Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; SP1: 97-101

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Dry matter portioning, yield attributes and yield of Bt cotton as influenced by different fertigation levels with conventional and water soluble fertilizers

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Abstract

A field experiment was undertaken to study the effect of different fertigation levels with conventional and water soluble fertilizers (WSF) on dry matter (DM) portioning, yield attributes and yield of Bt cotton at ARS, 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 DM portioning to different parts and total DM production per plant at different growth stages as compared to other treatments. Regarding to yield and yield contributing parameters, PR sowing with fertigation of 100 per cent RDF through CF applied in six equal splits (T_9) recorded significantly higher number of bolls plant^{-1} (54.40), seed cotton yield plant^{-1} (275.20 g) and 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 WSF and 25 per cent RDF through CF applied in six equal splits *i.e* T_5 (50.07, 251.43 g and 38.94 q ha^{-1}, 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, 243.27 g and 37.83 q ha^{-1}, respectively). Significantly lower bolls plant^{-1} (39.20), seed cotton yield plant^{-1} (196.40 g) and seed cotton yield 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). Number of sympodia plant^{-1} and mean boll weight did not differ significantly among different treatments, but increased fertigation levels resulted increased number of sympodia plant^{-1} and mean boll weight.

Keywords: Bt cotton, drip fertigation levels, Water soluble fertilizers, dry matter portioning, seed cotton yield.

Introduction

Cotton (*Gossypium spp.*) is an important cash crop both in world and India. It provides fibre, a raw material for textile industry along with cotton seed which plays a vital role in economy of the country. Cotton and its value-added products are major export earners for India's national income. Hence, it is popularly known as "White Gold" and also the 'king of the fibre'. Important milestone that helped to solve cotton bollworm problem was release of Bt cotton in the country during 2002. 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. Fertilizer and water play a major role in increasing the productivity of Bt cotton. However, 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. 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. 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) [11]. Drip irrigation has the added advantage as liquid fertilizer or 100 per cent water soluble fertilizer can be injected through the system via fertigation in precised amounts and when required to match the crop needs. By fertigation 25-30 per cent fertilizer saving is possible from the recommended dose resulting in reduced cost of fertilizers and application costs (Baskar and Jagannathan, 2014) [2]. Drip fertigation system resulted in saving of 50 per cent irrigation water and 60 kg N ha^{-1} with higher water and N use efficiency in hybrid cotton (Sankaranarayanan *et al*., 2007) [7].

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 dry matter portioning, yield attributes and yield 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 (CF) (37.5: 19: 19 N: P_2O_5: K_2O kg ha^{-1}) + T_1 ; T_6 - fertigation of 25 per cent RDF through CF + T_2 ; T_7 - fertigation of 25 per cent RDF through CF + T_3; T_8 - fertigation of 25 per cent RDF through CF + 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).

One 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 dry matter partioning

Different fertigation levels with conventional and water soluble fertilizers had significant effect on DM partitioning to different parts and total DM production (Table 1a, 1b, 1c and 1d). The variation in the DM partitioning was noticed due to treatment difference. Total DM production per plant depends on accumulation of DM in different plant parts *viz.*, leaf, stem and reproductive parts. During vegetative and early reproductive stages, leaf was the major sink for the photosynthesis, after this phase partitioning of biomass to reproductive parts increased compared to leaf and stem mainly due to number of functional leaves and leaf area $plant^{-1}$ were reduced considerably because of leaf senescence (Prakash *et al.*, 2008) [8].

It was observed that DM accumulation in different parts and total DM production was significantly higher 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) at all growth stages 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 (T_5). Fertigation of 15 per cent RDF (22.5: 11: 11 kg ha^{-1}) through WSF applied in six equal splits (T_4) recorded significantly lower DM accumulation. At 30 DAS, effect of different fertigation levels on DM accumulation in different parts was non significant. Baskar and Jagannathan (2014) [2] indicated that the amount of DM production and its partition into different plant parts depend upon the photosynthetic ability of a plant which in turn depends on leaf, leaf area and duration.

Ayyadurai and Manickasundaram (2014) [1] also stated that fertigation with higher levels of nutrients reported higher leaf area index which resulted in higher DM production. Higher DM production coupled with maximum partitioning of DM into sink decides the yield of any crop (Manjunatha, *et al.*, 2010) [6]. Increasing nutrient application with water soluble fertilizer resulted in an increase DM accumulation to leaf, stem and reproductive parts were realized (Baskar and Jagannathan, 2014) [2]

Effects on seed cotton yield and yield attributes

Fertigation of varied nutrient levels with CF and WSF and split application had significant effect on total number of bolls $plant^{-1}$, seed cotton yield per $plant^{-1}$ and seed cotton yield ha^{-1}, whereas number of sympodia $plant^{-1}$ and mean boll weight did not differ significantly among different treatments (Table 2). 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 number of bolls $plant^{-1}$ (54.40), seed cotton yield $plant^{-1}$ (275.20 g) and seed cotton yield ha^{-1} (40 q ha^{-1}) 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 and 25 per cent RDF through CF applied in six equal splits *i.e* T_5 (50.07, 251.43 g and 38.94 q ha^{-1}, respectively) and PR sowing with fertigation of 25 per cent RDF (37.5: 19: 19 kg ha^{-1}) through water WSF and 25 per cent RDF through CF applied in six equal splits *i.e* T_6 (48.13, 243.27 g and 37.83 q ha^{-1}, respectively).

