Int.J.Curr.Microbiol.App.Sci (2017) *6*(12): 45-52

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 12 (2017) pp. 45-52**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.612.006

Growth and Yield of Irrigated Bt Cotton (*Gossypium hirsutum* L.) as Influenced by Different Agronomic Practices

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Keywords

Bt cotton, Foliar spray, KH_2PO_4, Major and micronutrients, Polythene mulching.

Article Info

Accepted:
04 October 2017
Available Online:
10 December 2017

A B S T R A C T

A field experiment was conducted to study the influence of different agronomic practices on growth, yield attributes and yield of *Bt* cotton at the Main Agricultural Research Station, Raichur during *Kharif* 2016. Nine treatments comprising of normal spaced and fertilized non-*Bt* (cv. RAHH-455) and *Bt* hybrid (cv. Bindas) in addition to closer spacing *Bt* hybrid supplied with 125 % of recommended nutrients (187.5: 92.75: 92.75 kg $N:P_2O_5:K_2O$ ha^{-1}), foliar spray of 1% $MgSO_4$ twice and 1% KNO_3 thrice, soil application of $MgSO_4$ (25 kg ha^{-1}) and $FeSO_4$ (10 kg ha^{-1}) and $ZnSO_4$ (10 kg ha^{-1}), foliar spray of 1% $MgSO_4$ + 1% 19:19:19 or 1% KH_2PO_4 and polyethylene mulching replicated thrice. The results revealed that closer spaced *Bt* hybrid + 125 % RDF + 3 sprays of 1% each of $MgSO_4$ and 19:9:19 and polyethylene mulching recorded significantly higher plant height (159.2 cm), monopodia (2.0), sympodia (27.7), total dry matter production (347.0g), leaf area index (1.81), number of bolls $plant^{-1}$ (48.27) and seed cotton yield (4122 kg ha^{-1}) compared to other nutritional treatments. It also registered higher net returns (□ 1,59,296 ha^{-1}), gross returns (□ 2,22,588) and B:C ratio (3.52). It was followed by closer spaced *Bt* hybrid + foliar spray of 1% KH_2PO_4 thrice.

Introduction

Cotton (*Gossypium hirsutum* L.), is considered as an important fibre crop of India and Karnataka. It is the backbone of textile industries providing 85 % of raw material to textile industry and it earns about 33 per cent of total foreign exchange (Anon., 2014). Most of the *Bt* cotton hybrids bear fruiting parts by 20 to 25 days and also mature early in comparison to the erstwhile inter specific hybrids and hence need for optimum nutrition begins from the beginning in cotton otherwise there would be flower and/or boll drop, early leaf reddening *etc*. which greatly affect overall crop production. Being early and semi-determinate nature the rate of growth and rejuvenation **c**apacity of the plant after first flush of flowering is slow and therefore there is more nutritional requirement after first bearing and this necessitates additional nutrition (Mamatha *et al*., 2009). Further, the deficiency of micronutrients has become major constraint in productivity, stability and sustainability of cotton ecosystem now than ever before (Yadav and Meena, 2009).

Recently, plastic mulch is becoming popular in vegetable production under water constraints. Plastic (PE) mulches improve

physical, chemical and biological properties of soil and boost soil temperature and thereby enhance root activity, which is critical during winter in crops like cotton. Mulching reported to enhance yield by 50 - 60 % over no mulching under rainfed situations (Dilip Kumar *et al.*, 1990 and Rajput and Singh, 1970), which is an important consideration even in irrigation commands due to uncertainty rain and poor inflow to the reservoirs.

In Karnataka, North-eastern and Northern dry zone drenched with UKP and TBP irrigation commands account for major share in area and production of cotton. Though yields as high as 15 to 18 q ac^{-1} were realized after the advent of *Bt* cultivars, of late crop yields are either stagnating or declining due to many reasons raising concerns of all stake holders. Therefore, keeping above points in view a field experiment on yield maximization in cotton comprising of cultivars, plant density, enhanced primary and foliar nutrition, and polyethylene (PE) mulching in TBP irrigation command was envisaged during 2016-17 under irrigated condition.

