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Response of Cotton to Different Tillage Depth and Irrigation Levels in Southern Gujarat, India

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A B S T R A C T

A field experiment was conducted during *Kharif* season of 2008-2009 at the Main Cotton Research Station, Surat, Navsari. The soil of an experimental field was clayey in texture, medium in available nitrogen (297.9 kg ha^{-1}), medium in available phosphorus (49.19 kg ha^{-1}) and fairly rich in available potassium (528.5 kg ha^{-1}) with 7.5 pH. The experiment was conducted in split plot design, comprising three tillage depth in main plot *viz.* normal tillag eup to7.5 cm (Di), *tillage* up to 15 cm (D_2) and tillage up to 22.5 cm (D_3) and three irrigation levels in sub plot *viz.* two irrigations at 25 and 50 days after cessation of rainfall with 80 mm diw at each *irrigation* (I_2), two irrigations at 25 and 75 days after cessation of rainfall with 60 mm diw at each irrigation (I_2) and three *irrigations* at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation (l_3) were evaluated in split plot design with three replications. The results revealed that seed cotton (3918.90 kg ha^{-1}) and stalk yields (4119.12 kg ha^{-1}) The per cent increase in seed cotton yield by the treatment D_3 (tillage upto 22.5 cm) was to the tune of 21.34 and 62.96 per cent over D_2 (tillage upto 15 cm) and D_1 (tillage upto 7.5 cm) treatments, respectively. The treatment l_3 (three irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation) produced significantly the highest seed cotton (3340.31 kg ha^{-1}) and stalk (3686.86 kg ha^{-1}) yields. The increase in seed cotton yield due to the treatment I_3 (three irrigations at 25, 50 and 75 days after cessation of rainfall 60 mm diw at each irrigation) was 13.05 per cent higher over I_1 (25 and 50 days after cessation of rainfall with 80 mm diw at each irrigation). The highest nutrient content and uptake by plant was recorded in treatment I_3 (three irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diwat each irrigation). On the basis of experimental results, it can be concluded that the highest seed cotton yield and maximum net profit from *Kharif* cotton Cv. RCH-2 can be obtained by Ploughing the soil upto 22.5 cm depth with application of three irrigations each of 60 mm depth at 25, 50 and 75 days after cessation of rainfall with recommended dose of fertilizer.

Introduction

Cotton is a natural fiber of plant origin, like linen jute or hemp. India is the traditional home of cotton and textile. Indian economy has been consistently influenced and boosted by cotton through its production and processing sectors and by generating direct

and indirect employment to more than 8 million people. Cotton is also a vital crop of commerce popularly known as "WHITE GOLD' In South Gujarat, characterized by heavy rainfall zone and most of the farmers of this region adopted mechanical cultivation and continuous use of canal water for irrigation and use of high doses of chemical fertilizers without or very low application of organic manures in their field, thereby the soil of the South Gujarat zone was compacted with deterioration of the soil structure. Under such conditions cotton produces low yield and therefore is necessary to improve the soil health through proper soil management. For overcoming these situations, deep tillage and irrigation play a crucial role to improve soil health by increasing porosity and decreasing bulk density of soil and thereby increasing infiltration rate of the soil which increases the deep penetration of crop roots. In cotton crop, continuous wetness within rooting zone adversely affects the crop growth. Proper aeration is must for the proper function of the root growth. Therefore, irrigation scheduling based on rainfall cessation results in higher yield. Work on water requirement of cotton in India shows a wide range of results because there are several species in cotton having different life duration as well as growing seasons. Secondly, cotton being a *Kharif* crop in many regions the experiment is vitiated by variable rainfall pattern. Thirdly, the crop is grown on light soil as well as on heavy soils and therefore, frequency varies considerably with the soil type.

Materials and Methods

The field experiment was conducted in Cotton Research Station. Surat during the *Kharif* season of 2008-09. The Main Cotton Research Station, Surat is situated in South Gujarat at a cross point of 20^{o} – 12 'N latitude and 72^{o} – 52' longitude at elevation of 11.34 meters above the mean sea level. The average annual precipitation is 1187.7 mm. The total rainfall recorded during the year 2008-09 amounted to 1296.1 mm within 51 total rainy days, respectively during the crop growth period. Drained clayey soils which represent the typical black cotton soil of South Gujarat having predominate montmorillonite clay minerals by its organ and is medium in fertility. The experiment was conducted in split plot design, comprising three tillage depth in main plot *viz.* normal tillage up to 7.5 cm (Di), *tillage* up to 15 cm (D_2) and tillage up to 22.5 cm (D_3) and three irrigation levels in sub plot *viz.* two irrigations at 25 and 50 days after cessation of rainfall with 80 mm diw at each *irrigation* (I_2), two irrigations at 25 and 75 days after cessation of rainfall with 60 mm diw at each irrigation (I_2) and three *irrigations* at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation (l_3) were evaluated in split plot design with three replications. Cotton variety RCH-2 was used for experiment purpose. Crop was irrigated as per treatments based on rainfall cessations through canal irrigation water. Measured quantity of irrigation water was applied though through Parshalflume.