Among the treatments involving fertigation with only WSF, PR sowing with fertigation of 30 per cent RDF (45: 22.5: 22.5 kg ha^{-1}) applied in six equal splits (T_1) recorded higher number bolls $plant^{-1}$ (44.07), seed cotton yield $plant^{-1}$ (207.33 g) and seed cotton yield ha^{-1} (30.89 q ha^{-1}) as compared to other treatments. Significantly lower bolls $plant^{-1}$ (39.20), seed cotton yield $plant^{-1}$ (196.40 g) and seed cotton yield 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). Though number of sympodia $plant^{-1}$ and mean boll weight did not differ significantly among different treatments, PR sowing with fertigation of both WSF and 25 per cent RDF through CF recorded higher number of sympodia plant^{-1} and mean boll weight compared to their respective fertigation with WSF only.

The results indicated that, seed cotton yield ha^{-1} increased due to increment of fertigation levels which was attributed to increase in the number of sympodia plant^{-1}, higher number bolls plant^{-1}, mean boll weight and seed cotton yield plant^{-1}. 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}. Similar response of increased yield was reported by Pawar *et al.* (2014), Baskar and Jagannathan (2014) [2] and Bhakare *et al.* (2015) who obtained higher seed cotton yield ha^{-1} with application of higher levels of WSF through drip. Similarly boll weight, being the function of seed weight and lint weight in a boll, is the direct reflection of extent of photosynthates translocated to bolls. Jayakumar *et al.* (2015) [6] and Satyanarayana and Janawade (2006) [10] 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.

Table 1a: Dry matter accumulation in stem of Bt cotton as influenced by fertigation levels with conventional and water soluble fertilizers

Treatment	Dry matter accumulation in stem (g plant $^{-1}$)					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
T_1: Fertigation of 30% RDF through WSF	7.08	27.13	47.67	70.96	101.46	111.94
T_2: Fertigation of 25% RDF through WSF	7.06	26.02	46.30	68.55	99.05	109.90
T_3: Fertigation of 20% RDF through WSF	7.03	22.87	43.13	67.47	97.64	109.30
T_4: Fertigation of 15% RDF through WSF	6.93	21.96	39.55	64.75	92.08	103.70
T_5: Fertigation of 25% RDF through CF + T_1	7.16	31.78	59.73	86.85	112.17	131.70
T_6: Fertigation of 25% RDF through CF + T_2	7.13	30.90	55.70	84.22	111.55	125.93
T_7: Fertigation of 25% RDF through CF + T_3	7.12	29.00	53.57	77.89	107.36	122.67
T_8: Fertigation of 25% RDF through CF + T_4	7.10	27.72	51.32	74.25	103.89	115.28
T_9: Fertigation of conventional fertilizers with 100 % RDF	7.26	32.81	62.90	97.53	124.25	140.64
S. Em. ±	0.21	0.82	1.92	3.45	3.18	4.08
C.D. (P = 0.05)	NS	2.46	5.75	10.34	9.53	12.23

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

Table 1b: Dry matter accumulation in leaf of Bt cotton as influenced by fertigation levels with conventional and water soluble fertilizers

Treatment	Dry matter accumulation in leaf (g plant^{-1})					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
T_1: Fertigation of 30% RDF through WSF	5.23	25.37	51.12	88.45	52.36	35.52
T_2: Fertigation of 25% RDF through WSF	5.21	24.26	49.75	86.04	50.99	34.15
T_3: Fertigation of 20% RDF through WSF	5.18	21.11	46.58	84.96	47.49	30.65
T_4: Fertigation of 15% RDF through WSF	5.08	20.20	45.98	71.73	47.22	30.38
T_5: Fertigation of 25% RDF through CF + T_1	5.31	30.02	63.18	99.85	62.51	45.67
T_6: Fertigation of 25% RDF through CF + T_2	5.28	29.14	59.15	97.38	60.39	43.55
T_7: Fertigation of 25% RDF through CF + T_3	5.27	27.24	58.35	95.14	59.59	42.75
T_8: Fertigation of 25% RDF through CF + T_4	5.25	25.96	56.10	90.40	57.34	40.50
T_9: Fertigation of conventional fertilizers with 100 % RDF	5.41	31.05	67.88	105.23	68.71	51.87
S. Em. ±	0.21	0.82	1.63	4.64	1.69	1.69
C.D. (P = 0.05)	NS	2.46	4.88	13.92	5.07	5.07

