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Low Cost Drip - Cost Effective and Precision Irrigation Tool in Bt Cotton

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Foreword

India has the largest irrigation network in the world yet the irrigation efficiency is not been more than 40 per cent. In absence of new irrigation projects, bringing more area under irrigation would mostly rely on the efficient use of water. In this context, micro irrigation could play a key role in higher productivity and increased water use efficiency (WUE) besides fulfilling sustainability mandates with economy in use and higher crop productivity. Adoption of this might help in raising the irrigated area, productivity of crops and WUE .Drip-fertigation, where fertilizer is applied through an efficient irrigation system (drip method), nutrient use efficiency could be as high as 90 per cent compared to 40-60 per cent in conventional methods.

Cotton, being the most important commercial crop of India (10.3 m ha with a production of 29.5 M bales of lint in 2009-10) contributes to around 60% of the raw material to the textile industry and provides employment to nearly 60 million peoples with productivity of 494 kg/ha. Further impetus in improvement of Indian average cotton productivity (less than that of the world, 725 kg/ha) is possible through efficient & optimal use of precious on farm inputs i.e, water and nutrient. Management of water and nutrients plays a key role in breaking of the undesired tempo in productivity plateau reached after major enhancement by introduction of Bt cotton and occupying more than 85% area. Cotton is one of the identified crop for promotion of drip irrigation.

Although drip irrigation is an acceptable technology by the Indians farmers, its rate of adoption is sluggish in annual crops due to involvement of initial high capital cost. Nevertheless, the area under drip irrigation has increased manifolds from 1500 ha (1989) to 2 mha (2010), However, this is extremely miniscule when compared to the potential of 69 mha. While devising appropriate reason for this poor growth of this technology, high initial cost is one of the major constraints hindering its rapid adoption in annual crops including cotton. Adoption of drip system per hectare land of cotton is estimated at Rs 65,000 to Rs 75, 000 and the initial investment is high. For successful adoption, a technically feasible irrigation method should also be economically easier for adoption. Hence, two low cost drip systems of microtube drip (39.4%) and poly-tube based drip (57.8%) were developed through rigorous testing procedures for optimum efficiency at CICR, Coimbatore . The bulletin is prepared by including emphasis for reducing system cost, principles of irrigation in cotton and justification in promoting and following the low cost systems. Performance of low cost systems with respect to growth characters, yield, quality, input use efficiency, and economics are assessed and included. Thus, the bulletin is very much useful in promoting low cost drip system for an efficient on farm irrigation scheduling in Bt cotton.

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Low cost drip – Cost effective and precision irrigation tool in Bt cotton

1. Introduction

Cotton (*Gossypium hirsutum* L.) being the most important commercial crop of India (10.3 m ha with a production of 29.5 Million bales of lint in 2009-10) contributes to around 60 per cent of the raw material to the textile industry and provides employment to nearly 60 million people with productivity of 494 kg/ha. Further impetus to cotton productivity i.e., to the world average of 725 kg/ha is possible through efficient and optimal use of precious on farm inputs i.e., water and nutrient. Management of water and nutrients plays a key role in breaking of the undesired tempo in productivity plateau reached after major enhancement by introduction of Bt cotton which occupies more than 85% area under Cotton.

Good quality water is having multifarious application such as for irrigation, industrial use, power generation, livestock use, and domestic use both in urban and rural areas. Due to increasing cost of irrigation projects and limited supply of good quality water, water becomes a high value commodity and is known as liquid gold. As quoted by Sir. C. V. Raman, *water is the ELIXIR of life that makes wonders in earth if it is used properly, efficiently, optimally, equitably and judicially*. For this, the best known technique is micro-irrigation that is proven for its efficiency, water & input saving. Since indiscriminate use of water through conventional type with 60 per cent application efficiency is causing serious threat to available ground water resources on the other hand drip-fertigation, where fertilizer is also applied through an efficient (drip) irrigation system, Nutrients Use Efficiency could reach as high as 90 per cent besides achieving > 95 per cent application efficiency. Therefore, the amount of fertilizer lost through leaching could be as low as 10% in drip fertigation as compared to 50% in the traditional one. A study on drip fertigation in Israel indicated that realization of highest yield of seed cotton (6.3 t ha^{-1}) was possible, and the projected area of drip irrigation in India would be about 10 m ha by 2025.

Although drip irrigation is an acceptable technology by the Indians farmers, its rate of adoption is limited in annual crops due to involvement of initial high capital cost. Nevertheless, the area under drip irrigation has increased manifolds from 1,500 ha (1989) to nearly 2 mha (2010, Table 1). However, which is extremely miniscule when compared to the potential of 69 mha. Exploring the appropriate reason for the poor adoption rate of this technology through *Gomar Garetts ranking technique*, revealed that the high initial cost was of the major constraint hindering its rapid adoption. However, whatever little developments and adoption of drip technology have taken place so far, it is mainly concentrated in acute water scarcity areas and in high value crops like perennial and horticultural crops, but not in annual crops like cotton.