Materials and Methods

The field experiment was conducted during *kharif* 2016 and at the Main Agricultural Research Station Raichur, Karnataka. The experiment laid out in Randomized Complete Block Design (RCBD) with three replications comprised of 9 treatments *viz.*, T_1- Normal spaced and fertilized (90 cm X 60 cm) non-*Bt* hybrid cv.RAHH-455, T_2- Normal spaced and fertilized *Bt* hybrid (cv. Bindas), T_3- Closer spacing (90 cm X 45 cm) *Bt* hybrid (cv. Bindas), T_4- T_3 + 125 % of recommended nutrients (187.5: 92.75: 92.75 kg NPK ha^{-1}), T_5 - T_4 + Recommended foliar spray (1% spray of $MgSO_4$ at 90 and 110 days after sowing (DAS) and 1% spray of KNO_3 during flowering, boll initiation stage), T_6 -T_4 + Soil application of micronutrients $MgSO_4$ @ 25 kg ha^{-1}, $FeSO_4$ @ 10 kg and 10 kg $ZnSO_4$ ha^{-1}, T_7- T_4 + three sprays of 1% $MgSO_4$ + 1% 19:19:19 during 60-65, 80-85 and 100-105 DAS, T_8- T_4 + foliar application of @1% KH_2PO_4 at 60, 80 and100 DAS, T_9-T_7 + Soil mulching through polythene sheet (200 gauge). Sowing was done by hand dibbling and recommended fertilizer was applied using urea, DAP and muriate of potash. Data on growth and yield parameters were recorded from five randomly selected plants in each treatment; seed cotton yield (kg $plot^{-1}$) was calculated from whole plot and converted into kg ha^{-1}, besides economics was worked out.

Results and Discussion

Growth Parameters and Seed cotton yield

The plant height, number of monopodial branches $plant^{-1}$, number of sympodial branches $plant^{-1}$ and total dry matter production $plant^{-1}$ differed significantly due to different yield maximization practices (Table 1). The data revealed that closer spaced *Bt* hybrid + 125% RDF + three sprays of 1% each of $MgSO_4$ and 19:19:19 and polyethylene (PE) mulching (T_9) recorded significantly higher plant height (159.2 cm), monopodial $plant^{-1}$ (2.0), sympodia $plant^{-1}$ (27.7), leaf area index (1.81) and total dry matter production (347.0 g $plant^{-1}$) compared to other treatments. It was followed by closer spaced *Bt* hybrid + 125% RDF + foliar application of KH_2PO_4 @1% at 60, 80 and 100 DAS. Thus, these significant increases in all the growth parameters with increased fertilization in combination with foliar sprays of major and micro nutrients and PE mulching were responsible for higher assimilates production and their translocation to sink. Similar findings were reported by Sawan *et al.*, (2006), Sakarvadia *et al.*, (2009), Saleem *et al.*, (2010), Kaur *et al.*, (2010), Biradar (2011) and Hosamani *et al.*, (2013) who also

reported improved growth parameters and consequently cotton yield with higher nutrition and foliar spray of liquid soluble fertilizers over recommended practice.

Significant differences occurred in leaf reddening index (LRI) at different stages of development except at 90 DAS (Table 3). Non –*Bt* cv. RAHH 455 with normal spacing/ population recorded the maximum LRI at all the stages (0.71, 2.33 and 2.93 at 90 and 135 DAS and at final picking, respectively) among all closely followed by similar spaced *Bt* cultivar: others were also at par except T_9 (0.20, 1.07 and 1.93 at 90 and 135 DAS and at final picking) with around half the values of the highest recording treatment had lower LR indices among all.

Further, among the leaf reddening management (LRM) interventions, soil supplementation of micronutrients comprising of $MgSO_4$ @ 25 kg ha^{-1} and $FeSO_4$ and $ZnSO_4$ each at 10 kg ha^{-1} increased yield by 405 kg ha^{-1} over application of 125 % RDF with 12 % increase in yield. This was also found superior to foliar application of $MgSO_4$ and KNO_3 twice each.

Recent recommendation of 1 % each of $MgSO_4$ and 19:19:19 all thrice at flower initiation, boll development and boll bursting in the state resulted in and yield improvement by 509 and 1272 kg ha^{-1} (16 and 51 % more yield), respectively over application of 125% RDF and RDF and recommended spacing alone. The results are in conformity with Shivamurthy and Biradar (2014).

