Growth behaviour of *Bt* (*Bacillus thuringiensis*) cotton as influenced by mepiquat chloride under varying nitrogen levels

By
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Thesis submitted to the Chaudhary Charan Singh Haryana Agricultural University, Hisar in the partial fulfillment of the requirements for the degree of

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IN
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CERTIFICATE-I

This is to certify that this dissertation entitled **"Growth behaviour of *Bt* (*Bacillus thuringiensis*) cotton as influenced by mepiquat chloride under varying nitrogen levels"** submitted for the degree of **Master of Science** in the subject of **Agronomy** of the **Chaudhary Charan Singh Haryana Agricultural University, Hisar** is a bona-fide research work carried out by **Ms. Sadhana kumari,** Admn. No. 2017A11M under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of these investigations have been fully acknowledged.

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CERTIFICATE- II

This is to certify that this thesis entitled **"Growth behaviour of *Bt* (*Bacillus thuringiensis*)cotton as influenced by mepiquat chloride under varying nitrogen levels"**submitted by **Ms. Sadhana Kumari,** Admn. No. 2017A11Mto the**Chaudhary Charan Singh Haryana Agricultural University, Hisar** in partial fulfillment of the requirement for the degree of **Master of Science** in the subject of **Agronomy** has been approved by the student's advisory committee after an oral examination on the same.

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Place: Hisar ***(Sadhana Kumari)***
Date: June, 2019

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CHAPTER-I

INTRODUCTION

Cotton is one of the important cashcropin world.Cotton is used as raw material in textile industry and this industry contributes about 14% to the industrial production and 4% of the GDP.Around 35 million people are directly dependent on this sector for their employment. The handloom sector consumes around 12.5% of raw cotton and power loom sector around 62.7%. Mills and Hosiery sector consume nearly 3.4% and 21.4% of total raw cotton respectively.

Cotton crop attains excessive vegetative growth mainly due to high soil fertility; coincidence of vegetative growth period with rainy season coupled with high humidity. Thick crop canopy prevents penetration of light.Shading of bolls and utilization of plant energy for the formation of vegetative stature results in shedding of flower buds, flowers and immature bolls. Excessive vegetative growth often occurs at the expense of reproductive growth and a large fraction of squares and small bolls on the lower sympods either shed or open poorly resulting in low yield.

Cotton is also the source of edible oil, animal feed and linters. Huge biomass as dried cotton stalk is used as fuel. Lint is the most important economical product, provides a source of quality fiber for textile industry and cotton seeds which is the primary byproduct of lint production, are an important source of oil for human consumption and also used as livestock feed.

In India, cotton is grown on about 123 lakh ha of land and it occupies first position in production with 377 lakh bales (each of 170 kg) among all cotton producing countries in the world. Whereas, in world area under this crop is 3335 lakh ha with 1213.7 lakh bales production. Average productivity of cotton in India is 524 kg/ha, which is low as compared to world average of 792 kg/ha (Anonymous, 2018). Cotton is cultivated on a large scale in Karnataka, Madhya Pradesh, Maharashtra, Gujarat, Punjab, Uttar Pradesh, Rajasthan, Haryanaand Tamilnadu. Maharashtra is the largest producer of cotton in India followed by Gujarat and Andhra Pradesh.

In Haryana, area under the crop is 6.56 lakh ha with production of 25 lakh bales (170 kg) and lint yield is 648 kg/ha in 2017-18(Anonymous, 2018).Cotton is an important cash crop of *kharif* season in Haryana state and plays important role in state's economy at several points including employment and export earnings. The four major cotton growing districts of Haryana are Sirsa, Hisar, Jind and Fatehabad known as the cotton belt of Haryana.The four cultivated species of cotton in India are: *Gossypium*

herbaceum, Gossypium arboreum, Gossypium hirusutum, Gossypium barbadence and their hybrids. All these cotton species are grown under diverse agro-climatic and farming conditions. The production and productivity of these species are varying with climatic conditions of a particular area. The major area under cotton in Haryana is*Gossypium hirusutum* which is about 90 % (around 5.90 lakh ha) of total cotton area in the state. Desi cotton is cultivated on around 0.91% (6000 ha) area in the state.

There are various meteorological factors such as low and high temperature, moisture deficits and surpluses and solar radiation intensity etc. which play important rolesin crop growth and development and ultimately influence yield. For cotton crop, a daily minimum temperature of 15ºC is required for germination and 21-27ºC for proper vegetative growth. Temperature significantly effects leaf expansion, internodes elongation, dry matter production and partitioning of assimilate to different plant parts (Sankarnaryanan*et al.,* 2010).

