Original Research Article

Performance of Bt Cotton under different levels of irrigation and nitrogen in alfisols

ABSTRACT

Aims: To determine the optimum irrigation schedule and nitrogen level for Bt cotton in alfisols in Southern Telangana.
Study design: Split plot design.
Place and Duration of Study: ARI, Rajendranagar, Hyderabad during *kharif* 2014.
Methodology: The experiment was laid out with three irrigation schedules (I_1- 0.8 IW/CPE, I_2 - 0.4 IW/CPE and I_3 - Rainfed) as main plots and four nitrogen levels (N1- 0 kg ha^{-1}, N2 - 75 kg ha^{-1}, N3 - 150 kgha^{-1} and N4 - 225 kg ha^{-1}) as sub plot treatments replicated thrice. Treatments imposed as per the schedule and data recorded on yield, yield attributes, nitrogen uptake by adopting standard procedures
Results: Irrigation at 0.8 IW/CPE recorded significantly higher plant height (79 cm), drymatter at first picking (195 g $plant^{-1}$), bolls $plant^{-1}$ (16), seed cotton yield (1435 kg ha^{-1}), lint yield (541 kg ha-1), stalk yield (2057 kg ha-1) and nitrogen uptake (63 kg ha-1) and was not differed significantly with 0.4 IW/CPE and these were significantly superior to rainfed cotton. Among nitrogen levels, significantly higher plant height (90 cm), drymatter at first picking (214 g $plant^{-1}$) stage, days to reach boll development (90) stage, bolls $plant^{-1}$ (15), boll weight (5.3 g), seed index (9.9 g), seed cotton yield (1435 kg ha^{-1}), lint yield (547 kg ha^{-1}) and stalk yield (2214 kg ha^{-1}) were found with application of nitrogen at 225 kg ha-1 was comparable with 150 kg N ha^{-1} and were significantly superior over lower levels of nitrogen application. The substantial increase in yield and yield attributes might be due to favorable effect on growth attributes like plant height, increased bolls $plant^{-1}$, drymatter accumulation $plant^{-1}$ and its subsequent translocation towards sink improved the seed cotton yield.
Conclusion: It can be concluded that, higher seed cotton yield can be obtained with the irrigation scheduled at 0.4 IW/CPE and application of nitrogen at 150 kg ha^{-1} in Bt cotton grown in alfisols.

Comment [S1]: Enter the driving factors for carrying out this research

Keywords: Irrigation, Nitrogen, Cotton (Gossypium Hirsutum L.)

1. INTRODUCTION

Cotton is one of the most important commercial crops cultivated in India and accounts for around 25% of the total global cotton production. It plays a major role in sustaining the livelihood of an estimated 6 million cotton farmers and 40-50 million people engaged in related activity such as cotton processing & trade. The Indian Textile Industry consumes a diverse range of fibres and yams and the ratio of use of cotton to non - cotton fibres in India is around 60:40 whereas it is 30:70 in the rest of the world. Apart from being the provider of a basic necessity of life *i.e.,* clothing which is next only to food, cotton is also one of the largest contributor to India's net foreign exchange by way of exports in the form of raw cotton, intermediate products such as yam and fabrics to ultimate finished products in the form of garments, made ups and knitwear. Due to its economic importance in India, it is also termed as "White-Gold". India got 1st place in the world in cotton acreage with 120.55 lakh hectares area under cotton cultivation *i.e.*, around 36% of world area of 331 lakh hectares [1]. Around 67% of India's cotton is grown on rain-fed areas and 33% on irrigated area. In

Comment [S2]: it is best to complete the theoretical sources terms of productivity, India is on 40th rank with yield of 445 kg/ha. India is one of the largest cotton producing country in the world with estimated production of 315.43 lakh bales (5.36 Million Metric Tonnes during cotton season 2021 -22 which is 21% of world cotton production of 1522 lakh bales (25.89 Million Metric Tonnes). India is one of the largest consumer of cotton with estimated consumption of 326 lakh bales (5.54 Million Metric Tonnes*i.e.,* 21% of world cotton consumption of 1538 lakh bales (26.16 Million Metric Tonnes).