In the investigation, significantly higher number of total bolls per plant (48.27), boll weight (5.64g) and TDM production (347.0 g $plant^{-1}$) were recorded with closer spacing with 125% RDF and three sprays of 1% each of $MgSO_4$ and 19:19:19 at 60, 80 and 100 DAS with PE mulching over normal spaced non-*Bt* cv. RAHH-445 (35.37, 4.94g, 270g respectively total number of bolls, boll weight $plant^{-1}$ and TDM respectively). As a consequence of improved growth and yield components, Closer spaced *Bt* hybrid + 125% RDF + three sprays (60-65,80-85,100-105 days after sowing) of 1% each of $MgSO_4$ and 19:19:19 and polyethylene (PE) mulching (T_9) registered significantly higher seed cotton yield (4,122 kg ha^{-1}) compared to other treatments (Table 2). It was closely followed by closer spaced *Bt* hybrid + 125 % RDF + foliar application of KH_2PO_4 @1% at 60, 80 and 100 days after sowing (3912 kg ha^{-1}), closer spacing + three sprays of 1% $MgSO_4$ and 19:19:19 (3,777 kg ha^{-1}) and closer spaced *Bt* + 125% RDF + Soil application of micronutrients @ 25 kg $MgSO_4$ + 10 kg $FeSO_4$+ 10 kg $ZnSO_4$ ha^{-1} (3,673 kg ha^{-1}).

Kaur *et al.,* (2010), Biradar *et al.,* (2012) and Basavanneppa *et al.,* (2011) also observed higher yield and yield attributing characters and TDM production with higher doses of fertilizer compared to lower doses and recommended fertilizer practice. Soil and foliar application of $MgSO_4$ also increased seed cotton yield because of magnesium which is an integral part of chlorophyll, which increased chlorophyll content and its stability and thereby photosynthesis and seed cotton yield. The results are in conformity with the findings of Brar *et al.,* (2008), Rajendran *et al.,* (2011) and Hosmath (2011). KH_2PO_4 might have alleviated the inhibitive effects of climatic impacts of winter on cotton besides improving supply of P and K.

The superiority of PE mulch mainly lies in its effect in maintaining soil moisture balance and raising soil temperature as observed during October as shown in Figure 1, which probably prevailed throughout winter and specially during reproductive cycle of plant thereby invigorated root activity that complemented plant rhizosphere need.

Table.1 Growth attributes of *Bt* cotton as influenced by different agronomic practices

Treatment	Plant height (cm)	Monopodia plant^{-1}	Sympodia plant^{-1}	Leaf area index				TDM (g plant)
				45 DAS	90 DAS	135 DAS	At final picking	
T_1: Normal spaced (90 cm X 60 cm) non-*Bt* hybrid cv.RAHH-455.	142.0^{b}	2.2^{a}	18.0^{e}	8.51^{d}	66.83^{b}	96.89^{b}	1.18^{b}	270.0^{e}
T_2: Normal planting (90 cm X 60 cm) *Bt* hybrid Bindas	144.5^{ab}	2.2^{a}	23.8^{cd}	10.35^{bc}	70.18^{ab}	98.64^{ab}	1.64^{a}	299.1^{cd}
T_3: Closer spacing (90 cm X 45 cm) *Bt* hybrid Bindas	145.9^{ab}	1.8^{a}	21.5^{d}	9.48^{cd}	69.23^{ab}	98.36^{ab}	1.22^{b}	293.2^{d}
T_4: T_3 + 125 % of Rec. Nutrients (187.5: 92.75: 92.75 kg N:P_2O_5:K_2O/ha)	146.7^{ab}	1.6^{a}	23.9^{cd}	10.66^{b}	70.64^{ab}	99.12^{ab}	1.66^{a}	305.9^{cd}
T_5: T_4+ Recommended foliar spray (1 % spray $MgSO_4$ at 90 & 110 DAS and 1% spray of KNO_3 during flowering & Boll initiation stage)	155.1^{ab}	2.2^{a}	24.1^{cd}	11.19^{ab}	70.83^{ab}	100.21^{ab}	1.69^{a}	312.5^{b-d}
T_6: T_4 + Soil application of Micronutrients @ 25 kg $MgSO_4$/ha +10 kg $FeSO_4$+ 10 kg $ZnSO_4$ /ha.	156.7^{a}	1.9^{a}	24.6^{bc}	11.35^{ab}	71.59^{ab}	101.17^{ab}	1.72^{a}	319.0^{bc}
T_7: T_4 + three sprays of 1 % $MgSO_4$ + 1 % 19:19:19 during 60-65, 80-85 & 100-105 DAS	157.7^{a}	2.1^{a}	25.6^{a-c}	11.93^{a}	72.35^{ab}	102.28^{ab}	1.75^{a}	326.6^{b}
T_8: T_4 + foliar application of KH_2PO_4 @ 1 % at 60, 80 &100 DAS	158.7^{a}	2.2^{a}	27.3^{ab}	12.26^{a}	74.61^{a}	104.77^{a}	1.78^{a}	330.6^{ab}
T_9: T_7 + Soil mulching through polythene sheet (200 gauge)	159.2^{a}	2.0^{a}	27.7^{a}	12.34^{a}	75.18^{a}	105.21^{a}	1.81^{a}	347.0^{a}
S.Em±	3.4	0.34	0.9	0.38	1.92	2.03	0.08	6.28
LSD(0.05)	13.2	NS	2.7	1.15	5.77	6.08	0.24	18.6