Since cotton is one of the identified crops for adoption of drip irrigation commonly known for its response, accommodating of higher plant population (associated with annual crops) warrant longer laterals and drippers for water distribution and delivery. Laterals and drippers cost (constituting more than 60-80% of the total cost) plays an important role in deciding the cost of the system for annual and closely spaced crops like cotton. Adoption of drip system one hectare of cotton is estimated to meet initial investment of Rs 65,000 to Rs 75, 000. Keeping this in view, low cost drip systems were developed through rigorous testing procedures for optimum efficacy under farm situation

2. Drip Irrigation

Used in diverse soil types, this system, however, is more suitable for porous soils, water scarcity areas and undulated lands. Since the water is applied daily/alternate days at low rate and at low pressure (up to 1 kg/cm^2) over a long period of time and directly into the vicinity of plant roots, it maintains the soil moisture level around the root zone at/close to field capacity. Trials reveal that considerable flexibility is offered through the frequency of irrigation right from daily interval to once in eight

Table 1 Micro irrigation area (ha) in different states and crop wise Area under Drip Irrigation-March 2010

State	Drip (ha)	Sprinkler (ha)	Crop	Total Area (ha)
And. pradesh	505205	256911	Amla	1645
Aru. Pradesh	613	0	Banana	198655
Assam	116	129	Ber	35147
Bihar	301	435	Citrus	167285
Chattisgarh	6360	95740	Coconut	361647
Goa	793	582	Cotton	40845
Gujarat	226773	180572	Grapes	221575
Haryana	11351	533740	Guava	36867
Him. Pradesh	116	581	Mango	163493
Jharkhand	208	742	Papaya	15816
Karnataka	209471	385579	Pomegr.	114041
Kerala	15885	3540	Sapota	38325
Mad. Pradesh	51712	143233	Sugarcane	134605
Maharashtra	604440	295382	Vegetable	33764
Manipur	30	0	Arecanut	42363
Mizoram	72	106	Cashew	10806
Nagaland	0	3962	Cus. Apple	6057
Orissa	11046	33015	Fig	748
Punjab	17925	11414	Others	267229
Rajasthan	30047	866592	Total	1890913
Sikkim	23460	11339		
Tamilnadu	153437	27834		
Uttar Pradesh	12636	13310		
Uttaranchal	38	6		
West Bengal	247	150196		
Tripura				
Jammu&Kashmir				
Others (U.T.)	15000	30000		
Grand Total:-	1897282	3044940		

Source: 1.Jain irrigation Systems Ltd. 2. Rane,N.B., Development, Scope and Future Potential of Fertigation in India, Proceedings of National Seminar on Advances in Micro Irrigation, Feb 15-16, 2011, NCPAH, Ministry of Agriculture, GOI, pp.44-54.

days in cotton that also implies no response of cotton crop for a closed drip schedules in drip. Other advantage includes the use of saline water up to 8-10 dS/m without affecting the yield. In addition, fertilizers can also be combined and delivered simultaneously with irrigation water (drip-fertigation) more precisely to the root zone to tremendously increase the efficiency of fertilizer use. It is also reported that **lint** yield of >2250 kg/ha was realized using drip irrigation at Arizona, U.S.A. Improvement in quality of cotton is also observed in relation to fibre fineness & maturity.

3. Principles of water management

- Cotton seeds will not germinate until they absorb half their weight of water which is considerable
- A planned moisture regime that will restrain vegetative growth without adversely affecting yield is essential.
- Desirable that the plant completes most of its vegetative growth before the flowers appear and this is the best achieved by moisture regime that promotes regular and rapid but not excessive development of the young plant.
- During early part of the season, less water is used by the plant and more water is lost by evaporation than transpiration.
- The peak is reached when the plant is loaded with bolls and water consumption then begins to decline.
- Ample moisture during flowering and boll formation is essential.
- Moisture stress during these periods results in flower drop, boll shedding, poor development of bolls, low ginning percentage and ultimately low yield of fibre.

4. Potential advantages of Drip Irrigation

4.1 Enhanced water utility

Irrigation water requirements can be reduced with drip irrigation over traditional one although the water savings, of course, depend on the crop, soil, environmental conditions and the attainable on-farm irrigation efficiency. Primary reasons for water savings include precision irrigation, decreased surface evaporation, reduced irrigation-runoff from the field and controlled deep percolation losses below the crop root zone

4.2 Better crop growth and yield

Under drip irrigation system, soil water content in the active portion of the plant root zone remains fairly constant because irrigation water can be supplied slowly and frequently at a predetermined rate. Here, the total soil water potential increases (soil water suction decreased) with elimination of the wide fluctuations in the soil water content. Proven results revealed that the benefits of drip irrigation includes frequent irrigation to crop as far as practicable , free from irrigation induced soil aeration , less plant disease and restricted plant root growth.