Factors such as undependable monsoon, unsuitable soil, improper sowing time, non-adoption of recommended technologies especially fertilizer use limiting cotton production at farmers' field [2]. Among these factors, marginal soils with shallow depth and low fertility status and; low and erratic distribution of rainfall are the important factors affecting cotton growth, development and seed cotton yield. In India, yield gap in cotton was observed mainly due to delayed sowing (70% of cotton area), dependence on monsoon (70% of cotton area), low fertilizer use (40% of cotton area) and unsuitable soils (20% of cotton area). The yield gaps can be reduced with better crop management, such as optimal use of irrigation water and nitrogen. The cotton crop is generally grown in medium to deep black clayey soil, but in South Telangana Zone it is mainly grown on shallow sandy and sandy loams with low water holding capacity and low nutrient status resulting in poor yields under rainfed situation. This region receives an average rainfall of 524 mm during southwest monsoon period with erratic and uneven distribution besides, low water holding capacity of the alfisols, which necessitates the proper irrigation planning to ensure adequate yields and reduce risks of production. Farmers are using excessive nitrogen fertilizers leading to heavy pest incidence in certain pockets whereas in some areas it is below optimum mainly because of the risk associated with the investment under uneven and erratic distribution of rainfall. For obtaining higher seed cotton yields water, nutrients and soils are essential resources, of which water and nitrogen are yield limiting factors. Water and nitrogen are the key inputs which must be used in most efficient manner to sustain the cotton productivity at higher level. Moisture stress had adverse effect on yield as well as excess irrigation decreases the yield and increases the growing season [3]. Similarly nitrogen deficiency in cotton reduces vegetative and reproductive growth and induces premature senescence, there by potentially reduces the yields [4], where as high nitrogen availability may shift the balance between vegetative and reproductive growth towards excessive vegetative development thus delaying maturity. Since both irrigation and nitrogen are costly inputs, efficient utilization of these resources through optimum synergistic combination is essential for higher productivity of Bt cotton grown on alfisols under less rainfall receiving areas of South Telangana Zone. Scheduling irrigation in a scientific way is an option to tide over the challenges associated with rainfed system as it helps the farmer to apply water & fertilizers as per requirement of plant at particular growth stage. Keeping the above points in view, the study was carried out to determine the impact of different irrigation schedules and nitrogen levels on growth and yield of cotton.

2. MATERIAL AND METHODS

A study was carried out during *kharif* 2014 at Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad to determine the impact of different irrigation schedules and nitrogen levels on growth and yield of Bt cotton. The experiment was laid out in split plot design with three irrigation schedules (I_1- 0.8 IW/CPE, I_2 - 0.4 IW/CPE and I_3 - Rainfed) as main plots and four nitrogen levels (N_1- 0 kg ha^{-1}, N_2 - 75 kg ha^{-1}, N_3 - 150 $kgha^{-1}$ and N_4 - 225 kg ha^{-1}) as sub plot treatments replicated thrice.

Comment [S3]: it is best to complete the theoretical sources

Comment [S4]: it is best to complete the theoretical sources

Comment [S5]: It is best to complete climate and altitude data

Comment [S6]:
it is best to complete the research map

3. RESULTS AND DISCUSSION

3.1 Effect of irrigation

3.1.1 Plant height

The plant height did not differ significantly with irrigation schedules at any stage during the crop growth period (Table 1).

3.1.2 Phenology

Comment [S7]: it would be best to complete the discussion

Significantly more number days (31 and 31) taken to reach square initiation stage with 0.8 IW/CPE (I_1) and 0.4 IW/CPE (I_2), respectively which were comparable with each other and superior over rainfed (I_3) cotton which had taken less number of days (30) to reach square initiation stage. Days to flowering (46) did not differ significantly with irrigation schedules. Significantly more number days (90) taken to reach boll development stage with irrigation scheduled at 0.8 IW/CPE (I_1) over 0.4 IW/CPE (I_2), in turn which has taken 89 days and followed by rainfed (I3) cotton with less number of days (88) to reach boll development stage (Table 1).