Means with same letter do not differ significantly as per DMRT
DAS- Days after sowing TDM-Total dry matter production

Table.2 Yield and yield attributes as influenced by different agronomic practices in *Bt* cotton

Treatment	No. of bolls Plant^{-1}	Boll weight (g)	Seed cotton yield (g plant^{-1})	Seed cotton yield (kg ha^{-1})
T_1: Normal spaced (90 cm X 60 cm) non- *Bt* hybrid cv.RAHH-455.	35.37^{e}	4.94^{b}	130.1^{e}	2365^{d}
T_2: Normal planting (90 cm X 60 cm) *Bt* hybrid Bindas	40.83^{d}	5.04^{b}	140.7^{de}	2505^{d}
T_3: Closer spacing (90 cm X 45 cm) *Bt* hybrid Bindas	38.97^{de}	5.01^{b}	139.9^{de}	3189^{c}
T_4: T_3 + 125 % of Rec. Nutrients (187.5:92.75: 92.75 kg N:P_2O_5:K_2O/ha)	41.50^{cd}	5.11^{b}	142.7^{c-e}	3268^{bc}
T_5: T_4+ Recommended foliar spray (1 % spray $MgSO_4$ at 90 & 110 DAS and 1% spray of KNO_3 during flowering & Boll initiation stage)	42.97^{b-d}	5.20^{ab}	145.5^{c-e}	3314^{bc}
T_6: T_4 + Soil application of Micronutrients @ 25 kg $MgSO_4$/ha +10 kg $FeSO_4$+ 10 kg $ZnSO_4$ /ha.	43.10^{b-d}	5.25^{ab}	151.9^{b-d}	3673^{a-c}
T_7: T_4 + Three sprays of 1 % $MgSO_4$ + 1 % 19:19:19 during 60-65, 80-85 & 100-105 DAS	45.67^{a-c}	5.29^{ab}	157.3^{a-c}	3777^{ab}
T_8: T_4 + foliar application of KH_2PO_4 @ 1 % at 60, 80 &100 DAS	46.23^{ab}	5.44^{ab}	163.8^{ab}	3912^{a}
T_9: T_7 + Soil mulching through polythene sheet (200 gauge)	48.27^{a}	5.64^{a}	170.8^{a}	4122^{a}
S.Em±	1.33	0.15	5.00	162
LSD(0.05)	3.99	0.45	14.9	487

Means with same letter do not differ significantly as per DMRT DAS- Days after sowing

Table.3 Leaf reddening index (LRI) of *Bt* cotton at different growth stages as influenced by different agronomic practices

