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Assessing Moisture Conservation and Water Saving Technology for Bt Cotton (*Gossypium hirsutum* L.) Production

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ABSTRACT
A field experiment was conducted on calcareous clayey soil at Junagadh (Gujarat) during 2015 and 2016 to evaluate moisture conservation practices (flat bed, alternate between-row subsoiling, between-row subsoiling, in-row subsoiling and broad bed and

furrow) and irrigation (irrigation in each furrow, irrigation in alternate furrow, and irrigation in alternate furrow with wheat straw mulch @ 5 t/ha) for Bt cotton (*Gossypium hirsutum* L.). The results revealed that in-row subsoiling conserved higher moisture in soil and significantly enhanced root length, root dry weight, plant height, leaf area index, dry matter/plant, bolls/plant, single boll weight, 100-seed weight, ginning outturn, oil content and NPK uptake, which ultimately reflected in higher seed cotton (2161 kg/ha), lint (749 kg/ha), stalk yields (3113 kg/ha) and B:C (1.58). Alternate furrow irrigation with mulch was found equally effective to each furrow irrigation in respect of root length, root dry weight, plant height, dry matter/plant, bolls/plant, single boll weight, 100-seed weight, ginning outturn, oil content and NPK uptake, which eventually recorded equivalent seed cotton yield (2041 kg/ha), lint yield (683 kg/ha) and stalk yield (2947 kg/ha). Thus, the results of present investigation indicated that in-row subsoiling at a depth of 30 cm and irrigation each of 50 mm depth at 1 IW:CPE in alternate furrow with wheat straw mulch @ 5 t/ha enhanced cotton yield and B:C.

Key words: Cotton**,** Subsoiling, Broad bed and furrow, Flat bed, Furrow irrigation, Wheat straw mulch

Abbreviations: DAS (Days after sowing), IW: CPE (Irrigation water: Cumulative pan evaporation), BBF (Broad bed and furrow), FB (Flat bed), ABRS (Alternate between-row subsoiling), BRS (Between-row subsoiling), IRS (In-row subsoiling), EFI (Irrigation in each furrow), AFI (Irrigation in alternate furrow)

1. INTRODUCTION

Cotton is a very important commercial cash crop for India. It sustains the country's textile industry which is perhaps the largest segment of organized industries in the country. India earns substantial foreign exchange from exports of cotton yarn, thread, fabrics, apparel and made-ups. Cotton provides gainful employment to millions of people in the country who are engaged in cultivation, trading, processing, manufacturing, fabricating and marketing.

At present, nearly 70% of the country's gross cropped area is under rainfed conditions. Rainfed agriculture accounts for more than 40% of total food grain production, 75% of oilseeds, 90% of pulses and 70% of cotton. In Gujarat 70 to 80% of total area is under dry farming.

Inadequate rainfall and its uneven distribution along with frequent droughts are the common features of arid and semi-arid regions, which lead to low and unstable crop yield. The high intensity rains causing temporary water logging, severe erosion and runoff, which results in only a relatively small portion of the rainfall becoming available for crop production. The decline in crop yields in arid and semi-arid regions has been partially attributed to soil compaction and the formation of a hardpan as a result of repeated mechanical cultivations at shallow depth, machinery traffic and natural sedimentation. The dense and compact layer in subsoil is characterized by high mechanical impedance for root growth and low water transmission in the soil matrix. In general, heavy textured soils are more prone to compaction than light-textured soils (McCormak, 1987). Raper and Schwab (2009) stated that hardpans frequently restrict root development thus making crops susceptible to short-term droughts. In-row subsoiling has become the tillage tool of choice for alleviation of this compacted soil condition. Subsoiling breaks the hardpan or compact layer present in the profile and helps in sinking down of the rainwater in the lower layer of soil from where it is not easily lost by evaporation and favours deeper rooting, which helps in better exploitation of stored soil moisture and applied nutrients from the profile (Ghosh et al., 2006), which ultimately boosts crop growth and yield (Singh, 1995). Subsoiling reduced surface runoff and increased soil water content (Hasegawa et al., 2002; Kabaki et al., 2002). Improved storage of water in soil profile, increased yields of cotton, soybean and peanut, and net returns were also realized with subsoiling (Wesley et al., 2001; Simoes et al., 2009).