3.1.3 Drymatter production

Drymatter production observed with irrigation schedules at square initiation, flowering and boll development stages did not differ significantly and were comparable with each other at respective growth stages. Whereas, Significantly higher drymatter production (195, 175 and 151 g plant^{-1}) was recorded with irrigation scheduled at 0.8 IW/CPE (I_1) and was followed by 0.4 IW/CPE (I_2), in turn which recorded drymatter of 180, 167 and 137 g plant^{-1}. However they were at par with each other and superior over rainfed (I_3) cotton, where significantly lower drymatter production (147, 140 and 111 g plant^{-1}) was found at first, second and third picking stages, respectively (Table 1). Increased frequency of irrigation might have increased nutrient and moisture absorption as well as photosynthesis, increased translocation of photosynthates to the growing bolls, besides producing and retaining more number of bolls plant-1 at later stages of crop cycle resulted in higher drymatter production with irrigation scheduled at 0.8 IW/CPE (I_1). Whereas, soil moisture deficit under rainfed situation might have reduced cell elongation, low photosynthesis and carbohydrate synthesis which resulted in lower drymatter production. Similar results were reported

3.1.4 Number of bolls plant^{-1}

Significantly higher number of bolls plant^{-1} (16) was recorded with irrigation scheduled at 0.8 IW/CPE (I_1) over 0.4 IW/CPE (I_2) and rainfed (I_3) cotton (Table 2). Significantly higher number of bolls plant^{-1} (14) was recorded with 0.4 IW/CPE (I_2) over rainfed (I_3) cotton which recorded significantly lower number of bolls plant^{-1} (11). Optimum soil moisture status might have resulted in greater nutrient uptake, promoting the growth and development of more number of bolls plant^{-1}[6] and [7]. Positive influence of adequate irrigations on bolls plant^{-1} was also reported by [8].

3.1.5 Boll weight

The mean boll weight (4.9-5.2 g) did not differ significantly with irrigation schedules. Optimum soil moisture with 0.8 IW/CPE (I_1) and 0.4 IW/CPE (I_2) might have resulted in greater nutrient uptake, crop growth and drymatter accumulation and positive influence on number of bolls plant^{-1} resulted in higher mean boll weight of cotton [8].

3.1.6 Seed cotton yield

Significantly higher seed cotton yield (1435 kg ha^{-1}) was recorded with irrigation scheduled at 0.8 IW/CPE (I_1) and was not differed significantly with 0.4 IW/CPE (I_2) with seed cotton yield of 1269 kg ha^{-1}, and were superior over rainfed (I3) cotton (Table 2), in turn which recorded significantly lower seed cotton yield (982 kg ha^{-1}).
The higher seed cotton yields with 0.8 IW/CPE (I_1) might be resulted from greater nutrient uptake in the favorable regime of soil moisture leads to balanced vegetative growth, higher drymatter production, increased number of bolls $plant^{-1}$ which ultimately reflected in seed cotton yield. These observations confirms the [5] who reported that more number of bolls $plant^{-1}$ with increased boll weight and higher seed cotton yield under irrigated conditions as compared to rainfed cotton. The higher advantage in irrigated cotton over rainfed cotton was also reported by [9] and [10].

3.1.7 Lint yield

Significantly higher lint yield (541 kg ha^{-1}) was recorded with irrigation scheduled at 0.8 IW/CPE (I_1) over 0.4 IW/CPE (I_2) with lint yield of 480 kg ha^{-1} (Table 2). However, they were comparable with each other and were superior over rainfed (I_3) cotton, with reduced lint yield (367 kg ha^{-1}).

3.1.8 Stalk yield

Significantly higher stalk yield (2057 kg ha^{-1}) was recorded with irrigation scheduled at 0.8 IW/CPE (I_1) over 0.4 IW/CPE (I_2) with stalk yield of 1974 kg ha^{-1} (Table 2). These were comparable with each other and significantly superior over rainfed (I_3) cotton, with significantly lower stalk yield (1493 kg ha^{-1}).
Each successive increase in irrigation from rainfed (I_3) cotton to 0.8 IW/CPE (I_1) throughout the crop life cycle increases the stalk yield due to favourable soil moisture supply finally leading to increased vegetative growth. These results were in accordance with the findings of [6].

3.1.9 Harvest index, Ginning percentage, Lint Index, earliness index

Comment [S8]: it would be best to complete the discussion

Irrigation schedules did not exert significant influence on harvest index (0.39-0.41), ginning percentage (37.4-37.9), lint index (5.6-5.9) and earliness index (0.72-0.75) (Table 2).