4.3 Superior fibre quality

The influence of irrigation water on fibre quality is less pronounced compared to its effect on seed cotton yield. The extreme regime of either excess water or prolonged dryness could reduce the fibre length . But, limited irrigation has no influence on ginning percentage, fibre length and bundle strength although limited moisture increased the fibre staple length

4.4 Reduced salinity

Evidences suggest that waters of higher salinity can be used in drip irrigation without greatly reducing crop yields. Minimizing the salinity hazard to plants by drip irrigation can be attributed to dilution of the salt concentration in soil solution following irrigation to maintain high soil water status in the root zone and movement of salts beyond the active plant root zone. Drip system suitable to use saline water has practical utility in cotton being the major crop cultivated using poor to very poor quality water in most of the cases in south zone of India.

4.5 Higher fertilizer use efficiency

Drip irrigation offers considerable flexibility in fertilization. Frequent or nearly continuous application of plant nutrients along with the irrigation water is feasible and appears to be beneficial for crop production. The contributing factors for increased efficiency of fertilization include decreased quantities of applied fertilizer, improved timing of fertilization and improved distribution of fertilizer with minimum leaching or runoff.

4.6 Reduced weed competition

Since weed infestation depends on soil moisture content, drip irrigation reduces weed infestation due to limited wetting of root zone only. Significant reduction in weed biomass was observed in drip irrigation plot as compared to surface irrigated plots

4.7 Saving of labour

Drip irrigation systems can be easily automated where labour is limited or expensive. In addition to labour savings following automation, greater efficiency is achieved through other cultural operations like spraying, weeding, thinning, and harvesting of row crops etc. while the crop is still irrigated. Moreover, labour and operational costs can be reduced by the simultaneous application of water, fertilizer, herbicide, insecticide, or other additives through the drip system.

5. Cotton is a Candidate Crop for drip irrigation

Longer duration: Cotton is longer in duration favoring greater utility of the drip system as compared to short duration crops.

Suitability of growing environment: The drip irrigation system is the best suited for water scarce situation. Most of the cotton growing regions comes under semi arid condition and associated with water scarcity.

Early sowing: Facilitate early sowing of crop under water scarce situations. Occurrence of delayed rain leads to late sowing, poor establishment of crop, diversification of land to non-cotton crop and current fallow. The yield of seed cotton was decreased by delay in sowing.

Flexible drip system*:* Planning of flexible drip system by permanent laying of main and sub-mains in field bunds and using laterals for cotton and other succeeding crops in a holistic approach has a greater utility of the system.

Higher Economic return*:* Adoption of drip-fertigation system might result in enhanced marginal, physical and value product because of high responsiveness and high market value associated with cotton.

Higher fertilizer use: Higher application of NPK to hybrid cotton is commonly followed. Hence, drip-fertigation system can effectively utilize these nutrients to enhance the fertilizer use efficiency.

Enhancement of seed cotton yield: Drip irrigation increases the yield of cotton on an average of 27 per cent

Suitability to light soils: Drip irrigation makes it possible to grow cotton in all types of soil. In Light and shallow soils under Conventional method of irrigation due to inadequate storage of moisture for extended period is restricted.

***Uniform germination and maturity**:* Drip irrigation results in uniform germination and maturity

***Enhancement of fibre quality**:* Enhanced uniformity ratio and maturity ratio in desirable quality are reported under drip irrigation.

6. Drip Systems

6.1 Existing Drip System

In the existing drip system, single LLDPE (Linear Low Density Polyethylene) lateral was placed within the pair (60 cm) of paired rows planted cotton (120/60 x 60 cm; 120 cm between paired rows and 60 cm within the pair) for water distribution and dripper were positioned at 60 cm interval (intra-row spacing of 60 cm) for water delivery of two plants (Fig.1).


Fig.1 Existing Drip System

6.2 Low cost microtube drip system

In low cost micro-tube system, one LLDPE lateral was used to irrigate 2 paired rows of cotton (4 single rows) and single lateral is placed in between the two paired rows (120/60x60 cm) alternatively and micro tubes were inserted in both sides of the lateral in 60cm interval and extended to either side (2 rows of cotton in each side) of the pairs for water delivery and placed between the plants (Fig.2).

6.3 Low Cost polytube drip system

For low cost poly-tubes lateral system, instead of LLDPE lateral, polytubes 150 micron was used. The polytubes were punctured at single side at regular intervals (60 cm) and placed within the pair (60 cm) of paired rows planted cotton (Fig.3). The polytubes were positioned in such a way that perforated holes face towards bottom side for water delivery and were stretched and fixed. In polytube drip systems, main and sub main components of the existing drip system were kept as such and poly tubes of 150 micron were used with replacement of 100 % of lateral and dripper as that of existing drip system.


Fig.3 Low cost poly tube system

7. Method of planting

Bt hybrid has to be sown in paired rows (120/60 x 60 cm; 120 cm between paired rows and 60 cm within the pair) during August and was harvested during February. In drip irrigated plots, small furrow is opened at 120cm intervals by country plough to imitate the microclimate similar to raised bed condition.

