Precision Management of Water & Nutrient in ELS Cotton Production – A Review

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Abstract

The mismatch between the demand and supply of extra long staple (ELS) cotton continues in the country despite the significant breakthrough in overall production scenario. Besides several constraints in the production of ELS cotton, recent price spurt and premium available have made it more demanding both in domestic and international arena. Amongst many factors that contribute to its productivity, precision water and nutrient management especially drip-fertigation plays a key role as possibility of expansion of irrigated cotton area is remote. Higher water and nutrient use efficiency as irrigation water is applied precisely to root zone and enhancing or at least stabilizing on fibre quality front are other advantages of precision drip-fertigation. Other constraints and suitable remedial measures for the precision technology on water and nutrient management are also discussed.

Cotton, one of the most important commercial crops in India, is cultivated for its fibre and by-products. Fortunately, cotton production has been in excess of domestic consumption consecutively for the second season in India and there is an estimated production of 270 lakh bales from 91.32 lakh hectares with a productivity of 503 kg/ha during 2006-07 (AICCIP, 2006-07) leading to a satisfactory closing balance of 44 lakh bales for the next year.

Despite the significant breakthrough in overall production, the mismatch between the demand and supply continues in case of extra long staple (ELS) cotton. As against the demand of 8-10 lakh bales of ELS cotton, the supply position may not exceed a mere 5 lakh bales. In addition, the price increase in the case of medium and long staple categories was only 5 per cent as against a sharp 35 per cent increase in case of ELS cottons (DCH 32 and Suvin) during the last 3 year period. Moreover, imports of ELS cotton is expensive because of reduction in export subsidy, poor harvest in exporting countries and high international prices requiring research efforts for strengthening the local production of ELS.

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Constraints in ELS production

Several natural and other constraints fall within the purview of ELS cotton and these include-

- ELS cotton with its long duration, lowered per day productivity & profitability, longer gestation period to realize the income and severity in pink boll worm infestation,
- Susceptibility to sucking pests,
- Problems related to sterility of crop plants and poor boll bursting with more number of empty locules,
- Climate sensitivity limiting earliness,

- Intensive labour requirement and prolonged drudgery in its cultivation,
- Lesser suitability for rainfed regions,
- Sensitivity to water logging and nutrient deficiency,
- Potential threats from *hirsutum* hybrids and competing crops like maize, sugarcane, sunflower, turmeric, tapioca and vegetable and
- High cost of production with less margins.

Despite these constraints, the ELS types is gaining importance because of premium involved and spurt in its market demand. Therefore, the reorientation of ELS cotton with improved management practices will promote its production and is likely to take care of quality aspects (Praharaj, *et al.*, 2007). Management of key inputs like water and nutrients also need to be given due importance. Moreover, input use efficiency is also very low resulting in low crop productivity, degraded soil health and increased environmental pollution besides wastage of substantial quantity of these inputs. Synergistic interaction between these critical inputs especially that of water and nutrient in cotton has been researched to harness maximum benefits. This in turn requires precision management of irrigation and nutrient, such as drip-fertigation where small quantity of precious inputs could perform better.

1. Precision management of water and nutrients-Drip-fertigation

Although India is having the largest irrigation network in the world, its efficiency is only 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 (Sivanappan, 1985) since drip irrigation has proved its superiority over others due to direct application of water in the root zone and increased WUE. In addition, drip-fertigation, where fertilizer is applied through an efficient irrigation system, nutrient use efficiency could be as high as 90 per cent. The amount of fertilizer lost through leaching could be as low as 10 per cent in fertigation whereas it is 50 per cent in the traditional one.

Since fertigation permits application of a nutrient directly at the site of a high concentration of active roots as per crop need, scheduling fertilizer applications offers the possibility of reducing nutrient losses associated with conventional application. In addition, fertilizer savings through fertigation could be to the tune of 25-50 per cent (Haynes, 1985). Moreover, as drip irrigation wets only a portion of the soil volume around each plant and thus, traditional methods of fertilizer application is ineffective in this case. The limited root zone & the reduced amount of mineralization are the main reasons for the decreased nutrient availability to the plants with normal method of fertilizer application under drip irrigation (Magen, 1995). Fertigation (application of water soluble solids/liquid fertilizers so as to reach each and every plant) on weekly/monthly basis is an effective and convenient means of maintaining optimum fertility level and water supply according to the specific requirement (Shirgure, *et al.*, 2000). Micronutrients such as iron, manganese, zinc and copper can also be applied through irrigation water in chelated form (Fe EDTA) without causing any precipitations.