3.1.10 Nitrogen uptake

Nitrogen uptake differed significantly with irrigation schedules at all the stages, except square initiation stage (Table 2). Significantly higher nitrogen uptake (46, 82, 73 and 63 kg ha^{-1}) was recorded with irrigation scheduled at 0.8 IW/CPE (I_1) and was not differed significantly with 0.4 IW/CPE (I_2) with nitrogen uptake of 42, 73, 68 and 56 kg ha^{-1} at boll development, first, second and third picking stages, respectively and were significantly superior over rainfed (I_3) cotton, in turn which recorded the lowest nitrogen uptake (35, 57, 55 and 45 kg ha^{-1}) at boll development, first, second and third picking stages, respectively.
The higher nitrogen uptake mainly attributed to higher drymatter production at increased irrigation frequencies. The present results were in conformity with the findings of [10].

3.2 Effect of nitrogen

3.2.1 Plant height

Significantly higher plant height was registered with N_4 (225 kg ha^{-1}),N_3 (150 kg ha^{-1}) and N_2 (75 kg ha^{-1}) at square initiation (32, 32 and 30 cm), flowering (45, 44 and 42 cm) and boll development (59, 57 and 53 cm) stages, respectively was comparable with each other and were significantly superior over control N_1 (0 kg ha^{-1}) which recorded significantly lesser plant height of 26 cm, 36 cm and 45 cm at square initiation, flowering and boll development stages, respectively (Table 1). Whereas, at final picking stage significantly higher plant height (90 cm) was registered with N_4 (225 kg ha^{-1}) and was at par with N_3 (150 kg ha^{-1}) which recorded 85 cm of plant height and were significantly superior over N_2 (75 kg ha^{-1}) and N_1 (0 kg ha^{-1}). In turn, plant height (76 cm) recorded with N_2 (75 kg ha-1) was significantly superior over N_1 (0 kg ha^{-1}), which recorded the lowest plant height (66 cm). The increase in plant height with increase in nitrogen levels might be due to favorable effect of nitrogen on growth and development of cotton. Similar positive response on plant height with incremental increase in nitrogen was observed by [11] and [12].

3.2.2 Phenology

Graded levels of nitrogen had significant influence on different phenophases of cotton. Significantly more number of days (31, 48 and 90) recorded to attain square initiation, flowering and boll development stages with N_4 (225 kg ha^{-1}) and was on par with N_3 (150 kg ha^{-1}), where it has taken 31, 47 and 90 days, respectively and significantly superior over N_2 (75 kg ha^{-1}) and N_1 (0 kg ha^{-1}), and were comparable with each other, in turn they reached square initiation, flowering and boll development stages with N_2 (75 kg ha^{-1}) in 30, 45 and 89 days, with N_1 (0 kg ha^{-1}) in 30, 45 and 88 days, respectively (Table 1). [13] observed similar results and concluded that higher doses of nitrogen lead to more vegetative growth and causes delay in maturity.

3.2.3 Drymatter production

At square initiation stage, significantly higher drymatter production (9.3, 8.9 and 8.3 g plant^{-1}) was recorded with N_4 (225 kg ha^{-1}), N_3 (150 kg ha^{-1}) and N_2 (75 kg ha^{-1}), respectively. They were at par with each other and superior over N_1 (0 kg ha-1), which recorded significantly the lowest drymatter production (5.7 g plant^{-1}). Whereas, incremental increase in nitrogen level significantly increased the drymatter production over lower levels of nitrogen at flowering, boll development, first, second and third picking stages (Table 1). Significantly higher drymatter production (116, 151, 214, 200 and 160 g plant^{-1}) was registered with N_4 (225 kg ha^{-1}) and was comparable with N3 (150 kg ha^{-1}) at flowering, boll development, first, second and third picking stages, respectively and superior over N_2 (75 kg ha^{-1}) and N_1 (0 kg ha^{-1}). Similarly, significantly higher drymatter production (92, 111, 159, 139 and 121 g plant^{-1}) was registered with N_2 (75 kg ha^{-1}) over N_1 (0 kg ha^{-1}) which registered the lowest drymatter production (64, 77, 120, 112 and 93 g plant^{-1}) at flowering, boll development, first, second and third picking stages, respectively.

