714.8a	40.8b	40.7b
M_6	3.10a	3.07a	2254.7a	1799.5a	43.2a	42.3a
LSD	0.13	0.164	210.20	218.98	2.16	1.20

I_1: Drip irrigation, I_2: Furrow irrigation, M_0: Untreated, M_1: Pendimethalin (2.5 L ha^{-1}), M_2: S-metolachlor (2 L ha^{-1}), M_3: Glyphosate (4.7 L ha^{-1}), M_4: Pendimethalin + glyphosate, M_4: Pendimethalin + glyphosate, M_5: S-metolachlor + glyphosate, M_6: Manual weeding.

Regarding weeds management practices, manual weeding significantly yielded the maximum lint index (6.7 g) which was followed by S-metolachlor + glyphosate (5.9 g), pendimethalin + glyphosate (5.8 g), S-metolachlor alone (5.5 g) and pendimethalin alone (5.5 g) during 2009. However glyphosate alone treatment tended to increase the lint index than control but the results were non-significant. During 2010, manual weeding significantly and in equally pattern yielded the maximum lint index (6.4 g) which was followed by S-metolachlor + glyphosate (5.8 g), pendimethalin + glyphosate (5.6 g). However, treatments associating alone application of S-metolaclor, pendimethalin and glyphosate had resulted non-significantly increased lint index than untreated check (Table 3).

Water use efficiency

Data pertaining to water use efficiency indicated that all the drip irrigated treatments significantly (P≤0.05) increase the water use efficiency (2.2 and 3.1 kg ha^{-1} mm^{-1}) than furrow irrigation treatments (1.5 and 1.7 kg ha^{-1} mm^{-1}). During 2009, manual weeding showed highest water use efficiency (2.5 kg ha^{-1} mm^{-1}) which remained significant (P≤0.05) with S-metolachlor + glyphosate (2.2 kg ha^{-1} mm^{-1}). While pendimethalin + glyphosate (2.1 kg ha^{-1} mm^{-1}), S-metolachlor (1.9 kg ha^{-1} mm^{-1}) alone showed similar water use efficiency. It was noted during 2010 that all the treatments including pendimethalin + glyphosate (2.8 kg ha^{-1} mm^{-1}), S-metolachlor + glyphosate (2.9 kg ha^{-1} mm^{-1}) and manual weeding (3.0 kg ha^{-1} mm^{-1}) responded analogously for water use efficiency. Control treatments showed minimum (1.0 and 1.3 kg ha^{-1} mm^{-1}) water use efficiency during both cropping years (Table 4).

Seed index (g)

It was evident from the results that the drip irrigation method significantly (P≤0.05) produced more seed index (8.7 and 8.4 g) than furrow irrigation method (7.9 and 7.9 g) during both crop seasons. All weed management practices (except glyphosate applied alone) significantly (P≤0.05) showed higher seed index than control. Glyphosate alone non-significantly improved seed index than control treatment. Regarding weeds management practices, manual weeding significantly maximum seed index (8.7 g) which was followed by S-metolachlor + glyphosate (8.6 g), pendimethalin + glyphosate (8.4 g), and S-metolachlor alone (8.4 g) during 2009. However, treatments associating alone application of S-metolachlor, pendimethalin and glyphosate had

Table 4 - Effect of different chemical and mechanical weed management practices under different Irrigation systems, on seed index, lint index and WUE

Treatment	Seed index (g)		Lint index		WUE	
	2009	2010	2009	2010	2009	2010
Irrigation systems						
I_1	8.7a	8.4a	6.1a	5.8a	2.2a	3.1a
I_2	7.9b	7.9b	5.1b	5.1b	1.5b	1.7b
LSD	0.74	0.58	0.09	0.03	0.03	0.03
Weed management						
M_0	7.7b	7.7c	4.7e	4.9f	1.0f	1.3d
M_1	8.3a	8.0bc	5.5c	5.2d	1.7d	2.4b
M_2	8.4a	8.2ab	5.5c	5.3d	1.9c	2.5b
M_3	8.0ab	7.8c	5.0d	5.1de	1.5e	2.0c
M_4	8.4a	8.3ab	5.8b	5.6c	2.1b	2.8ab
M_5	8.6a	8.4a	5.9b	5.8b	2.2b	2.9a
M_6	8.7a	8.7a	6.7a	6.4a	2.5a	3.0a
LSD	0.42	0.38	0.20	0.11	0.09	0.13

I_1: Drip irrigation, I_2: Furrow irrigation, M_0: Untreated, M_1: Pendimethalin (2.5 L ha^{-1}), M_2: S-metolachlor (2 L ha^{-1}), M_3: Glyphosate (4.7 L ha^{-1}), M_4: Pendimethalin + glyphosate, M_4: Pendimethalin + glyphosate, M_5: S-metolachlor + glyphosate, M_6: Manual weeding.

resulted non-significant trend for seed index. Similar trends were also recorded during 2010, but non-significant greatest seed index (8.7 g) was obtained by manual weeding than the treatment where S-metolachlor was applied in combination with glyphosate only. S-metolachlor + glyphosate (8.4 g), pendimethalin + glyphosate (8.3 g) and S-metolachlor alone (8.2 g) produced non-significant seed index. However, minimum seed index (7.7 g) was obtained by untreated during both years (2009-10) (Table 4).