8. Drip System installation

Drip irrigation unit consisted of filter system with a mesh size of 100µ, water meter, water pressure meter, air release valve and control valve attached in series to the main PVC pipe of 63 mm diameter and sub main of 40 mm is required for low cost drip system . LLDPE laterals of 16 mm used for low cost microtube systems and 1 mm of microtubes used in microtube drip for water delivery. Polytubes with thickness of 150 micron used for low cost polytubes systems.

9. Irrigation Scheduling

The drip irrigation could be given at 0.8 ETc once in two days by adjusting with volume (*Vn*) as per calculation as under,

$$WR_d = E_p \times K_c \times K_p \times A \text{ (L)} \qquad \text{-------- (1)}$$

Net volume of water to be applied

$$V_n = WR_d - (R_e \times A) \quad \text{(L)} \qquad \text{-------- (2)}$$

Where, E_p-Mean pan evaporation (mm/day), K_c-crop factor, K_p-pan factor, A-Area to be irrigated (m^2), R_e- effective rainfall (mm), WR_d-water requirement per day in liters and V_n-Net volume of water applied in litres. K_c values varies with the crop duration viz., 0.45 for 0-25days, 0.75 for 26-70 days, 1.15 for 71-120 days and 0.70 for 121-150 days.

10. Fertigation Schedule

Recommended dose of 90-20-38 kg N-P-K/ha need to be applied in the form of urea, super phosphate and muriate of potash . In drip irrigation, N and K were applied through fertigation (Fig.4) in 5 equal splits while P was soil applied at the time sowing.

Fig.4 Fertigation

11. Field Performance

Performance of two low cost drip systems including microtube drip system and poly tube drip systems (polytubes 150 micron) were compared with existing drip system and ridges and furrow method of irrigation and details follows.

11.1 Growth characters


Fig.5 Low cost microtube system

The existing drip system of having LLDPE lateral and drip

However, the enhanced growth parameters were on par with low cost drip systems of including microtube drip system (Fig.5) and poly tube drip systems. Thus, these low cost drip systems are comparable with the existing drip system. Surface irrigation by ridge-furrow method registered the least values in terms of cotton growth characters. Higher frequency of irrigation and increased availability of soil moisture under drip irrigation might lead to effective absorption and utilization of nutrients and better proliferation of roots resulting in quick and higher canopy growth. In drip fertigation the plants were able to absorb nutrients easily, due to the restricted wetting area and root zone application of nutrients coupled with constant and continuous availability of higher soil moisture. In the case of furrow irrigation, that resulted in water deficit which might have led to many changes in plant anatomy such as decrease in cell size and intercellular spaces limiting cell division and elongation as was reflected in restricted plant growth

11.2 Yield and yield attributes

The significantly highest per plant burst bolls (31.2), single plant yield (149 g) and seed cotton yield (2.71 t/ha) were recorded with irrigating the crop with the existing drip system. The different low cost systems tested were produced on par results with existing drip systems with respect to burst bolls, single plant yield and seed cotton yield (table 2). It was reported that drip fertigation had increased the number of bolls and seed cotton yield when compared to farmers practice of surface irrigation and soil application of fertilizer. Low cost microtube and polytube (Fig.6) drip systems respectively produced yields equivalent to 93.4 and 96.7% of existing drip system.


Fig.6 Low Cost Polytube

Table 2 Yield parameters and yield as influenced by low cost drip systems

Systems	Seed cotton Yield (t/ha)	Boll weight (g)	Yield/ plant (g)	Burst Bolls	Dry Weight (kg/ha)
Existing drip	2.71	4.9	148.9	31.2	4248
Low cost microtube	2.53	5.1	137.8	28.6	3976
Low cost polytube drip	2.62	4.9	143.3	30.8	4028
Ridges &furrow	2.41	5.0	128.6	25.2	3675
SEd±	0.06	0.7	5.6	1.9	156
CD (P=0.05)	0.18	NS	11.2	3.8	312

Although the existing drip system produced 12.4% higher seed cotton yield than ridge-furrow irrigation, yet low cost drip systems were efficient also in raising a

better crop with comparable growth and yield characters and seed cotton yield. The increase in soil wetness with drip irrigation significantly improved the yield components and yield. The ability of cotton crop to produce and support more number of bolls depends on the Dry Matter Accumulation (DMA) and its translocation to sink. The flower production and their subsequent development into bolls and their retention in the plant are also controlled by soil moisture condition. Root system under the system showed a passive absorption and translocation of water from the soil to the plants parts under high moisture regimes. The energy required for water absorption was also less under high irrigation regimes and ultimately led to early energy translocation to the reproductive parts. This might be one of the reasons for increased yield attributes and yield under high irrigation régimes.

Moreover, lower seed cotton yield (2.41 t/ha) in ridge-furrow irrigation might be attributed to decrease in synthesis of metabolites and reduction in absorption and translocation of nutrients from soil to plant. The physiological response of plants by decreased cell division and cell elongation under moderate moisture stress at wider irrigation intervals might have also contributed to reduce seed cotton yield under furrow irrigation.