1.1 Potential advantages

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 (Aljibury, 1974). In a study at Coimbatore (T.N.) during winter season with MCU 5 cotton, the conventional method of irrigation with 33.9 cm of water produced 14.5 q/ha of seed cotton yield while the drip method with only 16.3 cm of water yielded 13.2 q/ha (Shanmugam et al., 1976). There was a 10 per cent increase in yield due to drip irrigation method compared to surface irrigation in a medium deep clay soils at Parbhani (M.H.). Moreover, seed cotton yield with 0.6 ETc in drip method was at par with higher schedules (0.8 and 1.0 ETc) and was significantly superior to 0.4 ETc in drip and surface irrigations (Vaishnava et al., 1995). Application of drip irrigation at 0.6 ETc on alternate days at Parbhani, Nagpur and Dharward; 0.8 ETc at Guntur and 1.0 ETc at Surat, Coimbatore and Sirsa was found beneficial (Anon, 2002).

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 the benefits of drip irrigation includes frequent irrigation to crop as far as practicable (Hillel, 1972), free from irrigation induced soil aeration (Dasberg and Steinhardt, 1974), less plant disease (Hanson and Patterson, 1974), and restricted plant root growth (Willoughby and Cockroft, 1974). Drip irrigation led to 10-25 per cent more seed cotton yield compared to furrow irrigation in a summer trial at Coimbatore (Padmakumari and Sivanappan, 1979). Drip irrigation raised the lint yield up to 670 kg/ha compared to furrow irrigation (Wilson, *et al.* (1984). The work done at Rahuri indicated that yield of cotton could be increased by 34 per cent with drip irrigation (Sonawane, 1984). Even buried drip system recorded higher lint yield as compared to surface drip system and conventional furrow irrigation at New South Wales, Australia (Constable and Hodgson (1990). In the sodic soil of Tamil Nadu, 10 per cent more cotton yield was realized in drip method over that in surface method (Muthusamy et al., 1993). At Akola, on a sandy clay loam soil, drip irrigation at 1.5 litres/day recorded significantly higher seed cotton yield (17.19 q/ha) when compared to 16 q/ha with 0.5 litre/day (Narkhede and Bharad, 1994).

Drip irrigation to a sandy soil in Nile valley, Egypt showed 63 per cent increase in yield of Giza 45 and enhanced fibre maturity by 13.5 per cent as against traditional irrigation (Nawar et al., 1995). In a blakhk soil of Narmada Command, drip irrigation was found to increase the yield of hybrid cotton by a quarter at 70 per cent replenishment level of pan evaporation (Anon, 1995). Studies made in USA indicated the lint yield increased 50, 40 and 58 per cent with drip system over flood, furrow and sprinkler irrigation methods respectively (Benke, 1996). At Bangalore (KTK), yields of the plant and ratoon cotton hybrid DCH 32 were increased by 13 & 3 per cent under turbo tape drip; and 12 & 6 per cent under emitter drip respectively over furrow irrigation (Srinivasa Reddy and Thimme Gowda, 1997). Trials in black soil at Dharwad indicated that increase in ET level from 50 to 100 per cent in drip irrigation has raised the seed cotton yield from 2070 to 2391 kg/ha (Anonymous, 1998). It was also found that drip irrigation treatments enhanced the seed cotton yield (11.6 to 16.4 q/ha) of cultivar Anjali as compared to the flood irrigation treatments (6.7 to 8.5 q/ha) (Shanmugam and Nalayini, 2001). Even drip irrigation at 100 per cent ET with 120 x 60 cm spacing produced the highest seed cotton yield (2509 kg/ha) and was 17, 12, and 25 per cent more than that with continuous furrow irrigation, alternate furrow irrigation and control respectively (Halemani, *et al.*, 2003).

Application of irrigation to NHH-44 through drip in alternate days resulted in significantly higher seed cotton yield (3066 kg/ha) than surface (2153 kg/ha) irrigation methods (ridges and furrow) (Anonymous, 2003).

Superior fibre quality

The influence of irrigation water on fibre quality is less pronounced compared to its effect on seed cotton yield. Weekly irrigation sometimes decreases the uniformity of fibre length, micronaire value and yarn length (Hearn, 1975). Contrarily, fibre quality was little affected by reducing the irrigation (Palomo and Quirate, 1978). The extreme regime of either excess water or prolonged dryness could also reduce the fibre length (Kittack, *et al.* 1983). But, limited irrigation has no influence on ginning percentage, fibre length and bundle strength (Howel, *et al.*, 1985) although limited moisture increased the fibre staple length (Hans and McMichael, 1986), while similar result with frequent irrigation regime (based on IW/CPE of 0.75) was also obtained by Subramanian, 1988. Also the higher the moisture regime, the greater is the seed and lint indices (Biswas *et al.*, 1988). In addition, buried and surface drip irrigation reduced the fibre micronaire value when compared to furrow irrigation. However, fibre length and strength were not affected by methods of irrigation (Constable and Hodgson, 1990).

