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Efficient use of canal water through drip irrigation in cotton (*Gossypium hirsutum*)

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ABSTRACT

A study was conducted during 2003–06 to optimally utilize the drip irrigation system already available with the orchardists of south-west Punjab wherein, adaptive research trials at farmers' fields using drip irrigation in cotton (*Gossypium hirsutum* L.) with paired row planting were laid in Abohar (Ferozepur district) to see the performance of crop and compare with the farmers' practice of applying irrigation through flooding. The average increase in yield in drip irrigated plot was 21% (with a maximum yield of 2 812 as compared to 2 036 kg/ha under flooding) with water savings of 30%, besides early maturity, labour savings and risk coverage under heavy downpour than the flooding method. The economic analysis showed that the method of using drip irrigation in cotton was technically feasible and economically viable in canal command area with a benefit cost ratio of (2.03:1) as compared to flooding (1.88:1).

Key words: Cotton, Drip irrigation, Water management

Cotton (*Gossypium hirsutum* L.) is an important commercial crop of south-west Punjab (Abohar, Fazilka, Ferozepur, Mansa, Mukatsar and Bhathinda districts). It is extensively grown in these canal command areas with conventional irrigation methods of flooding or furrow. However, the seed cotton yield and water-use efficiency achieved under these methods are low. Flooding irrigation cause high humidity in the micro climate of the plant which is a potential hazard for disease and pest attack.

Lot of work on the use of drip irrigation in cotton has been undertaken in India and abroad but research efforts on its adaptability and use in canal command areas have been either limited or site specific. Aujla *et al*. (2008) reported that under dense paired row sowing, an increase of 6% in seed cotton yield was achieved along with 25% reduction of irrigation water as well as cost of laterals. Sampathkumar *et al*. (2006) observed the highest plant height, more leaf area index, dry matter production and seed cotton yield (2 430 kg/ha) with drip irrigation. Rajak *et al*. (2006) reported maximum cotton yield (1.78 Mg/ha) under drip irrigation with 1.2 times evapotranspiration (ET) and lowest (0.18 Mg/ha) when applied with water equivalent to 0.8 ET with furrow irrigation (even on saline soils). Thus, we find that this method is certainly advantageous when used in cotton too but still the farmers in south-west Punjab need to be motivated through demonstrations to adopt this technology at their farms.

Higher initial cost is perhaps a discouraging factor for its low adoption in row crops including cotton. And how could this be reduced was another objective of this study. It was in this context that the adaptive research trials in cotton using canal water were laid out in and around Abohar tehsil of Ferozepur district of Punjab during 2003–06 to visualize the efficacy of the system at farmers' fields so that the farmers could see for themselves the advantages of this system over the conventional flooding and adopt the same in their fields with the existing set-up, and thereby harvest the rich benefits associated with this system without any extra cost.

MATERIALS AND METHODS

The adaptive research trials were started at 4 sites–2 in village Katehra (Abohar-Fazilka road) in 2004 and 2 in village Dhingawali (Abohar-Ganganagar road) in 2006 since at the second location, water storage facility and drip irrigation system were non-existent. The experiment at site III and IV could be started only after creation of irrigation facility at these two places. There were 3 irrigation treatments: every day, every third day applied through drip on the basis of 100% cumulative pan evaporation (CPE), and flooding – as per the existing farmers' practice, normally at 3–4 weeks' interval.

Quantity of water applied in drip system was based on consumptive use requirement of the crop, which was arrived

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at by measuring the daily evaporation and using crop coefficient. The crop under drip irrigation was sown in a paired row pattern at a spacing of 67.5 cm × 60 cm with each third row missing, thus giving a lateral spacing of 135 cm to economize on the cost of laterals (one lateral serving 2 rows) which otherwise is a discouraging factor for adoption of drip irrigation in cotton. The plant population was maintained by reducing the plant-to-plant spacing from 75 to 60 cm. It has been confirmed by Aujla *et al*. (2008) that such a crop geometry resulted in economizing on the length (read cost) of drip laterals used. Under flooding method, it was sown as per the recommended spacing 67.5 cm × 75.0 cm.