Fig.7 Existing Drip System

11.3 Water use efficiency

The mean total quantity of irrigation water used for drip systems and surface irrigation through ridges-furrow irrigation were 206.7 and 355 mm respectively (table 2). Thus, the drip system could save 41.8% of irrigation water in comparison to ridge-furrow irrigation. The primary reasons attributed for the water savings include irrigation of a smaller portion of the soil volume, decreased surface evaporation, reduced irrigation runoff from the drip field and controlled deep percolation losses below the crop root zone. Although highest WUE of 51.2 kg/ha-cm was calculated with the existing drip system (Fig.7), yet it was closely followed by polytube drip system (49.6 kg/ha-cm), and microtube drip system (48.0 kg/ha-mm). The uniformity coefficient determining the degree of uniformity for water delivery of different drip systems was also influenced by different emitter system followed. The existing drip system of dripper based delivery found higher uniformity coefficient of 97.4% followed by poly tube drip systems (95.1%) and the least one was calculated with microtube system (93.5 %).

11.4 Input use efficiency

Highest nutrient use efficiency (NUE) of 15 kg of seed cotton per kg of nutrients and economics nutrient use efficiency (ENUE) of 1.08 kg of seed cotton per rupees invested for nutrients were calculated with existing drip system. This was closely followed by low cost drip system of polytubes (14.6 kg per kg of nutrients (NUE) and 1.05 kg per rupees invested for nutrients (ENUE)) and microtube drip system (14.1 kg per kg of nutrients (NUE) and 1.01 kg per rupees invested for nutrients (ENUE)) (table 3).

Table 3 Input use efficiency as influenced by low cost drip systems

Systems	Irrig. water (mm)*	Total water (mm)	WUE (kg/ha -cm)	UC (%)	NUE (kg/kg)	ENUE (kg/Rs)
Existing drip	206.7	528.4	51.2	97.4	15.0	1.08
Low cost microtube	206.7	528.4	48.0	93.5	14.1	1.01
Low cost polytube	206.7	528.4	49.6	95.1	14.6	1.05
Ridges &furrow	355.0	676.7	35.6		13.4	0.96

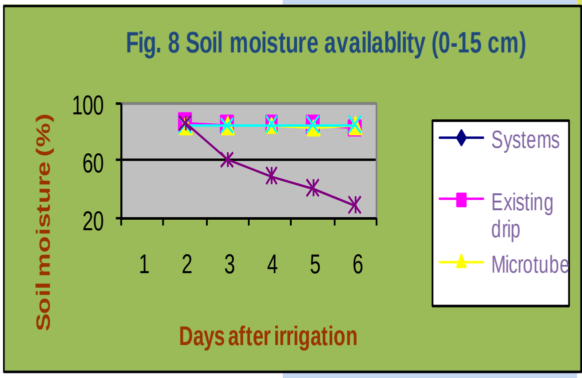
*This was in addition to Effective rain of 321.7 mm

UC-Uniformity coefficient, NUE-Nutrient use efficiency, ENUE-Economics nutrient use efficiency

This can be ascribed to the higher availability of soil moisture that might have increased the availability and uptake of nutrients by the crop and raised NUE and ENUE. Since fertigation by existing and low cost drip systems permits application of a nutrient directly at the site of a high density of active roots as required by the crop, offers the possibility of increasing yield and reducing nutrient losses associated with conventional application methods thereby increasing NUE. The least NUE of 13.4 kg of seed cotton per kg of nutrients and ENUE of 0.96 kg of seed cotton per rupee invested for nutrients had been realized with surface irrigation through ridge-furrow irrigation.

11.5 Soil moisture availability

Adequate soil moisture availability ensures successful cotton production under any type of cultivation. The available soil moisture was estimated at boll development period at four days interval in two different depth from 0 to 15 cm and 15 to 30 cm for a irrigation cycle followed in control (ridges and furrow



method) and moisture availability of drip irrigated plots of different

systems were also measured simultaneously and plotted in graph(Fig8&9). The results revealed that available soil moisture was consistent through out the period and was nearer to field capacity ranged at 83.7 - 85.6 and 86.5-89.5% with 0-15cm

& 15-30 cm depth respectively in drip irrigated plots, where as in ridge-furrow, it was declining steeply from the day of irrigation to last day of irrigation ranged at 87.1-28.7 and 89.8-37.1% of available soil moisture measured with 0-15 cm and 15-30 cm depth respectively and resulted in greater fluctuation in soil moisture availability. Under drip irrigation system, soil water content in a portion of the plant root zone remains fairly constant because of slow supply of irrigation water and frequently at a pre-determined rate. Generally, the total soil water potential increases (the soil water suction decreases) with elimination of the wide fluctuations in the soil water content, which typically result from traditional flood method. The best irrigation principle is to apply water as frequently as possible.