Rainwater conservation is a critical factor in stabilizing and stepping up of crop yields in drylands. Land configuration like broad bed and furrow (BBF) can increase infiltration of rainwater and thus helps to improve moisture storage in soil profile (Mathukia and Khanpara, 2009). In arid and semi-arid regions, high evaporative demand cause moisture loss from upper two to three inches layer of the loose and pulverized soil very rapidly and thus could not become available to plant. The BBF resulted in lower runoff and soil loss with higher yield, monetary returns and water use efficiency compared with flat bed (Jadhav et al., 2008; Suryawanshi *et al.*, 2008). Devi et al. (1991) observed that BBF resulted in larger water storage and higher seed yield of castor than the other tillage treatments.

When supply of water is limited, irrigation is applied through alternate furrows. Alternate-furrow irrigation reduces water application without affecting yield and thereby leads to more efficient water use. This method is very useful and crucial in areas of water scarcity and salt problems. Mulches improve soil water by reducing evaporation losses. Application of mulches on the soil surface obstructs the solar radiation reaching the soil. It also checks the escape of water vapour by physical obstruction. Application of mulches results in additional benefits like soil conservation, moderation of temperature, reduction in soil salinity, weed control and improvement of soil structure. Studies revealed that alternate furrow irrigation along with straw mulch could save 50% irrigation water without reducing cotton yield (Raman et al., 1990; Viradia and Patel, 2000; Sagarka et al., 2002). Considering these points, the present experiment was undertaken to evaluate the response of cotton (*Gossypium hirsutum* L.) to subsoiling, land configuration, irrigation and mulch to conserve soil moisture and to save irrigation water.

2. MATERIALS AND METHODS

A field investigation was carried out during rainy (*kharif*) seasons of 2015 and 2016 at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat). The soil was clayey in texture and slightly alkaline in reaction (pH 7.9 and EC 0.32 dS/m) with available N 261 kg/ha, available P_2O_5 29 kg/ha, available K_2O 284 kg/ha. Field capacity and permanent wilting point were 28.7 and 14.3%, respectively, whereas bulk density was 1.38 Mg/m^3 with 41.1% porosity. There were five main plots assigned to moisture conservation practices *viz*., M_1: Flat bed (FB), M_2: Alternate between-row subsoiling (ABRS), M_3: Between-row subsoiling (BRS), M_4: In-row subsoiling (IRS) and M_5: Broad bed and furrow (BBF) and three sub-plots allocated to irrigation *viz*., I_1: Irrigation in each furrow (EFI), I_2: Irrigation in alternate furrow (AFI) and I_3: Irrigation in alternate furrow + wheat straw mulch @ 5 t/ha (AFI+M). The experiment was laid out in split plot design with four replications.

Subsoiling to a depth of 30 cm was carried out by subsoiler, while a bed of 150 cm width with furrow of 30 cm width and 15 cm depth was formed by BBF former after preparatory tillage and before sowing (Mathukia and Khanpara, 2009). The Bt cotton variety 'G.Cot.Hy. 8 BG II' was sown at 90 cm x 60 cm on 20th June, 2015 and 18th June, 2016 and harvested according to maturity of bolls. The crop was fertilized with 60 kg N, 150 kg P_2O_5 and 150 kg K_2O/ha in the form of Urea Diammonium Phosphate (DAP) and Muriate of Potash (MOP) as basal application at sowing. Top dressing of 60 kg N/ha as Urea was done each at 30, 60 and 90 DAS. The total seasonal rainfall of 723 and 972 mm was received in 23 and 41 rainy days during 2015 and 2016, respectively. Irrigation each of 50 mm depth was applied at 1 IW:CPE after cessation of rainfall during both the years.