Water expense efficiency was calculated as described by Patel (1993).

$$\text{Water expense Efficiency (Kg ha mm}^{-1}) = \frac{\text{Seed cotton yield (kg/ha)}}{\text{Total quantity of irrigation water applied (mm)}}$$

Results and Discussion

Effect of tillage depth irrigation schedule on growth attributes

The significantly the tallest plant was observed at 120 DAS with tillage upto 22.5cm. Tillage depth increase root growth which favorably induces uptake of nutrients

and water as cotton is a deep rooted crop. Water holding capacity of soil also increases with better infiltration rate. Hence, deeper the tillage, more is the quantity of water stored in the soil and water is considered as essential input for plant growth. These findings corroborate the results of Triplett *et al.,* (1996) as well as Wiatrack *et al.,* (2005)

The significantly the tallest plant was obtained under scheduling of irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation at 120 DAS stages.

Dry matter accumulation of cotton was significantly higher with scheduling of irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation. Water storage capacity in soil and its efficient use due to better root development and distribution resulting significantly higher plant growth. These finding are on the line with the results of Stockon *et al.,* (1961) as well as Singh and Bhan (1993b).

Effect of tillage depth and irrigation scheduling on yield attributes and yield

Number of bolls per plant was significant and maximum value was noted under tillage depth upto 22.5 cm This might be due to profused vegetative growth ultimately more sympodial branches per plant provided better room for number of bolls. The results partial confirm the findings of Baker (1987), Solaiappan and Sheriff (1994) as well as Nayakatawa *et al.,* (2000).

The significantly highest seed (3918.90 kg ha-1) and stalk (4119.12 kg ha-1) yields were recorded with 22.5 cm tillage depth. This was because of favorable effect of deep Ploughing in improvement of growth attributes such as plant height, number of bolls per plant, dry matter accumulation and sympodial branch per plant as reported by Solaiappan and Sheriff (1994). Deep tillage improves physical condition and it would be favorable for seed germination, emergence, and nutrient availability and reduces weed population. These findings are in conformity with the results obtained by Gidda and Morey (1981), Adeoye (1982) as well as Triplett *et al.,* (1996).

The number of boll per plant was significantly highest under scheduling of irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation. This may be due to right time availability of water at reproductive stage which ultimately increased the number of bolls per plant. Similar results were obtained by Singh and Bhan (1993b).

This was due to sufficient availability of water through rainfall and irrigation scheduling at appropriate time resulted in favorable effect. The result corroborated the finding of Singh and Bhan (1993b). The number of boll per plant was significantly highest under scheduling of irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation.

This may be due to right time availability of water at reproductive stage which ultimately increased the number of bolls per plant. Similar results were obtained by Singh and Bhan (1993b). The scheduling of three irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation produced significantly higher seed cotton (3340.31kg ha^{-1}) and stalk (3686.86 kg ha^{-1}) yields (Table 1). This might be due to availability of right quantity of water at right time. At vegetative growth stage of cotton crop get water from rainfall and later at reproductive stage supplemented through irrigation. These findings are in conformity with the result obtained by Palchamy *et al.,* (1986), Khade *et al.,* (1988), Chimanshette *et al.,* (1990) as well as Singh and Singh (2000).

Table.1 Effect of tillage depth and irrigation levels on growth and yield of cotton

Treatment	Plant height 120 DAS (cm)	Dry matter accumulation (g plant^{-1})	Boll weight (g)	Number of bolls plant^{-1}	**Seed cotton yield (kg ha^{-1})**	**Stalk yield (kg ha^{-1})**	**Harvest index (%)**
Depth of tillage (D)							
Tillage upto 7.5 cm	74.2	203	3.8	38.1	2404	2889	45.5
Tillage upto 15 cm	86.8	257	3.9	44.3	3229	3394	48.7
Tillage upto 22.5 cm	96.4	279	4.1	48..3	3918	4119	48.6
S.E.±	2.3	3.18	0.07	1.12	64.1	63.03	0.87
CD (P = 0.05)	9.08	12.48	NS	4.40	251.8	247.4	NS
C.V. %	8.09	3.73	5.23	7.71	6.04	5.45	5.51
Irrigation level (I)							
2 irrigations at 25 and 50 DACR with 80 mm diw at each irrigation	81.5	246.9	3.94	41.6	2954	3262	47.3
2 irrigations at 25 and 75 DACR with 60 mm diw at each irrigation	85.8	257..8	3.97	43.8	3258	3453	48.2
3 irrigations at 25 and 50 and 75 DACR with 60 mm diw at each irrigation	90.0	263.1	4.05	45.3	3340	3686	47.2
S.Em. ±	1.02	2.70	0.06	0.70	49.6	32.7	0.3
CD (P = 0.05)	3.15	8.33	NS	2.14	152.8	110.1	NS
C.V.%	3..57	3.17	4.56	4.79	4.67	3.09	1.8
Interaction (D X I)							
S.Em.±	1.7	4.6	0.1	1.2	85.9	61.9	0.5
CD (P=0.05)	NS	NS	NS	NS	264.7	NS	1.6
C.V.%	3.5	3.1	4.5	4.7	4.6	3.0	1.8

