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Research Article

Water Saving Techniques and Water Use Efficiency Through Cultural Operations in Cotton

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Background

Two experiments were conducted to determine the cotton seed response to different irrigation levels and water use efficiency of cotton crop (*G. hirsutum* L.) sown under different cultural operations. These experiments were conducted at Regional agricultural research institute Bahawalpur Punjab, Pakistan in 2015-16. Three levels of irrigations were used 3,4 and 5, which were applied (45, 80 and 110), (45, 80, 95, 110) and (45, 65, 89, 95 and 110) days after sowing respectively. The cultural operations were, are control (simple hoeing), earthing up after the 1st irrigation (manually), ridge making in every row after the 1st irrigation, alternate row and earthing up after the 1st irrigation. Cotton crop secured maximum benefits from the available moisture in both years in alternate row and earthing up after the 1st irrigation by giving maximum water use efficiency 7.3 kg ha^{-1} mm^{-1} and maximum seed cotton yield 2552.3 kg/ha with 3 irrigations.

Keywords: Cotton; Water Saving Techniques; Water Use Efficiency; Cultural Operations

Introduction

Cotton (*G. hirsutum* L.) is very important cash crop and plays a significant role in the economy of Pakistan. Cotton crop have more than one use, it gives raw materials for oil, textile and many other industries. *G. hirsutum* L. share in the national GDP is 1% and it contributes in other agricultural valuable by products about 5.2% [1].

In agriculture, irrigation is one of the highly important factors for good production especially in arid or semi-arid regions of the world [2], and it also ensures the good crop yield [3,4]. Like all other crops, cotton crop water requirement chiefly dependent on condition of the environment. As the external environment turn into dryer and hotter than normal, water requirement of the plant also increases [5]. A wrong perception is made about cotton plant that it need excess amount of water, but cotton is drought tolerant crop [6]. Global-water foot print of cotton crop is about 2.6% of the total world's water use [7]. Cotton crop required 172.6 mm irrigation water whole growing season. Water requirement of cotton crop observed highest from August-September [6].

In recent years, water demand increases and water supply is limited, this leading Pakistan towards severe shortage of water. Pakistan is mainly dependent on Indus River and its tributaries which supplies about 140 MAF/annum. It makes the country quite vulnerable to depend on a single basin. About 90% of the Pakistan land categories as semi-arid and receive very low rainfall with seasonal variations [8].

WUE is a selection criterion to improve the yield of the crop under moisture stress condition and it also evaluate the best way of water application and its depth [9]. Adopting suitable planting geometry and water management strategy resulted in successful crop production by increasing WUE this is the most serious problem in the cotton growing zone, where canal water only the source of irrigation and underground water is almost blackish and the fresh water is being reduced day by day. Best water use efficiency (WUE) can be attained through adopting most appropriate water management practices [10].

This study is undertaken to estimate most suitable planting method for cotton crop to enhance water use efficiency (WUE) and seed cotton yield per ha.

Methodology

Site description

This research was conducted at Regional agricultural research institute Bahawalpur Punjab, Pakistan. District of Bahawalpur has very dry climate in summer as well as in winter. Maximum and minimum temperature of Bahawalpur district is 48°C and 7°C respectively with an average annual rain fall of 200 mm [11]. Bahawalpur district located at the map of Pakistan with the coordinates of GPS 29° 23' 44.5956'' N and 71° 41' 0.00244'' E [12]. Layout design which is used in this research is split plot design.

Layout

Layout design consist of three major plots, each plot has different irrigation numbers. In the 1st plot three irrigation was applied with the 45, 80 and 110 days intervals. In the 2nd plot 4 irrigation was applied at 45, 80, 95, 110 days and in the 3rd plot 5 were applied with the interval of irrigation application was 45, 65, 89, 95 and 110 days after sowing. These three major plots were divided into the four sub plots and treatments are control (simple hoeing) (P1), earthing up after the 1st irrigation (manually) (P2), ridge making in every row after the 1st irrigation (P3), alternate row and earthing up after the 1st irrigation in these plots (P4). Irrigation was applied with cut throat flume by using the formula t= Ad/Q or Qt= Ad. Rouni irrigation was 10.1 cm and other subsequent irrigation was 7.7 cm in depth. FH-114 cotton variety are sown in all plots of three replications and apply recommended dose of fertilizer to the cotton crop. Cotton crop yield (seed cotton) data were recorded and WUE was calculated by using given Viets (1962) [13] formula

$$WUE = \frac{\text{Economic Yield}}{\textit{Water used to Produced Yield } (I+R)}$$

I= Irrigation

R= Rain

Statistical analysis

This research was Randomized Complete Block Design (RCBD) with each treatment was replicated three times. The data collection was subjected to statistical analysis by using split plot analysis of variance (ANOVA). All treatments mean was further compared through Least Significance Difference (LSD) at alpha value 0.05 using statistix software (version 10.0).