Soil moisture content was estimated gravimetrically. Bulk density was determined by the core sampler method as suggested by Piper (1950) from the relationship of oven-dried mass of a known volume of soil. Leaf area of randomly selected five tagged plants from each plot was measured by leaf area meter (LICOR-3000) at 90 DAS and leaf area index (LAI) was worked out accordingly. Growth and yield attributes were recorded at harvest from the randomly selected and tagged five plants in each net plot. Nitrogen in seed and stalk was estimated on per cent dry weight basis as per Modified Kjeldahl's method as described by Jackson (1967). The oil content of seed sample was determined by non-destructive method using Nuclear Magnetic Resonance Spectrophotometer (Model Oxford 4000 NMR analyzer) as suggested by Tiwari et al. (1974). Phosphorus content in seed and stalk was determined by Vanadomolybdo phosphate yellow colour method (Jackson, 1967). Potash content in seed and stalk was determined by Flame Photometer method (Jackson, 1967). The uptake of nutrients (N, P and K) was calculated by multiplying nutrient content with seed/stalk yield. Gross return was worked out by multiplying seed cotton yield and stalk yield with respective market price. The cost of cultivation was calculated taking into consideration the expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost of inputs *viz*., seeds, fertilizers, pesticides, irrigation *etc*. applied to each treatments on the basis of prevailing local charges. The Benefit : Cost (B:C) ratio was calculated with the help of the following formula.

$$B:C = \frac{\text{Gross returns (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

3. RESULTS AND DISCUSSION

3.1. Moisture conservation practices

Different practices of moisture conservation could impose their significant influence on moisture content in soil as well as growth and yield attributes (Table 1).

Subsoiling and broad bed and furrow slightly reduced bulk density of soil as compared to the flat bed, but did not reach at the level of significance.

The in-row subsoiling (M_4) recorded significantly the highest moisture content (15.94%) in soil at 90 days after sowing (DAS), however it remained statistically at par with the broad bed and furrow (M_5) and between-row subsoiling (M_3). The lowest soil moisture content (14.39%) was observed under the flat bed (M_1).

The in-row subsoiling (M_4) also improved length and dry weight of root as compared to flat bed (M_1). Significantly higher length of root (46.75 cm) and dry weight of root (29.37 g) were recorded under the in-row subsoiling (M_4), however it remained statistically at par with the broad bed and furrow (M_5) in case of root dry weight. The flat bed (M_1) has the lowest length (36.24 cm) and dry weight (23.99 g) of root.

Moisture conservation practices accelerated growth and yield parameters *viz*., plant height, leaf area index (LAI), dry matter/plant, bolls/plant, single boll weight and test weight over the flat bed (M_1).

The highest plant height (106.16 cm) was registered with the in-row subsoiling (M_4), followed by the broad bed and furrow (M_5) having plant height of 100.97 cm. While the lowest plant height (91.63 cm) was found under the flat bed (M_1).

The in-row subsoiling (M_4) resulted in the highest LAI (3.05), but it was statistically comparable to the broad bed and furrow (M_5) with LAI of 2.99. On the other hand, the flat bed (M_1) had the LAI (2.63).

Significantly the highest plant dry matter (259.82 g) was recorded under the in-row subsoiling (M_4), however it remained statistically equivalent to the broad bed and furrow (M_5) by recording 250.68 g dry matter/plant. The flat bed (M_1) had the lowest dry matter/plant (222.09 g).

The in-row subsoiling (M_4) and the broad bed and furrow (M_5), being statistically at par with each other, recorded significantly higher weight of boll (4.00 and 3.87 g, respectively) as compared to the flat bed (M_1), which recorded single boll weight of 3.51 g.

Similarly, the in-row subsoiling (M_4) produced significantly the highest 100-seed weight (8.14 g), however it remained statistically at par with the broad bed and furrow (M_5) having 100-seed weight of 7.98 g. Eventually, the flat bed (M_1) recorded significantly the lowest test weight (7.54 g).

Data presented in Table 2 indicated that the in-row subsoiling (M_4) and broad bed and furrow (M_5) produced significantly higher seed cotton yield (2161 and 2044 kg/ha, respectively) compared to the flat bed (M_1), which recorded the lowest seed cotton yield of 1824 kg/ha.

The in-row subsoiling (M_4) has given significantly the highest lint yield (749 kg/ha), whereas the flat bed (M_1) recorded significantly the lowest lint yield (595 kg/ha).

Significantly the highest stalk yield (3113 kg/ha) was recorded under the in-row subsoiling (M_4), however it was found statistically equivalent to the broad bed and furrow (M_5), which produced stalk yield of 2969 kg/ha. The flat bed (M_1) registered the lowest stalk yield (2677 kg/ha).

On an average, the in-row subsoiling (M_4) and broad bed and furrow (M_5) increased seed cotton yield by 18.5 and 12.1%, lint yield by 25.9 and 16.1% and stalk yield by 16.3 and 10.9% over the flat bed (M_1), respectively.