Fig. 9 Soil moisture availablity (15-30 cm)

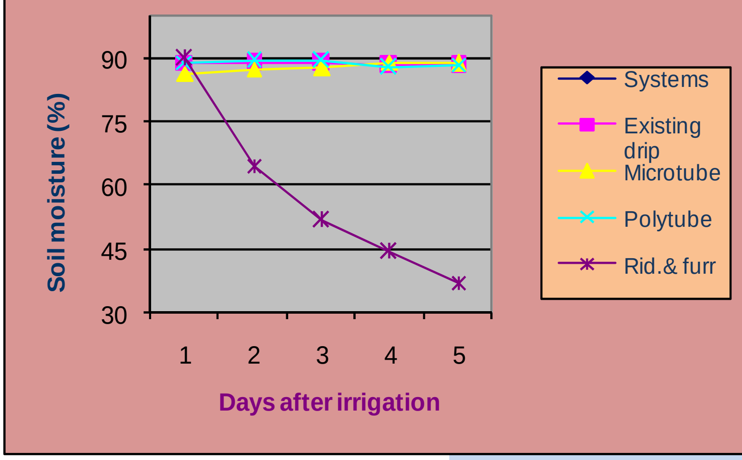
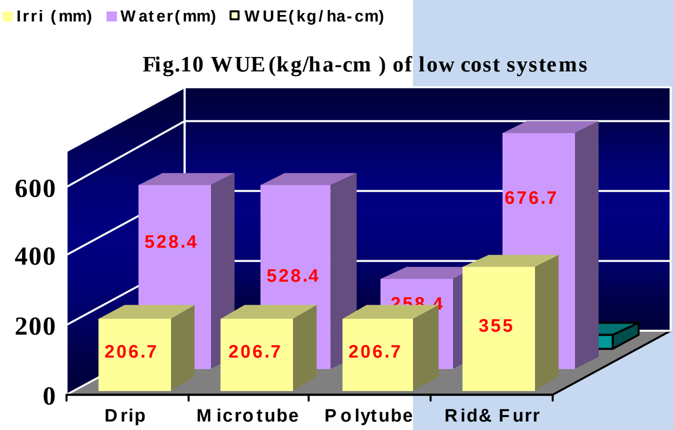


Fig.10 WUE (kg/ha-cm) of low cost systems



1.6 Fibre quality parameters

In general, the influence of irrigation water on fibre quality is less pronounced compared to its effect on seed cotton yield. Fibre quality parameters are by and large heritage. None of the quality parameters of cotton was significantly influenced by drip systems as compared to surface irrigation by ridge-furrow except seed index (table 4).

Table 4 Quality parameters of cotton as influenced by low cost drip systems

Systems	Seed index	Lint index	GP (%)	FQI	Count	Count Strength product
Existing drip	10.8	5.8	35.1	312	45	2143
Low cost microtube	10.8	6.0	35.7	317	46	2151
Low cost polytube	11.1	6.1	35.5	306	44	2133
Ridges &furrow	10.2	5.2	33.8	294	42	2112
SEd±	0.2	0.2	0.4			
CD (P=0.05)	0.4	NS	NS			

micronaire (4.2 to 4.5 µg/inch), fibre strength (21.3 to 21.8 g/tex) and elongation percentage (6.2 to 6.5) were assessed with drip systems and control (table 5).

Table 4 Quality parameters of cotton as influenced by low cost drip systems

Systems	2.5% S.L. (mm)	MR	UC (%)	Mic.	Strength	Elong. (%)
Existing drip	29.7	0.77	47.6	4.2	21.4	6.5
Low cost microtube	30.1	0.78	48.3	4.3	21.8	6.3
Low cost polytube	29.3	0.77	48.0	4.3	21.7	6.2
Ridges &furrow	29.2	0.78	48.4	4.5	21.3	6.4
SEd±	0.3	0.1	0.6	0.2	0.4	0.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS

The highest and least seed index of 11.1 and 10.2 was recorded respectively with low cost polytube drip system and ridges and furrow method of irrigation respectively. Usually, higher the moisture regime more is the seed index. The calculated fiber quality index, count and count strength Product (CSP) were also higher with drip systems and ranged from 306-317, 44-46 and 2133-2151 respectively. Ridge-furrow was calculated with the least fiber quality index of 294, count of 42 and count strength product of 2112.

11.7 Available Nutrient status

The post harvest soil samples were analysed to assess the major and micro nutrient status of soil after harvest of crop. Amongst the major nutrients, N availability was significantly influenced and the drip irrigated plots of different systems showed the highest (in a range of 176-186 kg/ha). Least (165 kg/ha) was analysed with ridge-furrow (table 6). The distribution and availability of nutrients in the soil depends upon their solubility, moisture distribution and its gradient. Higher post harvest available N in drip systems following lesser loss due to leaching and better movement of nutrients in the soil under drip irrigation as compared to basin flooding where these nutrients were found to leach out and become unavailable to the crop.