Treatment		Leaf reddening index (LRI)		
		90 DAS	135 DAS	At final Picking
$T_{1:}$	Normal spaced (90 cm X 60 cm) non-*Bt* hybrid cv.RAHH-455	0.71^{a}	2.33^{a}	2.93^{a}
$T_{2:}$	Normal planting (90 cm X 60 cm) *Bt* hybrid Bindas	0.62^{a}	2.02^{ab}	2.87^{a}
$T_{3:}$	Closer spacing (90 cm X 45 cm) *Bt* hybrid Bindas	0.55^{a}	1.87^{ab}	2.73^{ab}
$T_{4:}$	T_3 +125 % of Rec. nutrients (187.5:92.7:92.7 kg NPK/ha)	0.50^{a}	1.80^{ab}	2.60^{a-c}
$T_{5:}$	T_4 + Recommended foliar spray (1 % spray $MgSO_4$ at 90 & 110 DAS and 1 % spray of KNO_3 during flowering & Boll initiation stage)	0.43^{a}	1.66^{ab}	2.57^{a-c}
$T_{6:}$	T_4 + Soil application of Micronutrients @ 25 kg $MgSO_4$/ha+ 10 kg $FeSO_4$ + 10 kg $ZnSO_4$/ha	0.40^{a}	1.43^{ab}	2.40^{a-d}
$T_{7:}$	T_4 + 3 sprays of 1 % $MgSO_4$ + 1 % 19:19:19 during 60-65, 80-85 & 100-105 DAS	0.35^{a}	1.40^{ab}	2.20^{b-d}
$T_{8:}$	T_4 + foliar application of KH_2PO_4 @ 60, 80 &100DAS	0.27^{a}	1.37^{ab}	2.04^{cd}
$T_{9:}$	T_7+Soil mulching through polythene sheet (200 gauge)	0.20^{a}	1.07^{b}	1.93^{d}
	S.Em±	0.05	0.14	0.21
	LSD(0.05)	0.15	0.42	0.62

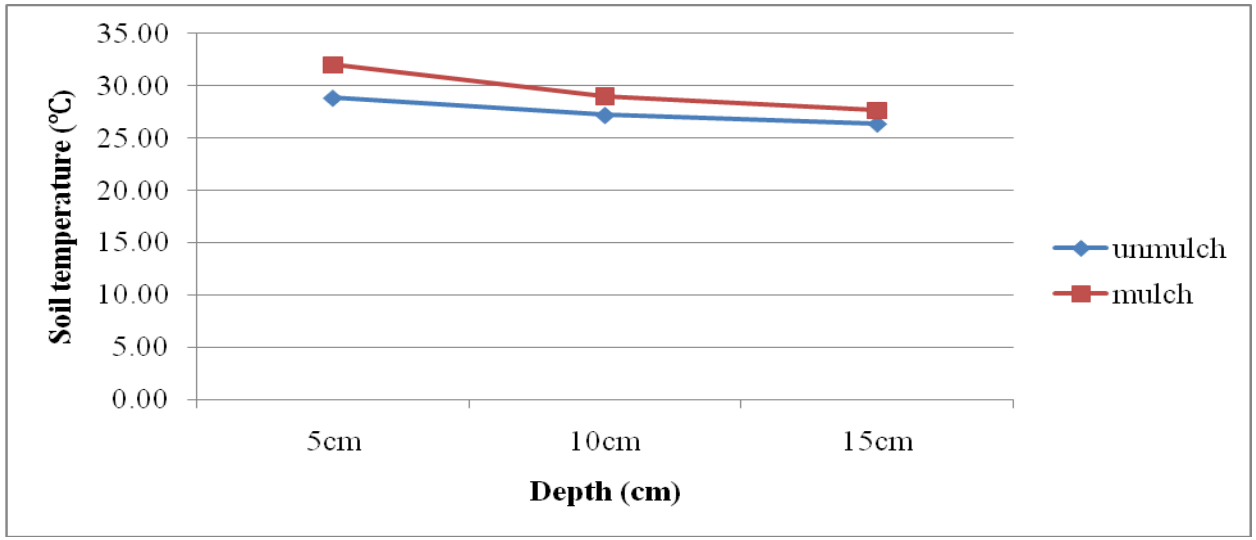
Means with same letter do not differ significantly as per DMRT. DAS-Days after sowing