Among the moisture conservation practices, the in-row subsoiling (M_4) and broad bed and furrow (M_5) have significantly higher ginning outturn (34.63 and 33.74%, respectively) over the flat bed (M_1), which showed the lowest ginning percentage (32.58).

Seed oil content was significantly higher (12.04 and 12.00%, respectively) under the in-row subsoiling (M_4) and broad bed and furrow (M_5) and it was the lowest (11.64%) under the flat bed (M_1).

Economics point of view, the in-row subsoiling (M_4) and broad bed and furrow (M_5) have significantly higher B:C (1.58 and 1.45, respectively), whereas the flat bed (M_1) gave the lowest B:C (1.33).

The in-row subsoiling (M_4) resulted in significantly the highest uptake of N (70.31 kg/ha), P (11.85 kg/ha) and K (28.77 kg/ha), which however remained at par with the broad bed and furrow (M_5) in respect of uptake of P (11.12 kg/ha) and K (27.03 kg/ha). Significantly the lowest removal of N (56.93 kg/ha), P (9.73 kg/ha) and K (23.62 kg/ha) was registered under the flat bed (M_1).

Subsoiling break the hardpan present in soil and raised bed provides loose and friable soil condition, which improved soil moisture and thus increased root growth and nutrients uptake. Improved growth, yield and quality could be attributed to increased soil moisture and favourable physico-chemical properties of soil under in-row subsoiling (M_4) and broad bed and furrow (M_5). Nitant and Singh (1995) while evaluating effects of subsoiling on soil properties and yield of dryland pigeonpea found that subsoiling improved soil properties and enhanced profile water storage compared with shallow tillage. Subsoiling also induced deeper root penetration by 39 cm, resulting in 127% more seed yield than the shallow tillage by country plough. Mathukia and Khanpara (2009) observed that in-row subsoiling significantly increased growth, yield attributes, yield, quality and nutrient uptake by castor over flat bed. Nikam and Firake (2002) and Vaghasia et al. (2007) assessed positive influence of BBF on growth, yield and quality of rainfed groundnut.

3.2. Irrigation

Irrigation treatments did not exhibit their significant effect on bulk density and soil moisture content. Whereas, growth and yield characters except LAI were significantly influenced by irrigation (Table 1).

Table 1

Effect of moisture conservation practices and irrigation on physical properties of soil, and growth and yield attributes of cotton (pooled over two years)

Treatments	Bulk density (Mg/m^3)	Soil moisture (%) at 90 DAS	Root length (cm)	Root dry weight (g)	Plant height (cm)	LAI at 90 DAS	Dry matter /plant (g)	Bolls/ plant	Single boll weight (g)	100-seed weight (g)
Moisture conservation practices										
M_1- FB	1.415	14.39	36.24	23.99	91.63	2.63	222.09	24.75	3.51	7.54
M_2- ABRS	1.385	14.77	37.22	25.33	93.53	2.75	231.91	25.88	3.70	7.69
M_3- BRS	1.359	15.76	38.55	26.15	97.24	2.90	238.69	26.72	3.79	7.90
M_4- IRS	1.351	15.94	46.75	29.37	106.16	3.05	259.82	29.63	4.00	8.14
M_5- BBF	1.360	15.81	40.62	27.95	100.97	2.99	250.68	27.72	3.87	7.98
CD (P=0.05)	NS	0.67	2.22	1.68	5.14	0.18	13.31	1.68	0.18	0.22
Irrigation										
I_1- EFI	1.387	15.39	41.31	27.86	102.87	2.88	247.49	28.09	3.93	8.05
I_2- AFI	1.374	15.31	38.12	24.86	90.81	2.83	231.69	25.29	3.56	7.50
I_3- AFI+M	1.362	15.29	40.20	26.95	100.03	2.89	242.74	27.44	3.83	8.00
CD (P=0.05)	NS	NS	1.15	1.02	4.01	NS	7.24	0.72	0.11	0.11

Application of irrigation in each furrow (I_1) and irrigation in alternate furrow together with mulch (I_3), both being at par, recorded significantly higher root length (41.31 and 40.20 cm, respectively) over alternate furrow irrigation (I_2) having the lowest root length (38.12 cm).