Table 6 Available nutrients of post harvest soil as influenced by drip systems

Systems	N (Kg/ha)	P_2O_5 (Kg/ha)	K_2O (Kg/ha)
Existing drip	181	19.7	1018
Low cost microtube	176	16.4	983
Low cost polytube	186	16.1	995
Ridges &furrow	165	18.8	1015
SEd±	3.0	1.1	2.7
CD (P=0.05)	6.0	NS	NS

11.8 Economics of low cost drip

Cost of existing drip system includes installation cost that is worked out at Rs 74,080/ha where the cost of component of main system (mains, sub-mains & accessories), laterals and drippers were calculated at 35, 37 and 28% of the total cost respectively. Laterals and drippers constituted about 64.6 per cent of total cost of the system. In microtube drip system, the cost of the system was worked out at Rs 45,196/ha. Thus, microtube drip was cheaper (by 39.4%) than the existing drip. The costs of polytube drip system are respectively of Rs. 31252, per hectare of land for using of 150, micron thickness of polytubes (table 6). The cost of polytubes contributes 15.7per cent of the total cost of the respective systems. Therefore, polytube drip system (150 micron) was cheaper by 57.8 % in comparison to existing dry system.

Per annum irrigation cost was worked out by taking into consideration of total initial investment made, amount of interest incurred on initial investment (calculating the prevailing interest rate of 7%) and adjusted with the expected life period of the system (10 years for all components except for polytubes). In polytube systems, life period of 2 years was considered. Least per annum irrigation cost of Rs. 7, 273/ha was calculated for polytube drip system (150 micron) was followed by microtube drip system (Rs. 7,983/ha). Highest per annum irrigation cost (Rs. 12,594/ha) was arrived with existing drip system.

11.8.1 Cost of cultivation

The cost of cultivation is higher with existing drip system (Rs 32,865/ha) as compared to polytube drip system (Rs27,190/ha) and microtube drip system (Rs 27,244/ha) and ridges and furrow method of irrigation (Rs25,550/ha) . The cost of cultivation is differed mainly because of varying per annum irrigation cost, harvesting charges, land shaping and weeding cost amongst the systems. All the drip systems including low cost one had been arrived with higher irrigation cost and harvesting charges. The cost towards weed control and land shaping is less with all drip systems.

Table 7. A comparative account of economics involved in low cost drip systems (Rs/ha)

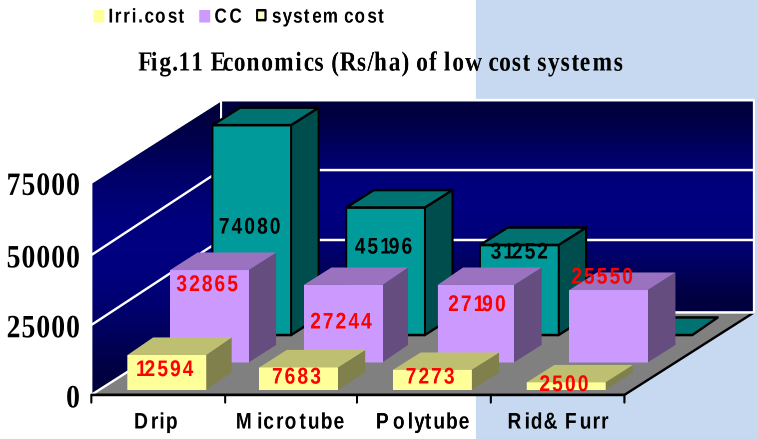
Items	Existing Drip system	Low cost microtube	Low cost polytube	Ridges & furrow
Mains, sub-mains & accessories	26168	25406	25406	-
Laterals	27080	13540	945	-
Drippers	20832	-	-	-
Microtubes	-	6250	-	-
Polytubes	-	-	4901	-
Sub total	47912	19477	5846	-
Total system cost	74080	45196	31252	-
Per annum irrigation cost	12594	7683	7273	2500
Saving in total cost of the system (%)	-	39.4	57.8	-
Saving in per annum irrigation cost (%)	-	39.4	42.3	-

CC excluding irrigation cost	20271	19561	19917	23050
Total cost of cultivation (CC)	32865	27244	27190	25550
Gross Return	67625	63367	65500	60300
Net Return	34760	36123	38310	34750
BCR	2.06	2.33	2.41	2.36

Since weed infestation depends on soil moisture content, in drip irrigation, only a fraction of the soil surface is wetted thus reduce weeding cost. Perfect land shaping is not required in drip system thus led to less cost.

