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**RESEARCH PAPER**

# Effect of fertigation levels with conventional and water soluble fertilizers on yield and economics of Bt cotton

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**Abstract:** A field experiment was undertaken to study the effect of different fertigation levels with conventional and water soluble fertilizers on seed cotton yield and economics of Bt cotton at the Agriculture Research Station, Dharwad, Karnataka during the *kharif* season of 2016-17. The results indicated that paired row (PR) sowing with fertigation of 100 per cent RDF (150:75:75 kg ha$^{-1}$) through conventional fertilizers (CF) applied in six equal splits ($T_9$) recorded significantly higher seed cotton yield ha$^{-1}$ (40 q ha$^{-1}$) than other treatments, but was on par with PR sowing with fertigation of 30 per cent RDF (45: 22.5: 22.5 kg ha$^{-1}$) through water soluble fertilizer (WSF) and 25 per cent RDF through CF applied in six equal splits *i.e* $T_5$ (38.94 q ha$^{-1}$) and PR sowing with fertigation of 25 per cent RDF (37.5: 19: 19 kg ha$^{-1}$) through WSF and 25 per cent RDF through CF applied in six equal splits *i.e* $T_6$ (37.83 q ha$^{-1}$). This higher seed cotton yield was mainly attributed to higher seed cotton yield per plant, number of bolls harvested per plant, boll weight and number of sympodia per plant. Economic analysis also revealed that PR sowing with fertigation of 100 per cent RDF (150:75:75 kg ha$^{-1}$) through CF applied in six equal splits ($T_9$) recorded highest gross returns (₹ 2,20,018 ha$^{-1}$), net returns (₹ 1,46,115 ha$^{-1}$) and benefit cost (BC) ratio (2.97) as compared to other treatments. PR sowing with fertigation of 30 per cent RDF (45: 22.5: 22.5 kg ha$^{-1}$) through WSF along with 25 per cent RDF through CF applied in six equal splits *i.e* $T_5$ and PR sowing with fertigation of 25 per cent RDF (37.5: 19: 19 kg ha$^{-1}$) through WSF along with 25 per cent RDF through CF applied in six equal splits *i.e* $T_6$ recorded comparable economics with $T_9$.

**Keywords:** Drip irrigation, Economics, Seed cotton, Water soluble fertilizers

## Introduction

Cotton *(Gossypium spp.)* the 'king of the fibre', as it is often referred to, still holds its position high and popularly known as "White Gold", is an important cash and fiber crop under diverse agro-climatic conditions across the globe and in India. Presently the area under cotton in India is about 11.8 m ha accounting to 33 per cent of the world cotton area and stands second in production (352 lakh bales) next to China with average productivity of 503 kg lint ha$^{-1}$. Among the cotton growing states, Karnataka ranks sixth in both area of 5.16 lakh ha and production of 18.90 lakh bales of lint with an average productivity of 556 kg lint ha$^{-1}$ (Anon., 2016). Important milestone that helped to solve cotton bollworm problem was release of Bt cotton in the country during 2002. In the present state of cotton production, Bt cotton not only offered resistance to bollworms, but helped to boost the productivity, income level of farmer, ecological gain by low pesticide consumption and low residual impacts on biological entities including human being. Production and productivity of Bt cotton in the country is gradually decreasing which is mainly due to non adoption of improved production technologies, late sowing, imbalanced fertilizer and irrigation water management. Fertilizer and water play a major role in increasing the productivity of Bt cotton. However, the rising prices for fertilizers and other inputs are of increasing concern for farmers as fertilizer and water management has an important impact on the profitability of cotton production. Hence careful scheduling, quantity and method of application of both water and fertilizer are needed. Drip fertigation is an efficient method of applying fertilizers where irrigation water is utilized as the carrier and distributor of plant nutrients thus ensuring accurate and uniform application of nutrients in the vicinity of active root zone. Drip irrigation has gained widespread popularity as an efficient method for fertilizer application in terms of farmers' acceptance. This is due to substantial saving in irrigation water and nutrients as compared to conventional irrigation and fertilization methods (Veeraputhiran and Chinnusamy, 2005). However, fertigation with liquid fertilizer or 100 per cent water soluble fertilizer has been found to increase the efficacy in the application of fertilizer besides reducing the quantity of fertilizers applied. This in turn, reduces the cost of production and also minimizes the ground water pollution thereby preventing ecological disturbances and health risks occurred due to leaching and accumulation of nitrates in the deeper layers. As such use of fertigation could prove as a blessing for Indian farming may pave the way for efficient use of costly and scarce fertilizers. Keeping this in view, the present study was conducted to assess the efficacy of water soluble fertilizers applied through drip fertigation as against the application of conventional fertilizer on yield and economics of Bt cotton.