Lint index (g)

It was clear from the results that the drip irrigation method significantly (P≤0.01 and 0.05) gave more lint index (6.1 and 5.8 g) than furrow irrigation method (5.1 and 5.1 g) during both crop seasons. In case of weed management stratigies, manual weeding performed better but it was followed with S-metolachlor + glyphosate and pendimethalin + glyphosate treatments combinations. Untreated plants significantly reduced the lint index and resulted in minimum value (Table 4).

Pertaining to our results, drip irrigation and all weed management practices significantly suppressed the weeds population and dry matter accumulation of weeds than control treatments. Glyphosate showed 90-95% weed control at 60 DAS. Basically, the drip irrigation provided optimum moisture and nutrition mainly comprised of growth element directly to the crop root. So, weeds growth was suppressed due to low moisture availability from the soil (Choudhary et al., 2012). Parallel to this, manual weed control has reduced growth and development of weeds. Resultantly, lush green Cotton crop boosted for secondary growth stages successfully. Glyphosate suppressed the remaining weeds more efficiently at lateral growth stages. It has been found by various scientists i.e., Mahar et al., (2007) Muhammad et al., (2011) Poddar et al., (2014) that manual weeding was best practice for suppressing (92-96%) weeds in Cotton. In addition, use of glyphosate, pendimethalin and S-Metolacholr at recommended dose has proved worthwhile in this regard (Cheema et al., 2005; Shaikh et al., 2006; Veeramani et al., 2008; Ikram et al; 2012; Ali et al., 2013a,b; Poddar et al., 2014).

The increment in yield and yield-related attributes by the application of water through drip irrigation strategy might be due to retention of soil moisture and soil friability by successive irrigation through drip method in order to complete the crop water requirements by equal quantification of evapotranspiration pull. Hullugale et al., (2002) found an improvement in chemical and physical characteristics of soil by adopting the drip irrigation method. Naturally, the flow of water from such method would ooze the similar quantity of water droplet, which resultantly fill the required soil porosity for the optimum growth and development of crop plants. In such circumstances, availability of nutrient from soil solution might become optimized, resulting a lush green growth by increasing the chlorophyll contents as compared to flooding or furrow irrigation practices. Thorburn et al., (2002) Chaudhary et al., (2006) Tiwari et al., (2014) and concluded that water and chemicals delivery to the root zone of plants can be more efficient through the drip irrigation method than any other irrigation system.

In contrarily, furrow method provides water on surface which initiates the crust formation and also increased the water loss through evaporation, percolation and run off mechanisms. Soil particles intacted with fertilizer are also lost due to such mechanism. Prior to this, huge quantity of water is lost which results in soil compactness that inturn hampers the germination percentage. Similarly, Sagarka et al., (2002) Chaudhary et al., (2012) and concluded that irrigation by furrow method would severely hamper plant growth and yield. Moreover, Shirahatti et al., (2007) also observed an increase of 28 and 10% in net return yield through drip method as compared to surface irrigation when applied in same quantity and 50 percent of water respectively. Yield was increased by the application of irrigation water through drip method (Grabow et al., 2006; Hassanli et al., 2009; Chaudhary et al., 2012; Tiwari et al., 2014).

All weed control treatments gave higher yield with greater boll weight, seed index and GOT %. This might be due to uniform availability of quality nutrition to crop by suppressing weed infestation for nutrition disorder in the existing eco-system. Raskar and Bhoj (2002); Ali et al., (2005); Awan et al., (2009); Ali et al., (2013a); Nadeem et al., (2013); Poddar et al., (2014).

The proper supply of water to plant roots might increase staple length, fiber strength, uniformity percentage and micronaire. Lansford et al., (2004) also observed that water stress directly affects the lint yield and quality of Cotton crop. Drip irrigation improved Cotton fiber length than overhead sprinkler irrigation method (Nuti et al., 2006). However, weed management practices also increased staple length. This might be associated with the availability of nutrients from the soil solution, due to reduced growth of weeds through different management strategies. Ali et al., (2013b) also found an improvement of staple length of fiber through intrusion of optimum balanced fertilizer and reduced weed infestation by suitable management scheme. Blaise, (2006) observed inconsistent trends with regards to effects of chemical and cultural weed management techniques on fiber quality.

Water use efficiency was significantly greater for drip irrigated treatments than for furrow irrigated treatments. It might be due to the equal supply of water, decrease evaporation rate, and easy availability of water and nutrients within the root zone. Different weed management practices gave higher water use efficiency than control. The main reason for this is less infestation of weeds in these treatments, which provide sufficient quantity of water for proper growth and development of Cotton crop. Ayars et al., (1999) Grabow et al., (2006); Hassanli et al., (2009), also found highest water use efficiency through drip irrigation method. It can be concluded that combination of post and pre-emergence herbicides improved cotton and water productivity, which can further be enhanced through the employment of an appropriate irrigation system.

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