Higher drymatter production is an index of higher photosynthetic capacity of a plant. Relatively higher plant height, leaf area might be contributed by adequate supply of nitrogen with favorable effect on cell elongation leads more plant height, leaf area by enabling the plant to trap higher quantity of radiant energy leading to accumulation of higher photosynthates and dry matter in the plant. Enhanced drymatter production with adequate supply of nitrogen as evidenced in this investigation corroborates with the findings of [5]and[12].

3.2.4 Number of bolls plant^{-1}

Increased levels of nitrogen application significantly increased the number of bolls plant^{-1}. Significantly higher bolls plant^{-1} (15) was recorded with N_4 (225 kg ha^{-1}). This was not differed significantly with N_3 (150 kg ha^{-1}) with 15 bolls plant^{-1} and were significantly superior over N_2 (75 kg ha^{-1}) and N_1 (0 kg ha^{-1}). In turn this was followed by significantly higher bolls plant^{-1} (13) with N_2 (75 kg ha^{-1}) over N_1 (0 kg ha^{-1}), which recorded the lowest number of bolls plant $^{-1}$ (11) over higher levels of nitrogen application (Table 2).

Nitrogen acts as a source for higher retention of bolls and more number of bolls plant^{-1} at higher level of nitrogen application might be due to favourable effect on growth and translocation of photosynthates towards squares. Whereas, when the plant was stressed with nitrogen, cessation of vegetative growth and boll shedding occurred with a lower number of actively grown bolls than when the plant was in an unstressed environment. Hence the response to applied N can be justified in retaining the higher green boll number. Similar results were reported by [14] and [11].

3.2.5 Boll weight

The mean boll weight (4.8-5.3 g) did not differ significantly with nitrogen levels.

3.2.6 Seed cotton yield

Perusal of data on seed cotton yield revealed that, incremental increase in levels of nitrogen application significantly increased the seed cotton yield (Table 2). Significantly higher seed cotton yield (1435 kg ha^{-1}) was recorded with N_4 (225 kg ha^{-1}) and was followed by N_3 (150 kg ha^{-1}) with seed cotton yield of 1428 kg ha^{-1}, however these were comparable with each other and significantly superior over N_2 (75 kg ha^{-1}) and N_1 (0 kg ha^{-1}). In turn, significantly higher seed cotton yield (1198 kg ha^{-1}) was registered with N_2 (75 kg ha^{-1}) over N_1 (0 kg ha^{-1}), which showed significantly reduced seed cotton yield (854 kg ha^{-1}).
The substantial increase in seed cotton yield due to application of higher levels of nitrogen might be due to favorable effect of nitrogen on growth attributes like plant height, increased number of bolls plant^{-1}, drymatter accumulation plant^{-1} and its subsequent translocation towards sink improved the seed cotton yield. These results are in conformity with [5]. Similar positive response of nitrogen on seed cotton yield was observed by [15] and [16].

Table 1: Plant height (cm), phenology and drymatter (g plant^{-1}) production of cotton under varied levels of irrigation schedules and nitrogen levels during *kharif*,2014