Scheduling irrigation at 8, 12, 16 or 20 cm CPE (cumulative pan evaporation) level did not influence the halo length, fibre fineness and ginning percentage significantly (Singh and Bhan, 1993). However, irrigation scheduled at 0.75 IW/CPE recorded significantly higher Bartlett index, lint index and ginning percentage as compared to 0.5 IW/CPE and irrigation at 0.75 per cent depletion of available soil moisture, yet other fibre properties were not influenced by the irrigation regimes (Christopher Lourduraj and Chinnasamy, 1993). Similarly, under Akola condition, drip irrigation regimes of 0.5, 1.0 or 1.5 lit/day/hill did not influence various quality parameters although uniformity ratio was higher with the lower drip irrigation regime of 0.5 lit/day/plant (Narkhede, *et al.*, 1996). Improvement fibre maturity and fineness were also observed (Sivanappan, 2004). Scheduling of drip irrigation to hybrid cotton at 50 per cent of PET throughout crop growth period saved 50 per cent irrigation water and enhanced WUE and cotton productivity (by 25 per cent) without affecting quality parameters (Patil, *et al.*, 2004). Seed index and lint index were also significantly higher with drip irrigation system (Sankaranarayanan, 2005).

Others reported significantly improved quality parameters under drip-fertigation viz., staple length & micronaire in summer season, and ginning percentage, seed index & lint index in both the seasons (Veeraputhiran, *et al.*, 2004).

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.

Higher fertilizer use efficiency

Drip irrigation offers considerable flexibility in fertilization (Lindsey and New, 1974). 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 (Bester, *et al.*, 1974).

Drip fertigation study at Bet Dagan, Israel indicated that the highest yield of seed cotton (6.3 t/ha) was achieved at 41 kg N/ha (25 ppm of soil NO3-N) during the crop growth period (Halevy and Karmer, 1986). On a medium deep clay soil at Parbhani, application of 100 kg N/ha through drip in six splits increased seed cotton yield by 16 per cent as compared to soil application. Nitrogen application at 75kg/ha through drip recorded comparable yield to that of 100 kg N/ha by soil application in a hybrid cotton NHH 44 (Vaishnava *et al.*, 1995). At the same location, application of 100 kg N/ha as urea through drip irrigation produced significantly higher seed cotton yield over soil application of 100 kg N/ha (at par with 75 kg N/ha) through drip besides improving GOT, micronaire value and bundle strength of lint over soil application in NHH 44 (Bharmbe, *et al.*, 1997).

At Akola, drip fertigation with liquid fertilizer at recommended dose increased the seed cotton yield by 28 per cent without improvement in fibre quality in addition to 50 per cent fertilizer saving compared to soil application (Benke, 1996). In hybrid cotton DCH 32, application of 100 and 50 per cent NPK through drip irrigation recorded comparable yield and were better over 100 per cent NPK combined with flood irrigation at Nagpur (Anonymous, 1997). Drip-fertigation favoured the growth of summer cotton at Coimbatore and resulted in a saving of 50 per cent water besides increasing the yield by 34.5 per cent compared with conventional flood irrigation (Nalayini and Shanmugam, 2002).

Reduced weed competition

Since weed infestation depends on soil moisture content, drip irrigation reduces weed infestation due to limited wetting of root zone only. The weed growth was about 50 per cent in the drip method compared to furrow method of irrigation in cotton (Padmakumari and Sivanappan 1979). Significant reduction in weed biomass (by 50 per cent) was observed in drip irrigation plot as compared to surface irrigated plots (Sivanappan, *et al.*, 1978).

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.

1.2. ELS cotton- a candidate crop

Longer duration of ELS cotton varieties and hybrids, suitability of growing environment especially for water scarce situation, hostile soil medium viz., red soils of major areas of Tamil Nadu, possibility of early sowing for higher yield realization, flexibility of drip system in lay out and its management for other crops in sequence, higher economic returns, import substitution for high priced

Pima or Giza cotton, higher fertilizer use efficiency and better and uniform fibre quality render the ELS cotton a candidate crop for precision management of water and nutrient.

1.3. Economics of drip-fertigation

A technically feasible irrigation method should also be economically viable. Drip irrigation studies on pre-monsoon cotton AHH 468 at Akola indicated that the gross return (16,150 Rs/ha), net return (Rs. 8,200/ha) and net return per rupee invested (2.02) were obtained at high level of drip irrigation (1.5lit/day/hill) as compared to lower drip irrigation level of 0.5 lit/day/hill (Narkhade, *et al.*, 1996).