Significantly higher root dry weight (27.86 and 26.95 g, respectively) was registered under the irrigation in each furrow (I_1) and irrigation in alternate furrow with mulch (I_3). While the alternate furrow irrigation (I_2) instigated the lowest root dry weight (24.86 g).

Irrigating in each furrow (I_1) gave significantly the highest plant height (102.87 cm), but it remained statistically at par with the irrigation in alternate furrow with mulch (I_3) having plant height of 100.03 cm. Whereas, significantly the smallest plants (90.81 cm) were observed under the alternate furrow irrigation (I_2).

The dry matter/plant (247.49 and 242.74 g, respectively) were significantly higher under the irrigation in each furrow (I_1) and irrigation in alternate furrow with mulch (I_3), and it was the lowest (231.69 g) in the alternate furrow irrigation (I_2).

The number of bolls/plant (28.09 and 27.44, respectively) and single boll weight (3.93 and 3.83 g, respectively) were significantly higher under the irrigation in each furrow (I_1) and irrigation in alternate furrow with mulch (I_3). While, the alternate furrow irrigation (I_2) had significantly the lowest bolls/plant (25.29) and single boll weight (3.56 g).

Application of irrigation in each furrow (I_1) and in alternate furrow along with mulch (I_3) gave significantly higher 100-seed weight (8.05 and 8.00 g, respectively) as compared to the alternate furrow irrigation (I_2) having the lowest test weight of 7.50 g.

A perusal of data furnished in Table 2 revealed that the each furrow irrigation (I_1) and alternate furrow irrigation + wheat straw mulch (I_3) gave significantly higher seed cotton yield of 2068 and 2041 kg/ha, respectively over the irrigation in alternate furrow (I_2), which produced significantly the lowest seed cotton yield (1834 kg/ha).

Table 2

Effect of moisture conservation practices and irrigation on yield, quality, B:C ratio and nutrient uptake (pooled over two years)

Treatments	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	Stalk yield (kg/ha)	Ginning (%)	Oil content (%)	B:C ratio	Nutrient uptake (kg/ha)		
							Nitrogen	Phosphorus	Potash
Moisture conservation practices									
M_1- FB	1824	595	2677	32.58	11.64	1.33	56.93	9.73	23.62
M_2- ABRS	1915	628	2770	32.86	11.78	1.37	60.86	10.22	24.81

M_3- BRS	1962	646	2834	32.90	11.82	1.34	62.64	10.58	25.72
M_4- IRS	2161	749	3113	34.63	12.04	1.58	70.31	11.85	28.77
M_5- BBF	2044	691	2969	33.74	12.00	1.45	65.88	11.12	27.03
CD (P=0.05)	140	46	175	1.44	0.20	0.17	4.26	0.74	1.80
Irrigation									
I_1- EFI	2068	703	2995	33.98	11.90	1.46	66.64	11.37	27.29
I_2- AFI	1834	599	2676	32.63	11.78	1.38	58.06	9.76	23.96
I_3- AFI+M	2041	683	2947	33.41	11.88	1.41	65.27	10.96	26.71
CD (P=0.05)	70	29	77	0.79	0.09	NS	2.23	0.38	0.81

FB = Flat bed, ABRS = Alternate between-row subsoiling, BRS = Between-row subsoiling, IRS = In-row subsoiling, BBF = Broad bed and furrow,
EFI = Each furrow irrigation, AFI = Alternate furrow irrigation, AFI+M = Alternate furrow irrigation + mulch

Similarly, the highest lint yield (703 kg/ha) was recorded with the each furrow irrigation (I_1) and it was found statistically comparable to the alternate furrow irrigation with wheat straw mulch (I_3) having lint yield of 683 kg/ha. On the other hand, significantly the lowest lint yield (599 kg/ha) was harvested from the treatment comprising irrigation in alternate furrow (I_2).

Irrigation in each furrow (I_1) and in alternate furrow with wheat straw mulch (I_3) recorded significantly the higher stalk yield (2995 and 2947 kg/ha) compared to the alternate furrow irrigation (I_2) having the lowest stalk yield (2676 kg/ha).

On an average, application of irrigation in each furrow (I_1) and in alternate furrow with mulch (I_3) increased seed cotton yield by 12.8 and 11.3%, lint yield by 17.4 and 14.0% and stalk yield by 11.9 and 10.1% over the alternate furrow irrigation (I_2), respectively.