## Material and methods

A field experiment was conducted at Agricultural Research Station, Dharwad, Karnataka during *kharif* season of 2016-17 ($15^0$ 07' N latitude and $76^0$ 06' E longitude; altitude 678 meters above mean sea level). The rainfall during the cropping season (June to December) was uniformly distributed with a total rainfall

of 537.5 mm. The soil of the experiment site was medium deep black with 0.40 per cent organic carbon, neutral pH (7.2) and available N, $P_2O_5$ and $K_2O$ were 236.8, 27.2 and 356.6 kg $ha^{-1}$. The experiment was laid out with nine treatments replicated thrice in randomized complete block design (RCBD). The treatments were $T_1$ - fertigation of 30 per cent RDF through water soluble fertilizer (WSF) (45: 22.5: 22.5 N: $P_2O_5$: $K_2O$ kg $ha^{-1}$); $T_2$ - fertigation of 25 per cent RDF through WSF (37.5: 19: 19 N: $P_2O_5$: $K_2O$ kg $ha^{-1}$); $T_3$- fertigation of 20 per cent RDF through WSF (30: 15: 15 N: $P_2O_5$: $K_2O$ kg $ha^{-1}$); $T_4$- fertigation of 15 per cent RDF through WSF (22.5: 11: 11 N: $P_2O_5$: $K_2O$ kg $ha^{-1}$); $T_5$- fertigation of 25 per cent RDF through conventional fertilizer (37.5: 19: 19 N: $P_2O_5$: $K_2O$ kg $ha^{-1}$) + $T_1$ ; $T_6$- fertigation of 25 per cent RDF through conventional fertilizer + $T_2$ ; $T_7$- fertigation of 25 per cent RDF through conventional fertilizer + $T_3$; $T_8$ - fertigation of 25 per cent RDF through conventional fertilizer + $T_4$ ; $T_9$- fertigation of conventional fertilizers with 100 per cent RDF (150: 75: 75 N: $P_2O_5$: $K_2O$ kg $ha^{-1}$). Water soluble fertilizers (WSF) were 19: 19: 19 and urea (46:0:0), whereas conventional fertilizers are urea, SSP (0:16:0) and MOP (0:0:60). Sowing of the potential interspecific hybrid Ajit-155 *BG-II was done* on 20th June 2016 by hand dibbling of seeds at 120 cm–60 cm–120 cm (paired row).

Drip irrigation was scheduled at 1.0 Etc level and scheduling of irrigation was done by using crop coefficient factors during cotton growth period and pan coefficient at every three days interval by considering rainfall using the following formula.

$$V = E_0 \times Kc \times Kp \times A \times 2$$

Where, V: Volume of water to be given through drip for two plants (l), $E_0$: Pan evaporation of two days (mm), Kc : Crop factor as per growth stages of cotton, Kp : Pan factor (0.70), A: Area to be irrigated (Spacing).

