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Original Research Article

Effect of Conventional and Water Soluble Fertilizers through Fertigation on Growth, Physiology and Yield of Bt Cotton

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A B S T R A C T

A field experiment was undertaken *in vertisols* at Agricultural Research Station, Dharwad, Karnataka during the *kharif* season of 2016-17 to assess the effect of different fertigation levels with conventional and water soluble fertilizers on growth and yield of Bt cotton. The results revealed that all the growth and physiology parameters *viz.* dry matter accumulation per plant, leaf area index, leaf area duration, chlorophyll content in leaf and yield attributes *viz.* sympodial branches, bolls plant^{-1} and seed cotton yield plant^{-1} were substantially enhanced by drip fertigation level and was found maximum at fertigation with 100 per cent RDF through conventional fertilizers (CF) applied in six equal splits (T_9) than other treatments, but 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) along with 25 per cent RDF through CF applied in six equal splits *i.e* T_5. 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 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 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}).

Keywords

Drip irrigation, Water soluble fertilizers, Seed cotton yield

Introduction

Cotton (*Gossypium hirsutum* L.) is the most important commercial fiber crop and it is grown in about 11.8 million hectares under diverse agro climatic conditions of India (Anon., 2016). It is known as 'king of the fibre', as it is often referred to, still holds its position high and popularly called as 'white gold'. However, in India the productivity of cotton is as low as 505 kg lint ha^{-1} as compared to global average of 735 kg lint ha^{-1} (Nasarabad *et al.*, 2013). Karnataka is the leading state and ranks sixth in both area (5.16 lakh ha) and production (18.90 lakh bales of lint) with an average productivity of 556 kg lint ha^{-1} (Anon., 2016). Bt cotton hybrids now constitute about 90 per cent of the cotton area sown in the country (Kakade *et al.*, 2017). The obvious reasons for low productivity of cotton can be attributed to large area (>90 per cent) under rainfed conditions, use of sub-optimum doses of fertilizers, application of nutrients and irrigation water at improper stages of crop growth as well as the imbalanced plant nutrition. To overcome these problems, it is imperative to apply optimum doses of nutrients with judicious use of irrigation water at proper crop growth stages. Water and fertilizers are the most important critical inputs for producing vigorous healthy plants and improving the yield of cotton crop. 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 and influences the uptake and yield of the crop with minimum losses of nutrients through volatilization, leaching and fixation in the soil (Yende, 2003 and Pawar *et al.,* 2014). The amount of fertilizer lost through leaching could be as low as 10 per cent in drip fertigation as compared to 50 per cent in the conventional method of fertilizer application (Sankaranarayanan *et al.,* 2010).

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. In view of the above, it was felt appropriate to study the efficacy of conventional and water soluble fertilizers applied through drip fertigation on growth, physiology and yield of Bt cotton.

Materials 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). For cotton crop the Kc values were 0.45, 0.75, 1.15 and 0.70 for seedling (0-25 DAS), crop development stage (26-70 DAS), boll development (71-120 DAS) and maturity stage (121 DAS to at harvest) respectively (Shruti and Aladakatti, 2017) 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

The results of the present study as well as relevant discussion have been summarized under following heads:

Growth parameters

The results (Table 1) revealed that concomitant increase in all the growth attributes were noticed with each increasing level of drip fertigation. In cotton, among the drip fertigation levels, PR sowing with fertigation of 100 per cent RDF (150:75:75 kg ha^{-1}) through CF applied in six equal splits (T_9) improved the dry matter accumulation per plant (329.39 g $plant^{-1}$) at harvest. However, it was found comparable 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 (307. 28 g $plant^{-1}$). Plant height and number of sympodia $plant^{-1}$ was found at par among the treatments during the course of investigation. Enhanced availability and uptake of nutrients under fertigation might have led to enhance photosynthesis, expansion of leaves and translocation of nutrients. The favourable increase in growth attributes in terms of plant height and dry matter accumulation due to drip fertigation was reported by Bhalerao *et al.*, (2011), and Ayyadurai and Manickasundaram (2014). Increased growth parameters with fertigation of 100 per cent RDF (150:75:75 kg ha^{-1}) through CF and fertigation of 30 per cent RDF (45: 22.5: 22.5 kg ha^{-1}) through WSF along with 25 per cent RDF through CF might be due to presence of favourable microclimate to the plants and application of sufficient nutrients in readily available form would have accelerated the proliferation of growth regulators such as auxin (IAA) and cytokinin which in turn stimulated the action of cell elongation and cell division and resulted in increased growth of cotton. Similar findings were reported by Kavitha *et al.*, (2007) in tomato and Anitta (2010) in maize. Fertigation with water soluble fertilizer helped the dissolved nutrients for better distribution along the wetting soil volume. This might have resulted in more uptake of nutrients and growth resulting in higher dry matter production. Veeraputhiran (2000), Sathyaprakash (2007), Bhalerao *et al.*, (2011) reported higher dry matter accumulation when fertilizers were applied through fertigation in splits. Nalayani *et al.*, (2012), Gokila (2012) and Ayyadurai and Manickasundaram (2014) also reported that split application of nutrients in more split enhanced the dry matter production.