Results and Discussion

Effect of cultural practices on plant height

Results of our both growing seasons showed that mean height of the plants was significantly affected which are shown in the Table 2 and 3**.** Results of 2015 experiment indicated that cotton plant showed maximum mean plant height 171.42 cm and 171 cm with the 4 and 5 irrigations respectively. Which were not significantly changed. While in the cultural practices treatment, cotton plant height was not significantly changed among the cultural practices and showed maximum result 171.22 cm in the control treatment. In the comparison among the treatment plant gave maximum height 173.67 cm in control treatment with five irrigations and minimum result was 159.33 cm in the earthing up after the 1st irrigation treatment with three irrigations. Similarly, in the 2016 experiment cotton crop showed best result in the 4 and 5 irrigations which are not significantly changed and gave maximum height 160.17 cm. In the comparison among the treatment plant gave maximum height 162 cm in control treatment with five irrigations and minimum result was 142 cm in the earthing up after the 1st irrigation treatment with three irrigations.

Rep3	P1	I4 P3	P2	P4	P3	P2	I3 P4	P1	P2	P4	I5 P1	P3
Rep2	P3	P2	I3 P4	P1	P2	P4	I5 P1	P3	P4	P2	I3 P3	P1
Rep1	P1	I3 P2	P3	P4	P3	P2	I4 P4	P1	P2	P4	I5 P1	P3

Table 1: RCBD Layout design of treated research area.

Treatment	Control	Earthing up after the 1st irrigation	Ridge in every row after 1st irrigation	Alternate row and earthing up after 1st irrigation	Mean
Irrigation 3	169.33 AB	159.33 C	167.00 B	167.00 B	165.67 B
Irrigation 4	170.67 AB	170.67 AB	172.67 AB	170.00 AB	171.00 A
Irrigation 5	173.67 A	171.00 AB	169.00 AB	172.00 AB	171.42 A
Mean	171.22 A	167.00 B	169.56 AB	169.67 AB	

Table 2: Plant height of cotton plant under different cultural practices in 2015.

Treatment	Control	Earthing up after the 1st irrigation	Ridge in every row after 1st irrigation	Alternate row and earthing up after 1st irrigation	Mean
Irrigation 3	148.00 ABCD	142.00 D	142.67 CD	146.33 BCD	144.75 B
Irrigation 4	148.33 ABCD	160.33 AB	157.00 ABC	154.67 ABCD	155.08 A
Irrigation 5	162.00 A	161.67 A	158.67 AB	158.67 AB	160.17 A
Mean	152.78 A	154.67 A	152.78 A	153.11 A	

Table 3: Plant height of cotton plant under different cultural practices in 2016.

Effect of cultural practices on bolls

No of boll per plant displayed non-significant change among the treatments in 1st growing season (2015) which are shown in Table 4. Result showed maximum mean 30.333 No of bolls per plant with the 5 irrigations. Where as in the cultural practices maximum 31.11 No of bolls per plant are produced with earthing up after the first irrigation (P2). In the interaction among treatments are also non-significant, results of this showed that maximum No of bolls per plant was 31.66 with 3 irrigations and ridge making in every row after the first irrigation (P3) and minimum No of bolls per plant was 29 with three irrigations and control treatment (P1). Table 5 predicted that cultural practices had non-significant influence on seed cotton yield per ha. Result indicated that maximum mean seed cotton per ha were obtained from 4 irrigations 2603.8 kg ha^{-1}. Where as in cultural practices maximum 2747.7 kg ha^{-1} seed cotton yield was observed in alternate row and earthing up after the 1st irrigation (P4) with 5 irrigations and minimum 1931.8 kg ha^{-1} seed cotton yield in ridge in every row after 1st irrigation (P3) with 3 irrigation.

Treatment	Control	Earthing up after the 1st irrigation	Ridge in every row after 1st irrigation	Alternate row and earthing up after 1st irrigation	Mean
Irrigation 3	29.000 A	31.333 A	31.667 A	29.000 A	30.250 A
Irrigation 4	29.667 A	31.333 A	30.333 A	29.667 A	30.250 A
Irrigation 5	30.333 A	30.667 A	29.667 A	30.667 A	30.333 A
Mean	29.667 A	31.11 A	30.556 A	29.778 A	

Table 4: No of mean bolls/ plant in cotton under different cultural practices in 2015.

Treatment	Control	Earthing up after the 1st irrigation	Ridge in every row after 1st irrigation	Alternate row and earthing up after 1st irrigation	Mean
Irrigation 3	1971.7 A	1933.7B	1931.8 B	2551.3 A	2097.1 A
Irrigation 4	2339.7 B	2434.3 B	2459.7 AB	2604.7 AB	2603.8 A
Irrigation 5	2442.0 B	2595.7 AB	2630.0 AB	2747.7 AB	2459.6 A
Mean	2917.8 A	2469.9 A	2489.8 A	2634.6 A	

Table 5: Seed cotton ha^{-1} under different cultural practices in 2015.