'Ankur 651' (hybrid) and 'F 1861' were sown at site 1 and 2 respectively during the first year and after watching their performance, only 'Ankur 651' was used at all the 4 sites thereafter. Quantity of irrigation water applied under drip was metered through water meters, while in the flooding method it was measured by using a 90° V-notch and noting the time duration for which it was applied. Recommended package of practices were adopted. Data on climatic parameters such as rainfall (by installing non-recording raingauges), dry and wet bulb temperature, soil temperature, humidity and daily evaporation were recorded regularly during the last 2 years based on the experience gained in the first year to monitor the climatic variations.

RESULTS AND DISCUSSION

Yield of cotton and amount of water used and saved during the 3 years of experimentation at 4 sites are given in Tables 1 and 2 respectively. The values show that there was an increase in cotton yield in the range of 18–31% with an average increase of 21% of seed cotton during all the 3 years. The maximum yield obtained was 2 812 and minimum 1 991 kg/ha (average of every day and every third day drip treatment), while under flooding method, this was 2 036 and 1 720 kg/ha, respectively at site I during the first and third year of experimentation. Water saving (Table 2) ranged between 23 and 36% with an average of 30%, the maximum being obtained during the second year. Aujla *et al*. (2005) observed that when the same quantity of water and N were applied through drip irrigation system, it increased the seed cotton yield by 32% as compared to check basin method of irrigation while with 75% water application, the increase was 12%. Similarly Ramesh *et al*. (2006) reported an improvement in the yield of summer cotton when drip irrigated at 100% PE once in 3 days interval, while Yazar *et al*. (2005) found that trickle irrigation with 6 days interval resulted in the highest yield of cotton among various treatments. Besides increase in yield and water savings, following additional advantages were observed:

Table 1 Yield of cotton (kg/ha) under different methods of irrigation at 4 sites

Year	Site	Drip treatment		Flooding	Per cent increase in yield in drip over flooding*
		Every day	Every 3rd day		
2004	I	2 802	2 822	2 036	38
	II	2 156	2 172	1 800	20
	III			1 990	
	IV			1 740	
Yearly average		2 479	2 497	1 892	31
2005	I	2 398	2 441	1 958	24
	II	2 420	2 351	1 925	24
	III			1 870	
	IV			2 041	
Yearly average		2 409	2396	1 948	23
2006	I	2 011	1 971	1 720	16
	II	2 159	2 184	1 785	22
	III	2 150	2 098	1 776	21
	IV	2 180	2 228	1908	16
Yearly average		2 125	2 120	1 797	18
Average of 3 years		2 338	2 338	1 879	24

*Based on the average of everyday and every third day drip

Table 2 Amount of water used (cm) and water saving under two methods of irrigation in cotton

Year	Treatment site	Drip	Flooding	Per cent saving (in drip over flooding)
2004	I	18	22	
	II	16	22	
	III		27	
	IV		22	
Yearly average		17*	23.3	26*
2005	I	22	35	
	II	23	35	
	III		35	
	IV		35	
Yearly average		22.5	35	36
2006	I	18	28	
	II	19	28	
	III	21	28	
	IV	21	28	
Yearly average		19.5	28	30
Average of 3 years		19.7	28.8	30

* Based on the average of everyday and every third day drip

Early maturity

From physical appearance and comparison of standing crop all through this period, it appeared that crop under trickle irrigation matured earlier by about 10 days than flood irrigated crop which is also evidenced by the yield data of first picking itself [data of only 2 sites for 2004 are shown in Table 3, similar data for other sites and years could be found in PAU (2005)]. It shows that out of total produce of 2 800 kg nearly 2/3 rd (1 850 kg) was picked up during the first