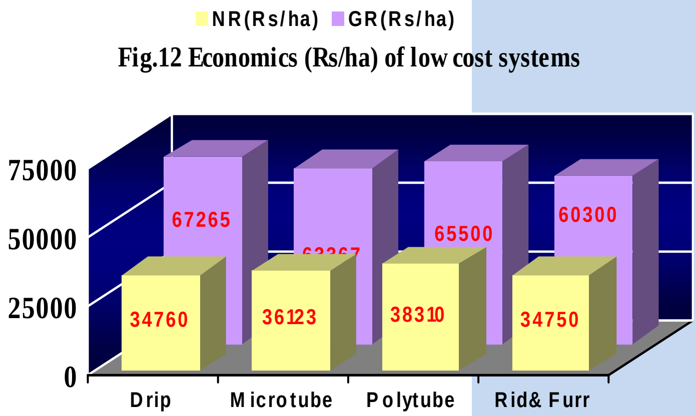
Moderately higher yield (2620 kg/ha) with all the positive effects (of drip) along with lower cultivation cost (Rs 27,190/ha) were incurred in poly tube drip system further led to higher net return (Rs 38,310/ha) and BCR (2.41) (table 7). Thus, the trial focused on the suitability and viability of the use of low cost polytube drip for an efficient on farm irrigation scheduling in Bt cotton. Even though, the existing drip system had higher growth, yield attributes and seed cotton yield (2705kg/ha) but higher per annum irrigation cost (Rs. 12,594/ha) incurred, ultimately leads to increased cost of cultivation (Rs. 32,865 /ha) thus reduced the net return (Rs.34,760/ha) and benefit cost ratio (2.06) of the system.

Fig.11 Economics (Rs/ha) of low cost systems



For successful adoption, a technically feasible irrigation method should also be economically easier for adoption. Thus, low cost polytube drip system performed higher in terms of crop growth characters, yield attributes & seed cotton yield and in optimum efficiency through water use efficiency, uniformity coefficient, nutrient use efficiency and economics of nutrient use efficiency. Thus, the bulletin showed the suitability and viability of low cost polytube drip system for an efficient on farm irrigation scheduling in Bt cotton.

Fig.12 Economics (Rs/ha) of low cost systems



12. Adoptive trial - Low cost drip system in cotton

Dhanraj S/o. K. Rangasamy a farmer of Vadapudhur village, Kinathukadav (block), Pollachi (TK) Coimbatore has ten acres of land with two open wells of 30” depth. Scarcity of water is the major limiting factor for him and others farmers also. Water availability of both the wells cumulatively could irrigate four acres of land. The remaining six acres is cultivated as rainfed condition. His field fertility status was red sandy loam, low in available N (234 kg/ha), medium in available P (13.8 kg /ha) and high in available K (200 kg /ha) with neutral pH (6.7) and EC (0.09 dsm^{-1}). The micro nutrient status of soil was as follows: Fe-15.6 ppm, Mn -11.6 ppm, Zn-1.5 ppm and Cu-0.50 ppm. The predominant crops are being cultivated are tomato and cotton in the domain. Low cost drip system developed and tested by Central Institute for Cotton Research, Regional Station, Coimbatore had been demonstrated under National Agriculture Innovation Project – Cotton Value Chain in an acre of land. The Extra Long Staple (ELS) genotype RCHB 708 Bt hybrid was planted in drip and conventional irrigated plots. Out of two acres of cotton crop one acre he adopted low cost drip system and remaining one acre is under conventional irrigation. Under drip irrigation, irrigation is given once in four days for 45 minutes. The conventional irrigation plots are irrigated once in 15 days, and it requires seven hours of pumping to cover one acre of land. The recommended level of 36 kg nitrogen and 18 kg potassium (K_2O) were applied in splits through drip as fertigation in the form of urea and potassium chloride respectively for drip irrigated plots. The recommended quantity of 18 kg of P_2O_5 had been applied as basal in the form of super phosphate. In conventional irrigated plots, 36: 18: 18 kg of N, P_2O_5 and K_2O per acre were applied. Out of this, 50 % N, 100 % P_2O_5 and K_2O were applied as basal in the form of urea, super phosphate and potassium chloride respectively and remaining 50% of nitrogen was applied as top dressing at 45 days after sowing. He had harvested 14 q of seed cotton yield from acre of drip irrigated plots against 7 q / acre from conventional one. The economic analysis found that low cost drip irrigation system had been calculated per annum irrigation cost and cost of cultivation of Rs. 2,900 /ac and Rs. 20,500/acre respectively. Irrigation cost of Rs. 1,200 /ac and cost of cultivation of Rs. 13, 000 / acre incurred with conventional irrigation method. Kapas sold at the rate of Rs. 4650 /q. He realized gross return, net return and benefit cost ratio of Rs. 65,100 /acre, Rs. 44,600/acre and 3.2, respectively from low cost drip irrigation adopted plot. For conventional irrigation method, gross return of Rs 32, 550 / acre, net return of Rs. 19, 550 / acre and benefit cost ratio of 2.5 were arrived. The kapas samples collected, subjected to quality analysis by CIRCOT, Regional Unit, Coimbatore. Drip irrigated plots had higher 2.5 % span length (37.5 mm), fiber strength (28.9 g/tex) and fiber quality index (590) in comparison to conventional irrigation plots, which had 36.0 mm of 2.5 % span length, 26.0 g/tex of fiber strength and fiber quality index of 503. He is confident about the superiority of the technology and he is willing to adopt low cost drip irrigation system for entire ten acres of land to bring whole farm into irrigated cultivation with available water.