	Plant height (cm)				Days to phenology				drymatter (g plant^{-1}) production					
Treatments	**SI**	**Flow**	**BD**	**III Pick**	**Days to SI**	**Days to Flow**	**Days to BD**	**III Pick**	**SI**	**Flow**	**BD**	**I Pick**	**II Pick**	**III Pick**
Irrigation (I)														
I_1 - 0.8 IW/CPE	30 a	43 a	55 a	79 a	31 a	46 a	90 a	138	8.6 a	104 a	130 a	195 a	175 a	151 a
I_2 - 0.4 IW/CPE	30 a	42 a	54 a	78 a	31 a	46 a	89 b	138	8.1 a	96 a	121 a	180 a	167 a	137 a
I_3 - Rainfed	29 a	41 a	52 a	78 a	30 b	46 a	88 c	138	7.5 a	85 a	106 a	147 b	140 b	111 b
S. Em±	1.8	2.4	2.9	1.9	0.14	0.26	0.17	-	0.84	8.1	9.9	7.3	4.0	5.6
CD (p=0.05)	NS	NS	NS	NS	0.6	NS	0.7	-	NS	NS	NS	28.8	15.9	22.1
Nitrogen (N)														
N_1 - 0 kg ha^{-1}	26 b	36 b	45 b	66 c	30 b	45 b	88 c	138	5.7 b	64 c	77 c	120 c	112 c	93 c
N_2 - 75 kg ha^{-1}	30 a	42 a	53 a	76 b	30 b	45 b	89 b	138	8.3 a	92 b	111 b	159 b	139 b	121 b
N_3 - 150 kg ha^{-1}	32 a	44 a	57 a	85 a	31 a	47 a	90 a	138	8.9 a	108 a	137 a	205 a	192 a	158 a
N_4 - 225 kg ha^{-1}	32 a	45 a	59 a	90 a	31 a	48 a	90 a	138	9.3 a	116 a	151 a	214 a	200 a	160 a
S. Em±	1.3	1.9	2.6	1.4	0.18	0.39	0.24	-	0.75	4.4	5.5	5.3	2.8	5.8
CD (p=0.05)	3.9	5.9	7.7	4.9	0.55	1.2	0.72	-	2.2	13.1	16.4	15.7	8.4	17.1
Interaction (I X N)														
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	NS	NS	NS

SI - Square initiation stage; Flow –Flowering stage; BD - Boll Development stage; Days to SI - Days to square initiation stage; Days to Flow - Days to flowering stage; Days to BD - Days to boll development stage; I Pick - 1st picking stage; II Pick - 2nd picking stage; III Pick - 3rd picking stage

Means with the same letter are not significantly different

Table 2: Yield and yield attributes, Ginning percentage, lint index and earliness index and Nitrogen uptake (kg ha^{-1}) of cotton under varied levels of irrigation schedules and nitrogen levels during *kharif*, 2014

Treatments	No. of bolls plant^{-1}	Boll weight (g)	Seed index (g)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index	Ginning (%)	Lint index	Earliness Index	Nitrogen uptake (kg ha^{-1})				
											SI	BD	I Pick	II Pick	III Pick
Irrigation (I)															
I_1 - 0.8 IW/CPE	16 a	5.2 a	9.7 a	1435 a	541 a	2057 a	0.41 a	37.9 a	5.9 a	0.72 a	3.7 a	46 a	82 a	73 a	63 a
I_2 - 0.4 IW/CPE	14 b	5.1 a	9.6 a	1269 a	480 a	1974 a	0.39 a	37.7 a	5.8 a	0.73 a	3.4 a	42 a	73 a	68 a	56 a
I_3 - Rainfed	11 c	4.9 a	9.4 a	982 b	367 b	1493 b	0.40 a	37.4 a	5.6 a	0.75 a	3.0 a	35 a	57 b	55 b	45 b
S. Em±	0.32	0.16	0.4	46	17.2	108	0.02	0.24	0.2	0.02	0.34	1.8	2.9	2.5	2.0
CD (p=0.05)	1.25	NS	NS	181	67	423	NS	NS	NS	NS	NS	7.1	11.5	9.7	8.0
Nitrogen (N)															
N_1 - 0 kg ha^{-1}	11 c	4.8 a	9.2 a	854 c	321 c	1324 c	0.40 a	37.1 a	5.6 a	0.74 a	2.3b	25 c	41 c	38 c	32 c
N_2 - 75 kg ha^{-1}	13 b	5.0 a	9.5 a	1198 b	444 b	1719 b	0.41 a	37.6 a	5.6 a	0.74 a	3.4 a	37 b	52 b	46 b	40 b
N_3 - 150 kg ha^{-1}	15 a	5.3 a	9.6 a	1428 a	537 a	2107 a	0.40 a	37.7 a	5.8 a	0.73 a	3.8 a	48 a	93 a	87 a	73 a
N_4 - 225 kg ha^{-1}	15 a	5.3 a	9.9 a	1435 a	547 a	2214 a	0.39 a	38.1 a	6.1 a	0.72 a	4.0 a	53 a	97 a	91 a	74 a
S. Em±	0.39	0.19	0.2	47	17.1	88	0.05	0.36	0.1	0.01	0.30	2.6	2.3	1.3	2.2
CD (p=0.05)	1.15	NS	NS	141	51	260	NS	NS	NS	NS	0.90	7.8	6.8	4.2	6.6
Interaction (I X N)															
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SI - Square initiation stage; BD - Boll Development stage; I Pick - 1st picking stage; II Pick - 2nd picking stage; III Pick - 3rd picking stage