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

Table 1c: Dry matter accumulation in reproductive parts of Bt cotton as influenced by fertigation levels with conventional and water soluble fertilizers

Treatment	Dry matter accumulation in reproductive parts (g plant^{-1})				
	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
T_1: Fertigation of 30% RDF through WSF	9.13	56.42	97.90	111.58	121.86
T_2: Fertigation of 25% RDF through WSF	9.06	55.05	95.49	109.17	120.19
T_3: Fertigation of 20% RDF through WSF	9.05	51.49	94.08	107.76	119.22
T_4: Fertigation of 15% RDF through WSF	8.96	49.83	88.52	102.54	117.72
T_5: Fertigation of 25% RDF through CF + T_1	9.85	67.04	108.61	122.29	132.62
T_6: Fertigation of 25% RDF through CF + T_2	9.51	64.16	107.99	121.67	126.85
T_7: Fertigation of 25% RDF through CF + T_3	9.49	63.40	103.80	115.77	123.59
T_8: Fertigation of 25% RDF through CF + T_4	9.29	61.40	100.33	113.80	122.20
T_9: Fertigation of conventional fertilizers with 100 % RDF	10.75	73.18	119.35	132.25	141.56
S. Em. ±	0.28	1.80	3.18	3.40	3.64
C.D. (P = 0.05)	0.83	5.39	9.54	10.18	10.92

DAS: Days after sowing, RDF: 150: 75: 75 N: P_2O_5: K_2O kg ha^{-1}, WSF: Water soluble fertilizer (19: 19: 19), CF: Conventional fertilizer

Table 1d: Total dry matter accumulation of Bt cotton as influenced by fertigation levels with conventional and water soluble fertilizers

Treatment	Total dry matter accumulation (g $plant^{-1}$)					
	30 DAS	60 DAS	90 TDM	120 TDM	150 TDM	At harvest
T_1: Fertigation of 30% RDF through WSF	12.32	61.63	155.20	257.32	265.40	269.31
T_2: Fertigation of 25% RDF through WSF	12.26	59.35	151.10	250.09	259.22	264.24
T_3: Fertigation of 20% RDF through WSF	12.21	53.04	141.21	246.52	252.89	259.17
T_4: Fertigation of 15% RDF through WSF	12.00	51.13	135.36	225.00	241.84	251.80
T_5: Fertigation of 25% RDF through CF + T_1	12.46	71.65	189.95	295.31	296.97	307.28
T_6: Fertigation of 25% RDF through CF + T_2	12.42	69.75	179.01	289.59	293.60	296.34
T_7: Fertigation of 25% RDF through CF + T_3	12.39	65.73	175.32	276.83	282.72	289.00
T_8: Fertigation of 25% RDF through CF + T_4	12.35	62.97	168.82	264.98	275.04	277.98
T_9: Fertigation of conventional fertilizers with 100 % RDF	12.68	74.72	203.97	322.12	325.21	329.39
S. Em. ±	0.41	1.83	5.22	9.72	7.11	8.30
C.D. (P = 0.05)	NS	5.50	15.64	29.13	21.33	24.88

NS: Non significant, DAS: Days after sowing, 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: Number of sympodia per plant, number of bolls per plant, boll weight, seed cotton yield per plant, seed cotton yield per hectare 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, RDF: 150: 75: 75 N: P_2O_5: K_2O kg ha^{-1}, WSF: Water soluble fertilizer (19: 19: 19), CF: Conventional fertilizer.

Conclusion

The present study revealed that paired row sowing with fertigation of 30 per cent RDF (45: 22.5: 22.5 kg ha^{-1}) through water soluble fertilizers (WSF) (19: 19: 19) and 25 per cent RDF through CF applied in six equal splits found to be optimum for better dry matter partitioning to different parts and also total dry matter production per plant which is on par to that of fertigation with 100 per cent RDF through CF(150:75:75 N: P_2O_5: K_2O kg ha^{-1}). The results also showed that paired row sowing with fertigation of 25 per cent RDF (37.5: 19: 19 N: P_2O_5: K_2O kg ha^{-1}) through WSF along with 25 per cent RDF through CF applied in six equal splits found to be optimum for higher number of bolls $plant^{-1}$, seed cotton yield $plant^{-1}$ and seed cotton yield ha^{-1} which was on par with that of fertigation of 100 per cent RDF through CF and also reduced the quantity of fertilizers by 50 per cent to that of fertigation with 100 per cent RDF through CF.

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