12.5 mm inline lateral with 4 lph drippers at 60 cm spacing was laid for each pair of plants and fertigation was done in six equal splits at an interval of 15 days each at 15, 30, 45, 60, 75 and 90 days after sowing (DAS) common for all treatments. Other production factors remained uniform for all the treatments except for the nutrient levels with conventional and water soluble fertilizers. Observations were recorded as per the standard procedure laid out for cotton crop and the data were subjected to statistical analysis as described by Gomez and Gomez (1984).

## Results and discussion

### Effects on yield attributes

The yield attributes like total number of bolls $plant^{-1}$ and seed cotton yield $plant^{-1}$ influenced significantly due to varied fertigation levels with conventional and water soluble fertilizers with split application and PR sowing with fertigation of 100 per cent RDF (150:75:75 kg $ha^{-1}$) through conventional fertilizers applied in six equal splits ($T_9$) favourably increased these yield attributes (54.40 and 275.20 g, respectively), than other lower levels of fertigation (Table 1). However, PR sowing with fertigation of 30 per cent RDF (45: 22.5: 22.5 kg $ha^{-1}$) through WSF and 25 per cent RDF through CF applied in six equal split *i.e.,* $T_5$ (50.07 and 251.43 g, respectively) and PR sowing with fertigation of 25 per cent RDF (37.5: 19: 19 kg $ha^{-1}$) through WSF and 25 per cent RDF through CF applied in six equal splits *i.e* $T_6$ (48.13 and 243.27 g, respectively) were equally effective in enhancing number of bolls $plant^{-1}$ and seed cotton yield $plant^{-1}$. Mean boll weight was found at par among the treatments during the course of investigation. Increase in number of bolls $plant^{-1}$ and seed cotton yield $plant^{-1}$ with higher levels of fertigation than lower levels was due to improvement in various growth attributes *viz*., number of sympodia $plant^{-1}$, functional leaves, leaf area and dry matter accumulation $plant^{-1}$ and its subsequent translocation to sink. The cumulative effect of these attributes finally improved the ability of cotton crop to produce and support more number of bolls depends on dry matter accumulation and its translocation to sink. The results are in conformity with earlier reports of Bhattoo *et al*. (2008), Reddy and Aruna (2010), Bhalerao *et al*. (2011) and Gokila (2012), who reported improvement in the number of bolls $plant^{-1}$ and seed cotton yield per $plant^{-1}$ under higher level of fertigation of nutrients. This might be due to enhanced availability and uptake of nutrients leading to enhanced photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts compared to lower levels of fertigation. The favourable effect of fertigation with increased levels of WSF on the physiology of plant through its simulating effects on initiating more boll forming points and their subsequence retention and development in plant leading to higher number of bolls $plant^{-1}$ which must have consequently lead to increase the seed cotton yield $plant^{-1}$ and thus seed cotton yield $ha^{-1}$. Jayakumar *et al.* (2015) and Satyanarayana and Janawade (2006) indicated that total bolls per plant and mean boll weight were significantly more in the crop applied with higher levels of nutrients through WSF. Higher fertigation levels increased photosynthetic rate which might have resulted in higher accumulation of metabolites, thus impacted higher boll weight.

### Seed cotton yield

Paired row sowing with fertigation of 100 per cent RDF (150:75:75 kg $ha^{-1}$) through CF applied in six equal splits ($T_9$) recorded significantly higher seed cotton yield (SCY) $ha^{-1}$ (40 q $ha^{-1}$) compared to other treatments (Table 1). However, it was on par with PR sowing with fertigation of 30 per cent RDF (45: 22.5: 22.5 kg $ha^{-1}$) through WSF and 25 per cent RDF through CF applied in six equal splits *i.e* $T_5$ (38.94 q $ha^{-1}$) and PR sowing with fertigation of 25 per cent RDF (37.5: 19: 19 kg $ha^{-1}$) through WSF and 25 per cent RDF through CF applied in six equal splits *i.e.,* $T_6$ (37.83 q $ha^{-1}$). Significantly lower SCY $ha^{-1}$ (26.38 q $ha^{-1}$) was recorded in PR sowing with fertigation of 15 per cent RDF (22.5: 11: 11 kg $ha^{-1}$) through WSF applied in six equal splits ($T_4$). Drip fertigation with increased levels of WSF had marked and favourable influence on growth and yield parameters *viz.* number of sympodia $plant^{-1}$, leaf area index, dry matter production, number of bolls $plant^{-1}$and seed cotton yield $plant^{-1}$ of cotton. The favourable influences of these parameters were reflected on SCY. Similar response of increased yield was reported by