Means with the same letter are not significantly different

3.2.7 Lint yield

Significantly higher lint yield (547 kg ha^{-1}) was recorded with N_4 (225 kg ha^{-1}) and was followed by N_3 (150 kg ha^{-1}) with lint yield of 537 kg ha^{-1}(Table 2) however these were comparable with each other and significantly superior over N_2 (75 kg ha^{-1}) and N_1 (0 kg ha^{-1}). Further, significantly higher lint yield (444 kg ha^{-1}) with N_2 (75 kg ha^{-1}) over N_1 (0 kg ha^{-1}), which recorded significantly the lowest lint yield (321 kg ha^{-1}).

The increased lint yield might be due to availability of adequate nitrogen at increased levels of nitrogen application which resulted in more mature fibers which led to higher lint yield. These results were in accordance with the findings of [17].

3.2.8 Stalk yield

Graded levels of nitrogen significantly influenced the stalk yield. Significantly higher stalk yield (2214 kg ha^{-1}) was recorded with N_4 (225 kg ha^{-1}) and was followed by N_3 (150 kg ha^{-1}) with stalk yield of 2107 kg ha^{-1}(Table 2), however these were comparable with each other and were significantly superior over N_2 (75 kg ha^{-1}) and N_1 (0 kg ha^{-1}). Further, significantly higher stalk yield (1719 kg ha^{-1}) was obtained with N_2 (75 kg ha^{-1}) over N_1 (0 kg ha^{-1}), with significantly lesser stalk yield (1324 kg ha^{-1}).

3.2.9 Harvest index, Ginning percentage, Lint Index, earliness index

Incremental increase in nitrogen application from N_1 (0 kg ha^{-1}) to N_4 (225 kg ha^{-1}) did not exert significant influence on harvest index (0.39-0.41), ginning percentage (37.1-38.1), lint index (5.6-6.1) and earliness index (0.72-0.74).

3.2.10 Nitrogen uptake

The difference in nitrogen uptake was conspicuous with graded levels of nitrogen application. At square initiation stage significantly higher nitrogen uptake (4.0, 3.8 and 3.4 kg ha^{-1}) was recorded with N_4 (225 kg ha^{-1}), N_3 (150 kg ha^{-1}) and N_2 (75 kg ha^{-1}), respectively (Table 2). They were at par with each other and significantly superior over N_1 (0 kg ha^{-1}), which recorded significantly the lowest nitrogen uptake (2.3 kg ha^{-1}). However, at boll development, first, second and third picking stages an incremental increase in nitrogen levels significantly increased the nitrogen uptake. Significantly higher nitrogen uptake (53, 97, 91 and 74 kg ha^{-1}) was registered with N_4 (225 kg ha^{-1}) and was comparable with N_3 (150 kg ha^{-1}) with 48, 93, 87 and 73 kg ha^{-1} of nitrogen uptake, respectively and in turn these were significantly superior over N_2 (75 kg ha^{-1}) and N1 (0 kg ha^{-1}). Further, significantly higher nitrogen uptake (37, 52, 46 and 40 kg ha-1) was registered with N_2 (75 kg ha^{-1}) over N_1 (0 kg ha^{-1}), which recorded significantly the lowest nitrogen uptake (25, 41, 38 and 32 kg ha^{-1}) at boll development, first, second and third picking stages, respectively.

The increased uptake of nitrogen might be due to favourable soil moisture and nutrient nitrogen availability in the soil at higher levels of application increases plant height, boll number, boll weight and increased drymatter production. These findings were in close agreement with those obtained by [17].

4. CONCLUSION

From the experiment, it can be concluded that, higher kapas yield was obtained with the irrigation scheduled at 0.4 IW/CPE and application of nitrogen at 150 kg ha^{-1} in Bt cotton in alfisols of Southern Telangana Zone.