At Bangalore on DCH 32 hybrid cotton, the mean maximum net return per hectare for main and ratoon crop sequence was obtained in furrow irrigation and turbo tap drip (Rs. 61,000/- in both) and emitter type of drip irrigation (Rs. 53,400/-). The pay back period for the turbo tape and emitter drip irrigation were 3 years (6 crops) and 5 years (10 crops) respectively (Srinivasa Reddy and Thimma Gowda, 1997). Under Maharashtra condition, the higher net income (Rs. 80,000/-) and benefit cost ratio (1.59) were obtained by the adoption of drip irrigation in cotton as compared to the net income (Rs. 50,000/-) and benefit cost ratio (1.20) under flood irrigation (Patil, 1998). The cost of the drip system used in cotton planted in paired row is about Rs. 47, 000/- with benefit cost ratio of 1.83 and a pay back period of 1½ years (Ashokarajan and Palanisamy, 2003). Higher net return and cost benefit ratio was also reported with drip-fertigation at Coimbatore (Sankaranarayanan (2004).

1.4. Successful adoption

Adoption of drip irrigation was influenced in most cases by scarcity of water. Serious problem associated with the system is salt encrustation and clogging of conveyance pipes in case of salt water. While ranking the reasons for non-adoption of drip irrigation by Garetts ranking technique, salt encrustation and clogging of conveyance pipes ranked first, followed by high initial cost, delay in subsidy amount disbursement and finally undulated terrain nature. (Palanisamy and Venkitapalanisamy, 2000). To meet the high initial cost and to popularize these water saving method, the Government has extended subsidies for varying categories of farmers at present upto 50 per cent of the drip irrigation system cost (Asokarajan and Palanisamy, 2003).

1.5. Low initial cost

Drip system can be economical only if the design provides optimum size of main, sub main and laterals. Besides this, proper design, laterals and drippers' cost play an important role in determining the cost of the system as a whole for annual and closely spaced crops like cotton, and it constitutes more than 80 per cent of the cost of the system. Thus, it is desirable to reduce the length of laterals and number of drippers required, or alternately to find out low cost materials for laterals and drippers. Two Low cost drip systems viz., micro tube against the dripper emitter and poly-tubes laterals against the LLDPE lateral have been tested at CICR, Coimbatore during the last few years.

In the former, one lateral (LLDPE) is placed between the two paired rows and micro tube was inserted in lateral and extended to either side of the pairs for water delivery. Water saving up to 46 per cent was observed with the micro tube method of drip irrigation as compared to conventional method of irrigation. The total cost of drip system for microtube method is Rs. 32,100/ha and ordinary drip system is Rs. 62,800/ha. Maximum net income of Rs. 16,400/ha with the highest benefit cost ratio of 1.56 were realized with microtube method (Sankaranarayanan, 2004).

In the latter, instead of LLDPE lateral, different thickness of polytubes punctured at regular interval and tied by waste clothes are placed between the paired rows. The polytubes are recommended to use temporary and seasonal use. Polytubes.laterals system was calculated with less total cost Rs.13000 to 17000/ha. The total cost of the irrigation system was highest with LLDPE with drippers (Rs.62,800/ha.). Total cost of cultivation was higher with LLDPE with drippers (Rs.37800/ha) followed by polytube (450 gauge) (Rs.30800/ha) and control (Rs.26,900/ha).Maximum net return (Rs.17,200 /ha.) and benefit-cost ratio (1.56) was calculated with poly-tubes lateral system while LLDEP and drippers with the least net return (Rs.4000/ha) and benefit cost ratio (1.1). Thus, using poly-tubes laterals, the total cost of the drip irrigation system is reduced up to 70 per cent as compared to existing LLDPE with drippers. Moreover, poly-tubes laterals drip system improve the water use efficiency (32.5 per cent) and saving (41 per cent) of irrigation water as compared to ridges & furrow method (Sankaranarayanan, 2005).

1.6. Salt encrustation and clogging

The water passage into the drippers is relatively narrow (0.5-1.5mm dia) requiring efficient filtration, and is therefore key to efficient functioning of the system. Acidification with injection of phosphoric acid at 0.5 to 2 per cent for 30 minutes and shutting down the system for 24 hours and then flushing out all main, sub main and laterals is recommended to manage clogging problem. Diluted HCL and H2SO4 can also be used at 0.5 to 2 per cent concentration. For chlorination, 500 ppm of sodium hypochlorite is recommended.

Conclusion

Deployment of precise water and nutrient management techniques will definitely bring a revolutionary change in efficient cotton cultivation. Enhanced yield and quality advantages under drip-fertigation will boost up of production, productivity and quality of ELS cotton. Increased water and fertilizer use efficiency under drip-fertigation also ensures effective utilization of these scarce inputs. Moreover, for increasing the extra long staple cotton area under remunerative drip system, adoption of flexible & low cost system and providing reasonable financial support, field level training to farmers & technical guidance to manage clogging & salt encrustation and maintenance of the system are some of the steps suggested upon.

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