Table 1. Growth and yield parameters and seed cotton yield of Bt cotton as influenced by fertigation levels with conventional and water soluble fertilizers

| Treatment | Number of sympodia plant$^{-1}$ | Number of bolls plant$^{-1}$ | Boll wt (g) | Yield per plant (g) | Seed cotton yield (q ha$^{-1}$) |
|---|---|---|---|---|---|
| $T_1$: Fertigation of 30% RDF through WSF | 19.27 | 44.07 | 6.03 | 207.33 | 30.89 |
| $T_2$: Fertigation of 25% RDF through WSF | 19.00 | 42.73 | 6.03 | 205.20 | 28.90 |
| $T_3$: Fertigation of 20% RDF through WSF | 18.67 | 42.40 | 6.02 | 198.80 | 27.80 |
| $T_4$: Fertigation of 15% RDF through WSF | 18.53 | 39.20 | 5.98 | 196.40 | 26.38 |
| $T_5$: Fertigation of 25% RDF through CF + $T_1$ | 20.53 | 50.07 | 6.16 | 251.43 | 38.94 |
| $T_6$: Fertigation of 25% RDF through CF + $T_2$ | 20.27 | 48.13 | 6.12 | 243.27 | 37.83 |
| $T_7$: Fertigation of 25% RDF through CF + $T_3$ | 19.53 | 46.27 | 6.11 | 214.93 | 33.35 |
| $T_8$: Fertigation of 25% RDF through CF + $T_4$ | 19.27 | 44.60 | 6.09 | 211.47 | 31.68 |
| $T_9$: Fertigation of conventional fertilizers with 100 % RDF | 20.80 | 54.40 | 6.22 | 275.20 | 40.00 |
| S. Em. ± | 0.78 | 2.16 | 0.18 | 12.59 | 1.35 |
| C.D. (P = 0.05) | NS | 6.49 | NS | 37.75 | 4.04 |

NS: Non significant WSF: Water soluble fertilizer (19: 19: 19)
RDF: 150: 75: 75 N: $P_2O_5$: $K_2O$ kg ha$^{-1}$ CF: Conventional fertilizer

Pawar *et al*. (2014), Baskar and Jagannathan (2014) and Bhakare *et al.* (2015) who obtained higher seed cotton yield ha$^{-1}$ with application of higher levels of WSF through drip. Shanmugham *et al*. (2007), Hadole *et al*. (2012), Nalayani *et al.* (2012) and Kakade *et al*. (2017) also reported that increased seed cotton yield under higher fertigation levels was due to Increased nutrient availability and absorption by the crop at the optimum moisture supply coupled with frequent and higher nutrient supply by fertigation and consequent better formation and translocation of assimilates from source to sink. Results also indicated that, fertigation of both WSF and CF ($T_5$ and $T_6$), saved 45 and 50 per cent fertilizer and also recorded on par yield with fertigation of 100 per cent RDF through CF only. Balasubramanian *et al*. (2000), Bhakare *et al.* (2015), Nalayini *et al*. (2012) and Shruti and Aladakatti (2017) also reported saving of fertilizer through drip fertigation to cotton and opined that as nutrients are supplied through WSF along with the water in the root zone through drip system, root proliferation was greater resulting in enhanced uptake of nutrients and water and hence increase SCY.