Comment [S9]: it would be best to complete the discussion

Comment [S10]: it would be best to complete the discussion

Comment [S11]: It is best to also enter the lowest one

REFERENCES

1. ICAC Journal 'Cotton This Month' -June 1, 2022
2. Ramasundaram and Hemachandra 2001. Constraints to cotton production in India. CICR Technical Bulletin No: 19.
3. Wanjura, D, F., Upchurch, D. R., Mahan, J. R and Burke, J. J. 2002. Cotton yield and applied water relationships under drip irrigation. *Agricultural Water Management* 55(3): 217-237.
4. Tewiodle and Fernadez, C. J 1997. Vegetative and reproductive dry weight inhibition in nitrogen and phosphorus deficient Pima cotton. *Indian Journal of Agronomy* (38)4: 609-612.
5. Dadgale, P. R., Chavan, D. A., Gudade, B. A., Jadhav, S. G., Deshmukh, V. A and Suresh Pal. 2014. Productivity and quality of Bt cotton (Gossypium hirsutum) as influenced by planting geometry and nitrogen levels under irrigated and rainfed conditions. *Indian Journal of Agricultural Sciences* 84 (9): 1069–1072
6. Ahlawat, I. P. S and Gangaiah, B. 2010. Response of *Bt*cotton (*Gossypium hirsutum*) hybrids to irrigation. *Indian Journal of Agricultural Sciences* 80 (4): 271–274
7. Alse, U. N and Jadhav, A. S. 2011. Agronomic efficency of Bt and Non Bt cotton hybrids under irrigated conditions. *Journal of Cotton Research and Development*. 25 (1) : 38-41
8. Bhunia, S. R. 2007. Effect of methods of irrigation and levels of phosphorus on *desi* cotton (*Gossypium arboreum*) in shallow water-table condition. *Journal of Cotton Research and Development* 21(2): 184–186.
9. Shinde, V. S., Deshmukh, L. S and Raskar, S. K. 2009. Response of cotton (*Gossypium arboreum*L.) to protective irrigation at different critical growth stages. *Journal of cotton Research and Development* 23(1): 93–95.
10. Bandyopadhyay, K. K., Prakash, A. H., Sankaranarayanan, K., Dharajothi, B and Gopalakrishnan, N. 2009. Effect of irrigation and nitrogen on soil water dynamics, productivity and inputuse efficiency of *Bt*cotton (*Gossypium hirsutum*) in a VerticUstropept. *Indian Journal of Agricultural Sciences* 79 (6): 448–453.
11. Gundlur, S.S., Rajkumara, S., Neelakanth, J.K., Ashoka, P and Khot, A.B. 2013. Water and nutrient requirement of Bt cotton under vertisols of Malaprabha command. *Karnataka Journal of Agricultural Sciences*, 26 (3): 368-371.
12. Sunitha, V., Chandra Sekhar, K and Veera Raghavaiah, R. 2010. Performance of Bt cotton hybrids at different nitrogen levels. *Journal of Cotton Research and Development*. 24 (1) : 52-55
13. Howard, D.D., Gwathmey, C.O., Essington, M.E., Roberts, R.K and Mullen, M.D. 2001. Nitrogen fertilization of no-till cotton on loess- derived soils. *Agronomy Journal*. 93: 157–163.
14. Hosamani, V., Halepyati, A.S., Desai, B. K., Koppalkar, B. G and Ravi, M. V. 2013. Effect of macro nutrients and liquid fertilizers on the growth and yield of irrigated Bt cotton (*Gossypium hirsutum*L.). *Karnataka J. Agric. Sci.,*26 (2) : 200-204
15. Basavanneppa, M. A., Angadi, V.V and Biradar, D.P. 2015. Productivity and endotoxin expression as influenced by nutrient levels and nitrogen doses application in *Bt* cotton under irrigation. *Journal of Cotton Research and Development* 29 (1) 39-44.
16. Meena, R. L., Babu, V. R and Nath, A 2007. Effect of fertilizer management on cotton under saline soils of Gujarat. *Bharatiya Krishi Anusandhan Patrika* 22: 206-210.
17. Modhvadia, J. M., Solanki, R. M., Nariya, J. N., Vadaria, K. N and Rathod, A. D 2012. Effect of different levels of nitrogen, phosphorus and potassium on growth, yield quality of Bt cotton hybrid under irrigated conditions. *Journal of Cotton Research and Development.* 26 (1) : 47-51.