Table 3 Yield of cotton at different pickings

Picking date	Yield (kg/ha)		
	Drip irrigation		Flooding method
	Daily	Third day	
Site 1			
2 October 2004	1 848	1 896	1 025
27 October 2004	790	746	819
23 November 2004	164	180	192
Total	2 802	2 822	2 036
Per cent increase in yield (over flooding)	37.62	38.6	
Site 2			
9 October 2004	1 156	1 180	708
29 October 2004	694	718	768
25 November 2004	306	274	324
Total	2 156	2 172	1 800
Per cent increase in yield (over flooding)	19.78	20.67	

picking itself as compared to 40 to 50% only in the flooding method. This in turn would lead to savings in terms of reduced number of 1 or 2 sprays of insecticides/pesticides, besides fetching higher market price because of early arrival in the market. The early maturity could act as insurance, since it would lower the risk of reduction in cotton yield due to high incidence of pest attack (which usually occurs in the second half of September).

Labour saving

Table 1 reflects that there is not much difference in seed cotton yield under everyday and every third day drip irrigation treatment. Thus, if every third day irrigation scheduling is adopted, this will reduce the number of operational days of drip system thus leading to significant labour savings and cutting the cost of production. Ramesh *et al*. (2006) had also observed that drip irrigation at 100% PE once in 3 days interval improved the yield of summer cotton.

Security of crop under heavy downpour

In the event of high showers occurring immediately after irrigation, it is perceived that reduction in yield under drip irrigation will be negligible as compared to flooding method. A heavy downpour immediately after irrigation may cause stagnation of rainwater in the flood irrigated fields while in the drip-irrigated fields, since 40–50% field area remains dry even after irrigation, it could absorb substantial amount of rainfall, whereas in a flood-irrigated field, the high antecedent moisture conditions in whole of the field may cause stagnation of water because of low infiltrability (subsequent to rainfall) of wet soil. This difference might have a significant impact on the yield of cotton crop in case of a prolonged wet spell as cotton crop is highly susceptible to standing water. Indirectly also, there may be higher incidence of disease due to insects and pests under such high humidity conditions if prevailed for a long spell.

Economic analysis

Complete economic analysis on the use of drip irrigation in cotton for two situations (one for conventional system of irrigation where only one crop could be taken and under the second situation when the drip irrigation system and the storage tank already exist and two crops could be taken) was also undertaken. In the second case the analysis is based on the premise that the existing drip irrigation system is functional at the farm level but needs to be extended to cotton crop. It was found that under conventional system of flood method of irrigation, the cost benefit:ratio (B:C) was 1.88:1 as compared to 2.03:1 under drip system of irrigation. The analysis clearly shows that use of drip irrigation is economically viable when a farmer already has installed a drip irrigation system with storage tank (for storing canal water); what he needs is to simply extend it to cotton crop. This way the system will not remain idle but would be optimally utilized. The analysis also showed that if whole drip system was to be installed afresh along with a new storage tank, then the B: C ratio gets reduced from 2.03 to 1.83 (PAU 2005). It is also worthnoting when pest attack is there, difference in yield between drip irrigated and flood irrigated crop would be more. Since the pest attack is maximum usually in the second half of September, the crop under drip irrigation which would have matured by that time (due to early maturity by about 10 days) and hence will not suffer much yield loss, whereas the crop under flood irrigation will be the most susceptible to yield reduction in case of high incidence of pest attack around the maturity stage. Also, if high rainfall was there, the yield in flood irrigated crop would be reduced more than in drip irrigated crop because there would be accumulation of rainwater in the former (and cotton crop is susceptible to standing water) while in the latter, effect of flooding would be much less as most of the area under drip would remain dry which would help in the absorption of rainwater and thus save the crop from possible damage and reduction in yield.

It is thus concluded that use of drip irrigation in canal command area of cotton-growing belt of south-west Punjab was technically feasible and economically viable provided the orchardists already possess a drip irrigation system along with the storage reservoir for storing canal water so as to use it for high frequency drip irrigation as and when required. This leads to optimal utilization of drip irrigation system round the year.

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