Table.4 Monetary returns of *Bt* cotton as influenced by different agronomic practices

Treatment	Cost of cultivation (□ ha^{-1})	Gross returns (□ ha^{-1})	Net returns (□ ha^{-1})	B:C ratio
T_1: Normal spaced (90 cm X 60 cm) non- *Bt* hybrid cv.RAHH-455.	54955	127692	72737	2.32^{d}
T_2: Normal planting (90 cm X 60 cm) *Bt* hybrid Bindas	56715	135288	78573	2.39^{d}
T_3: Closer spacing (90 cm X 45 cm) *Bt* hybrid Bindas	57265	172217	114952	3.01^{bc}
T_4: T_3 + 125 % of Rec. Nutrients (187.5: 92.75: 92.75 kg N:P_2O_5:K_2O/ha)	59443	176466	117023	2.97^{bc}
T_5: T_4+ Recommended foliar spray (1 % spray $MgSO_4$ at 90 & 110 DAS and 1% spray of KNO_3during flowering & Boll initiation stage)	61060	178947	117887	2.93^{c}
T_6: T_4 + Soil application of Micronutrients @ 25 kg $MgSO_4$/ha +10 kg $FeSO_4$+ 10 kg $ZnSO_4$ /ha.	61907	198348	136441	3.20^{abc}
T_7: T_4 + Three sprays of 1 % $MgSO_4$ + 1 % 19:19:19 during 60-65, 80-85 & 100- 105 DAS	59657	203959	142832	3.34^{ab}
T_8: T_4 + foliar application of KH_2PO_4 @ 1 % at 60, 80 &100 DAS	60542	211248	150706	3.49^{a}
T_9: T_7 + Soil mulching through polythene sheet (200 gauge)	63292	222588	159296	3.52^{a}
S.Em±		14081	10378	0.12
LSD(0.05)		42252	31115	0.37

Means with same letter do not differ significantly as per DMRT. DAS-Days after sowing

Fig.1 Effect of soil temperature variation between mulched and unmulched treatments



Economics

Consequent upon higher yield, gross (□ 2,22,588 ha^{-1}) and net (□ 1,59,296 ha^{-1}) returns and B:C (3.52) were significantly higher with closer spacing with 125% RDF and three sprays of 1% each of $MgSO_4$ and 19:9:19 at 60, 80 and 100 DAS with PE mulching (T_9).

Further the gross and net returns and B: C reached the minimum (□ 1,27,692 and 72,737 ha^{-1} and 2.32, respectively) with normal spaced non-*Bt* cv. RAHH-445 (T_1).

This is on the expected line as higher the nutrition to the crops higher will be the cotton yield and it ultimately lead to higher gross and net returns. The results are in conformity with Kaur *et al.,* (2010), Biradar *et al.,* (2011), Basavanneppa (2012) and Hosamani *et al.,* (20l3) who also obtained higher net returns with increased fertilizer levels.

From the study, it was inferred that, *Bt* cultivar with 25 % higher population (90 cm X 45 cm) and 125 % RDF (187.5:92.75:92.75 kg N: P_2O_5: K_2O ha^{-1}) is monetarily advantageous in Tunga Bhadra Project (TBP) irrigation command. Further, leaf reddening management practice through foliar nutrition of 1% each of $MgSO_4$ and 19:19:19 thrice (60-65, 80-85 and 100-105 DAS) and KNO_3 twice (during flowering, boll initiation stage and boll bursting stages) and soil mulching with polyethylene mulch would further enhance yield and monetary returns (Table 4). Alternately, 1% KH_2PO_4 thrice (60, 80 and 100 DAS) could be adopted.

Acknowledgement

To the University agricultural sciences, College of Agriculture Raichur for provision of research facilities is gratefully acknowledged.

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How to cite this article:

Basavaraj, B.M. Chittapur, A.S. Halepyati, A. Ameregouda, G.S. Yadahalli and Ajayakumar, M.Y. 2017. Growth and Yield of Irrigated Bt Cotton (*Gossypium hirsutum* L.) as Influenced by Different Agronomic Practices. *Int.J.Curr.Microbiol.App.Sci.* 6(12): 45-52.
doi: https://doi.org/10.20546/ijcmas.2017.612.006