Table 6 showed the non-significant results of No of bolls per plant of cotton crop in 2nd growing season (2016). In results maximum mean 28.917 No of bolls per plant with five irrigations are obtained. Where as in cultural practices maximum mean 28.889 No of bolls per plant are obtained with alternate row and earthing up after the 1st irrigation (P4). In comparison among the treatment which are not significantly changed. Results of this showed that maximum No of bolls per plant was 30.333 with five irrigations and alternate row and earthing up after the first irrigations. While minimum 25 No of bolls per plant with 3 irrigations and the control treatment (P4). Table 7 predicted seed cotton yield per ha which is not significantly influenced by the cultural practices. Result indicated that maximum mean 2415.6 kg ha^{-1} seed cotton yield per ha was obtained from 5 irrigations which is significantly changed. Where as in cultural practices maximum mean 2405.1 seed cotton yield was obtained from alternate row and earthing up after the 1st irrigation treatment (P4). While in the interaction of different treatments gave maximum 2586 kg ha^{-1} seed cotton yield with 5 irrigations in alternate row and earthing up after the 1st irrigation treatment and minimum 1974.3 kg ha^{-1} seed cotton with 3 irrigations and control treatment (P1) which is not significantly different from each other.

Treatment	Control	Earthing up after the 1st irrigation	Ridge in every row after 1st irrigation	Alternate row and earthing up after 1st irrigation	Mean
Irrigation 3	25.000 A	26.000 A	27.667 A	27.000 A	26.417 A
Irrigation 4	27.333 A	28.667 A	28.333 A	30.333 A	28.667 A
Irrigation 5	27.667 A	29.000 A	29.667 A	29.333 A	28.917 A
Mean	26.667 A	27.889 A	28.556 A	28.889 A	

Table 6: No. of bolls/plant under different cultural practices in 2016.

Treatment	Control	Earthing up after the 1st irrigation	Ridge in every row after 1st irrigation	Alternate row and earthing up after 1st irrigation	Mean
Irrigation 3	1974.3 F	2085.3 EF	2071.7 EF	2252.0 CD	2095.8 C
Irrigation 4	2104.7 DEF	2146.7 DE	2182.7 DE	2377.3 BC	2202.8 B
Irrigation 5	2196.7 DE	2433.0 AB	2446.7 AB	2586.0 A	2415.6 A
Mean	2091.9 C	2221.7 B	2233.7 B	2405.1 A	

Table 7: Seed cotton ha-1 under different cultural practices in 2016.

Effect of cultural practices on WUE

Yield of seed cotton and water use efficiency in relation to cultural practices (Table 8 and 9) are told that cotton crop took maximum benefit from the available water in alternate row and earthing up after the 1st irrigation (P4) with 3 irrigations in both years and producing maximum seed cotton yield in both year were 2551.3 kg/ha and 2252 kg/ha respectively. Minimum yield of seed cotton was obtained in both years 2442 kg/ha and 2196.7 kg/ha in control treatment (P1) with 5 irrigations. Water use efficiency (WUE) significantly influenced by the cultural practices (Table). Maximum WUE was observed in both years (7.3 kg ha^{-1} mm^{-1} and 6.5 kg ha^{-1} mm^{-1}) in alternate row and earthing up after the 1st irrigation (P4). Minimum WUE was observed in both years (4.16 kg ha^{-1} mm^{-1} and 3.66 kg ha^{-1} mm^{-1}) in control treatment (P1).

Treatment	Cultural practices	Seed cotton ha^{-1}	Total Water Used	WUE
Irrigation 3	P1	1971.7	382	5.16
	P2	1933.7	362	5.34
	P3	1931.8	357	5.41
	P4	2551.3	348	7.33
Irrigation 4	P1	2339.7	459	5.09
	P2	2434.3	439	5.54
	P3	2459.7	425	5.78
	P4	2604.7	415	6.27
Irrigation 5	P1	2442.0	587	4.16
	P2	2595.7	544	4.77
	P3	2630.0	513	5.12
	P4	2747.7	498	5.51

Table 8: Effect of cultural practices on seed cotton and WUE in 2015.

Treatment	Cultural practices	Seed cotton ha^{-1}	Total Water Used	WUE
Irrigation 3	P1	1974.3	413	4.78
	P2	2085.3	378	5.51
	P3	2071.7	365	5.67
	P4	2252.0	345	6.52
Irrigation 4	P1	2104.7	465	4.52
	P2	2146.7	446	4.81
	P3	2182.7	434	5.02
	P4	2377.3	415	5.72
Irrigation 5	P1	2196.7	600	3.66
	P2	2433.0	567	4.29
	P3	2446.7	537	4.55
	P4	2586.0	524	4.93

Table 9: Effect of cultural practices on seed cotton and WUE in 2016.

These findings are compatible with [9,14,15] stated that water use efficiency of the crop can be increased by adopting most suitable irrigation system.

Conclusion

About 1% of national GDP is dependent on the cotton crop and the country is facing with the water scare conditions. So we concluded that by increasing the WUE of cotton crop per unit area by adopting major efforts of cultural practices. By this study we observed that Water use efficiency (WUE) significantly influenced by the cultural practices. Maximum WUE was observed in both years in alternate row and earthing up after the 3-irrigation. Minimum WUE was observed in both years in control treatment. By enhancing the water productivity, we can get maximum benefit by adopting the appropriate cultural practices according to the local edaphic and environmental conditions.

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