Among the irrigation treatments, the irrigation in each furrow (I_1) and in alternate furrow along with mulch (I_3) gave significantly higher ginning outturn (33.98 and 33.41%, respectively), while the alternate furrow irrigation (I_2) had the lowest ginning percentage (32.63).

The oil content of cotton seed was significantly higher (11.90 and 11.88%, respectively) under the irrigation in each furrow (I_1) and in alternate furrow along with mulch (I_3) and it was the lowest (11.78 %) under the alternate furrow irrigation (I_2).

Looking to economics, the irrigation in each furrow (I_1) and in alternate furrow along with mulch (I_3) accrued higher B:C (1.46 and 1.41, respectively) over alternate furrow irrigation (I_2), but the result was found non-significant.

The irrigation in each furrow (I_1) removed significantly the highest amount of N (66.64 kg/ha), P (11.37 kg/ha) and K (27.29 kg/ha), which however remained at par with the alternate furrow irrigation with mulch (I_3) in case of uptake of N (65.27 kg/ha) and K (26.71 kg/ha). Significantly the lowest uptake of N (58.06 kg/ha), P (9.76 kg/ha) and K (23.96 kg/ha) was detected under the alternate furrow irrigation (I_2).

Better availability of moisture in soil under the each furrow irrigation (I_1) and alternate furrow irrigation with mulch (I_3) might have increased nutrients availability in soil and with increased root growth favoured growth and development of the crop and ultimately promoted yield and quality of the crop. Lourduraj and Chunaswami (1996) reported that alternate furrow irrigation saved 35% irrigation water compared with every furrow, but it resulted in lower seed cotton yield (15.5%) and net returns. Raman et al. (1990) from Navsari (Gujarat) reported that there were no differences in yield of cotton and sugarcane irrigated in flat beds, in furrows or in alternate furrows, but there was a 50% reduction in irrigation water used with the alternate row. Similarly, Viradia and Patel (2000) at Surat and Sagarka et al. (2002) at Junagadh also recorded almost equal or slightly lower growth, yield attributes, yield and quality of cotton with alternate furrow irrigation than every furrow irrigation, however alternate furrow irrigation resulted in increased WUE and about 50% water saving. Positive effect of organic mulch on soil properties were reported by Vijay Kumar (2014). Subba Reddy et al. (2015) reported that furrow irrigation with plastic mulch improved yield attributes and yield of tomato along with higher net return and B:C.

4. CONCLUSION

Based on the study, it could be concluded that in-row subsoiling to a depth of 30 cm and application of 50 mm irrigation in alternate furrow along with wheat straw mulch 5 t/ha enhanced cotton yield and economic return as well as save 50% irrigation water on calcareous clayey soil of South Saurashtra Agroclimatic Zone of Gujarat.

SUMMARY OF THE RESEARCH

1. A field experiment was conducted on calcareous clayey soil at Junagadh (Gujarat) during 2015 and 2016 evaluate moisture conservation practices and irrigation for Bt cotton (*Gossypium hirsutum* L.). There were five main plots assigned to moisture conservation practices *viz.*, flat bed, alternate between-row subsoiling, between-row subsoiling, in-row subsoiling and broad bed and furrow and three sub-plots allocated to irrigation *viz.*, irrigation in each furrow, irrigation in alternate furrow and irrigation in alternate furrow + wheat straw mulch @ 5 t/ha. The experiment was laid out in split plot design with four replications.
2. The parameters including bulk density, soil moisture, root length, root dry weight, plant height, LAI, dry matter /plant, bolls/plant, single boll weight, 100-seed weight, seed cotton yield, lint yield, stalk yield, ginning percentage, oil content, B:C ratio and NPK uptake were studied.
3. In-row subsoiling to a depth of 30 cm and irrigation each of 50 mm depth in alternate furrow with wheat straw mulch 5 t/ha enhanced cotton yield and B:C ratio and saved 50% irrigation water.

FUTURE ISSUES

Farmers and scientists should consider the importance of subsoiling, alternate furrow irrigation and organic mulch for conservation of natural resources.

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Conflict of Interest:

The authors declare that there are no conflicts of interests.

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External peer-review was done through double-blind method.

Data and materials availability:

All data associated with this study are present in the paper.

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