Physiological parameter

As indicated in Table 2, the physiological characters like leaf area index (LAI), chlorophyll content in leaf (SPAD value) at 90 and 120 DAS and leaf area duration (LAD) at 90 to120 DAS influenced significantly due to different fertigation levels with conventional and water soluble fertilizers applied in six equal splits. Significantly higher LAI (1.86 and 2.54), SPAD value (42.20 and 47.63) at 90 and 120 DAS and LAD (66.05) at 90 to120 DAS was 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) over 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 and 25 per cent RDF through CF applied in six equal split *i.e* T_5 (1.66 & 2.31, 39.93 & 43.70 and 59.58, respectively). High LAI, LAD and SPAD value was mainly due to higher frequency of irrigation and increased availability of soil moisture under drip irrigation coupled with fertigation might have led to effective absorption and utilization of nutrients and better proliferation of roots resulting in better canopy growth. Ayyadurai and Manickasundaram (2014) also stated that fertigation with higher levels of nutrients reported higher LAI. Jayakumar *et al.*, (2015) indicated that LAI increased slowly in early stages of crop growth and rapidly after seedling stages. As leaf area index increased, light interception was more resulting in higher dry matter production. However, chlorophyll content in leaf is directly related to nitrogen content in leaf. So concentration of N in leaf strongly influences the SPAD value. Brar *et al.*, (2002) and Hallikeri *et al.*, (2011) indicated that status of chlorophyll content in leaf was affected by nitrogen.

Yield attributes and yield

Different fertigation levels with conventional and water soluble fertilizers had marked and favourable influence on growth and yield parameters *viz*. number of sympodia $plant^{-1}$, dry matter production, number of bolls $plant^{-1}$, seed cotton yield $plant^{-1}$. These favourable influences on these parameters were reflected on seed cotton yield (SCY) due to various treatments (Table 1). PR sowing with fertigation of 100 per cent RDF (150:75:75 kg ha^{-1}) through CF applied in six equal splits (T_9) favourably increased the yield attributes *viz.* number of bolls $plant^{-1}$ and seed cotton yield $plant^{-1}$ (54.40 and 275.20 g, respectively), than other lower levels of fertigation. 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 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). Mean boll weight was found non-significant among the treatments. Higher number of bolls $plant^{-1}$ and seed cotton yield $plant^{-1}$ with higher levels of fertigation than lower levels was due cumulative effect of various growth attributes *viz.* number of sympodia $plant^{-1}$, functional leaves, leaf area index and dry matter accumulation $plant^{-1}$ and its subsequent translocation to sink. Similar response of increased yield $plant^{-1}$ was reported by Muthuchamy and Subramanaian (2004) and Bhakare *et al.*, (2015) with the application of WSF through drip.

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	Plant height (cm)	Total dry matter production (g plant^{-1})	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	117.13	269.31	19.27	44.07	6.03	207.33	30.89
T_2: Fertigation of 25% RDF through WSF	116.33	264.24	19.00	42.73	6.03	205.20	28.90
T_3: Fertigation of 20% RDF through WSF	115.53	259.17	18.67	42.40	6.02	198.80	27.80
T_4: Fertigation of 15% RDF through WSF	114.93	251.80	18.53	39.20	5.98	196.40	26.38
T_5: Fertigation of 25% RDF through CF + T_1	124.93	307.28	20.53	50.07	6.16	251.43	38.94
T_6: Fertigation of 25% RDF through CF + T_2	124.73	296.34	20.27	48.13	6.12	243.27	37.83
T_7: Fertigation of 25% RDF through CF + T_3	119.13	289.00	19.53	46.27	6.11	214.93	33.35
T_8: Fertigation of 25% RDF through CF + T_4	118.80	277.98	19.27	44.60	6.09	211.47	31.68
T_9: Fertigation of conventional fertilizers with 100 % RDF	128.87	329.39	20.80	54.40	6.22	275.20	40.00
S. Em. ±	4.58	8.30	0.78	2.16	0.18	12.59	1.35
C.D. (P = 0.05)	NS	24.88	NS	6.49	NS	37.75	4.04

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

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

Treatment	Leaf area index		Leaf area duration (days)	SPAD value	
	90 DAS	120 DAS	90-120 DAS	90 DAS	120 DAS
T_1: Fertigation of 30% RDF through WSF	1.34	2.14	52.25	37.23	40.40
T_2: Fertigation of 25% RDF through WSF	1.13	2.13	49.00	36.50	39.63
T_3: Fertigation of 20% RDF through WSF	1.10	2.11	48.15	36.13	38.70
T_4: Fertigation of 15% RDF through WSF	1.02	2.04	45.85	35.60	38.53
T_5: Fertigation of 25% RDF through CF + T_1	1.66	2.31	59.58	39.93	43.70
T_6: Fertigation of 25% RDF through CF + T_2	1.59	2.23	57.30	39.30	42.47
T_7: Fertigation of 25% RDF through CF + T_3	1.52	2.16	55.15	37.73	42.40
T_8: Fertigation of 25% RDF through CF + T_4	1.45	2.14	53.93	37.47	41.57
T_9: Fertigation of conventional fertilizers with 100 % RDF	1.86	2.54	66.05	42.20	47.63
S. Em. ±	0.11	0.08	2.16	1.26	1.48
C.D. (P = 0.05)	0.34	0.25	6.48	3.77	4.45

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

The favourable effect of fertigation 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$^{-1.}$ 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.

Seed cotton yield increased with each level of fertigation where 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 significantly higher seed cotton yield (SCY) ha^{-1} (40 q ha^{-1}) compared to other treatments (Table1). 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 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.

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 at 15 days interval found to be optimum for higher seed cotton yield, 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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