Note: DACR: Days After Cessation of Rainfall

Table.2 Effect of tillage depth and irrigation levels on water expenses efficiency (kg ha mm^{1})

Treatment	Rainfall (mm)	Quantity of water applied (mm)	Total Quantity of water applied (mm)	water expenses efficiency (kg ha mm^{1})
Depth of tillage (D)				
Tillage upto 7.5 cm	1296.1	-	1296.1	16.50
Tillage upto 15 cm	1296.1	-	1296.1	21.48
Tillage upto 22.5 cm	1296.1	-	1296.1	26.88
S.E.±	-	-	-	0.43
CD (P = 0.05)	-	-	-	1.68
C.V. %	-	-	-	5.99
Irrigation level (I)				
2 irrigations at 25 and 50 DACR with 80 mm diw at each irrigation	1296.1	160	1456.1	18.47
2 irrigations at 25 and 75 DACR with 60 mm diw at each irrigation	1296.1	120	1416.1	27.15
3 irrigations at 25 and 50 and 75 DACR with 60 mm diw at each irrigation	1296.1	180	1476.1	18.56
S.Em. ±	-	-	-	0.34
CD (P = 0.05)	-	-	-	1.05
C.V.%	-	-	-	4.77
Interaction (D X I)				
S.Em.±	-	-	-	0.59
CD (P=0.05)	-	-	-	1.89
C.V.%	-	-	=	4.77

Note: DACR: Days After Cessation of Rainfall

Table.3 Interaction effect tillage depth and irrigation levels on seed cotton yield and stalk yield (kg ha^{-1})

Treatment	Tillage up to 7.5 cm	Tillage up to 15 cm	Tillage up to 22.5 cm
2 irrigations at 25 and 50 DACR with 80 mm diw at each irrigation	2190	3083	3590
2 irrigations at 25 and 75 DACR with 60 mm diw at each irrigation	2361	3436	3976
3 irrigations at 25 and 50 and 75 DACR with 60 mm diw at each irrigation	2662	3168	4189
S. Em. ±	85.9		
CD (P = 0.05)	264.7		
C.V.%	4.67		

Note: DACR: Days After Cessation of Rainfall

Table.4 Effect of tillage depth and irrigation levels on water expenses efficiency (kg ha mm^{-1}) of cotton

Treatment	Tillage up to 7.5 cm	Tillage up to 15 cm	Tillage up to 22.5 cm
2 irrigations at 25 and 50 DACR with 80 mm diw at each irrigation	13.6	19.2	22.4
2 irrigations at 25 and 75 DACR with 60 mm diw at each irrigation	19.6	28.6	33.1
3 irrigations at 25 and 50 and 75 DACR with 60 mm diw at each irrigation	14.7	17.6	23.2
S.Em. ±	0.5		
CD (P = 0.05)	1.8		
C.V.%	4.7		

Note: DACR: Days After Cessation of Rainfall

Soil moisture studies

Significantly the highest effect on water expense efficiency was observed scheduling of two irrigations at 25, 75 days after cessation of rainfall with 60 mm diw at each irrigation because less quantity of water use which is 120 mm results in highest water expense efficiency. Since increasing % water quantity provides wet surface for longer periods and consequently greater would be the loss due to evaporation. More frequently irrigated crop had profuse vegetative growth led to more transpiration resulting in more consumptive use. Whereas, reverse trend was observed in case of water use efficiency because of limited irrigation water in which less amount of available soil moisture was more efficiently utilized for crop yield. These finding are on the line with the results of Doss *et al.,* (1964), Cull *et al.,* (1981), Khade *et al.,* (1988) as well as Singh and Bhan (1993a).

Interaction effects

Interaction effect on seed cotton yield

Tillage depth upto 22.5 cm coupled with three irrigations at 25, 50 and 75 days after cessation of rainfall with 60 mm diw at each irrigation) recorded significantly higher (4189.69 kg ha^{-1}) seed cotton. Deep tillage along with appropriate irrigation water at proper stage with right quantity provided nutrient from deep root zone and longer period of crop life which reflected in better growth and development of plant and ultimately resulted in increased seed cotton yield. Singh and Singh (2000) as well as Balkcom *et al.,* (2006) reported similar results in cotton crop (Table 3).

Interaction effect on water expenses efficiency

Tillage depth upto 22.5 cm coupled with three irrigations at 25, 75 days after cessation of rainfall with 60 mm diw at each irrigation) recorded significantly the highest (33.14 kg ha mm^{-1}) water expense efficiency (Table 4).

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