## Economics

Higher gross returns (₹ 2,20,018 ha$^{-1}$), net returns (₹ 1,46,115 ha$^{-1}$) and benefit cost ratio (2.97) were recorded in PR sowing with fertigation of 100 per cent RDF (150:75:75 kg ha$^{-1}$) through CF applied in six equal splits ($T_9$) as compared to other treatments and was on par with PR sowing with fertigation of 30 per cent RDF (45: 22.5: 22.5 kg ha$^{-1}$) through WSF along with 25 per cent RDF through CF applied in six equal splits *i.e* $T_5$ and PR sowing with fertigation of 25 per cent RDF (37.5: 19: 19 kg ha$^{-1}$) through WSF along with 25 per cent RDF through CF applied in six equal splits $T_6$. Lowest net returns (₹ 79,673 ha$^{-1}$) and B C ratio (2.22) was recorded in PR sowing with fertigation of 15 per cent RDF (22.5: 11: 11 kg ha$^{-1}$) through WSF applied in six equal splits ($T_4$). Higher gross and net returns was mainly attributed to higher seed cotton yield which was resulted because of higher availability of water and nutrient to the crop for the better growth. The results are in conformity with the findings of Rajendran and Arunvenkatesh (2014) and Bharathraj *et al.* (2015) who indicated the economic superiority of drip fertigation with WSF through higher yield, net returns and B C ratio.

## Conclusion

The present study revealed that paired row sowing with drip fertigation of 25 per cent RDF (37.5: 19: 19 N: $P_2O_5$: $K_2O$ kg ha$^{-1}$) through water soluble fertilizers (19: 19: 19) along with 25 per cent RDF through conventional fertilizers (37.5: 19: 19 N: $P_2O_5$: $K_2O$ kg ha$^{-1}$) applied in six equal splits found to be

Table 2. Economics of Bt cotton as influenced by fertigation levels with conventional and water soluble fertilizers

| Treatment | Cost of cultivation (₹ ha$^{-1}$) | Gross returns (₹ ha$^{-1}$) | Net returns (₹ha$^{-1}$) | B:C |
|---|---|---|---|---|
| $T_1$: Fertigation of 30% RDF through WSF | 73,586 | 1,69,877 | 96,290 | 2.31 |
| $T_2$: Fertigation of 25% RDF through WSF | 70,697 | 1,58,932 | 88,235 | 2.24 |
| $T_3$: Fertigation of 20% RDF through WSF | 67,998 | 1,52,900 | 84,902 | 2.25 |
| $T_4$: Fertigation of 15% RDF through WSF | 65,398 | 1,45,072 | 79,673 | 2.22 |
| $T_5$: Fertigation of 25% RDF through CF + $T_1$ | 79,480 | 2,14,170 | 1,34,690 | 2.69 |
| $T_6$: Fertigation of 25% RDF through CF + $T_2$ | 77,032 | 2,08,083 | 1,31,051 | 2.70 |
| $T_7$: Fertigation of 25% RDF through CF + $T_3$ | 72,638 | 1,83,407 | 1,10,769 | 2.52 |
| $T_8$: Fertigation of 25% RDF through CF + $T_4$ | 69,918 | 1,74,258 | 1,04,340 | 2.49 |
| $T_9$: Fertigation of conventional fertilizers with 100 % RDF | 73,903 | 2,20,018 | 1,46,115 | 2.97 |
| S. Em. ± | - | 7,412 | 6,738 | 0.10 |
| C.D. (P = 0.05) | - | 22,221 | 20,201 | 0.29 |

RDF: 150: 75: 75 N: $P_2O_5$: $K_2O$ kg ha$^{-1}$ WSF: Water soluble fertilizer (19: 19: 19) CF: Conventional fertilizer

optimum for higher seed cotton yield, net return and B C ratio which was on par with the seed cotton yield obtained with 100 per cent RDF through conventional fertilizers (150:75:75 N: $P_2O_5$: $K_2O$ kg $ha^{-1}$) which reduced the quantity of fertilizers by 50 per cent to that of fertigation with 100 per cent RDF through conventional fertilizer.

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