Cotton plants must have a harmonic balance between vegetative and reproductive growth for adequate photosynthates supply for healthy boll development leading to better productivity. The loss of reproductive structures alters the physiological growth and development of the plant by redirecting assimilates which normally are incorporated into these abscised organs to other plant parts.Under extreme cases, rotting of lower bolls also occurs. Most source sink research has focused on leaf boll relationships (harmonic balance) with little study of vegetative storage reserves.The best way to prevent excessive vegetative growth is to manage for early and high fruit set. If early fruit are not set, the crop may compensate by setting fruit at higher nodes and at outer fruiting positions leading to delayed crop maturity.

Plant growth regulators (PGRs) may enhance yield by increasing the retention of photosynthates into developing bolls. PGRs have been widely used in developed nations for increasing cotton production by adjusting plant growth and to improve lint yield and fiber quality.Gwathmey and Clement (2010) reported that source sink balance can be altered by using plant growth regulator such as mepiquat chloride (MC). Shekar *et al*, (2015) reported that the use of mepiquat chloride increases the N uptake resulting into higher seed cotton yield. Growth retardants like mepiquat chloride (MC) are known to reduce inter nodal length, thereby, reducing plant height and stimulating the translocation of photosynthesis towards reproductive sinks (developing cotton bolls), all of which result in higher yields.

Mepiquat chloride (MC) is used in cotton production across the globe to control plant growth and maximize yield and quality. Application of MC at squaring stage or at

both squaring and flowering stages significantly improved cotton quality parameters like fiber length (1.7%) and fiber strength (2.8%) without significant loss of yields(Ren*et.al.*,2013). The present investigation was carried out to study the effect of varying nitrogen levels and mepiquat chloride on growth and yield of cotton.

CHAPTER-II

REVIEW OF LITERATURE

A brief review of literature related to the present investigation on "Growth behaviour of *Bt* cotton as influenced by mepiquat chloride under varying nitrogen levels" has been presented under the following headings:

2.1Effect of Nitrogen

2.1.1Growth and development

Nitrogen has been reported to increase plant height in cotton (Mukand *et al*., 1989).Brar*et al.* (2000) observed that 225 kg N/ha significantly increased the plant heightamong different levels of nitrogen (75, 150 and 225 kg N/ha).

Zhao and Oosterhuis (2000) indicated that low N supply at the reproductive stage decreased cotton leaf area and leaf net photosynthetic rate.The split application of N as 25% at sowing + 25% at first irrigation + 50% at flowering with one hoeing at 3 weeks and earthing up at 6 weeks treatment resulted as maximum leaf area index (LAI) with significant increase compared to other treatments (Anjum *et al*., 2007).

Manjunatha *et al*. (2017) reported that total dry matter production was significantly higher with application of 180 kg N/ha (294.5 g) as compared to other nitrogen levels. Total dry matter production per plant depended on accumulation of dry matter in different plant parts *viz.*, leaf, stem and reproductive parts. Increase in total dry matter production at 180 DAS increase was to the tune of 12.0 and 5.5 per cent over 120 and 150 kg N/ha.

Mahadevappa *et al.* (2018) observed that among different nitrogen levels, significantly higher plant height (109 cm), dry matter production at first picking (247 g/plant) stage, were found with application of nitrogen at 225 kg/ha which were comparable with 150 kg/ha and were significantly superior over lower levels of nitrogen application.

2.1.2 Yield attributes and yield

Nitrogen has been reported to increase number of monopodial and sympodial branches/plant and number of mature bolls/plant in cotton (Mukand *et al*., 1989). Excesses of N promote vegetative growth,delay maturity and usually result in lower yields of cotton (McConnell *et al.*, 1996).

Increase in seed-cotton yield due to applied nitrogen under rainfed condition has been reported by Venugopal and Mannikar (1998). Brar *et al.* (2000) observed that 225 kg N/ha significantly increased sympodial branches/plant, whereas significantly more number of bolls/plant were recorded with 150 kg N/ha out of different levels of nitrogen (75, 150 and 225 kg N/ha).

Zhao and Oosterhuis (2000) indicated that low N supply at the reproductive stage decreased lint yield. Venugopalan and Blaise (2001) observed that significantly higher seed cotton yield was obtained with 50 kg N/ha out of different nitrogen levels (0, 50, 75 and 100 kg/ha).

A field experiment conducted by Sagarka *et al.* (2002) showed that application of nitrogen @ 160 kg N/ha significantly increased seed cotton yield of cotton. Kasap and Killi (2004) observed that application of 150 to 250 kg N/ha gave the highest number of sympodial branches and bolls/plant in cotton crop.

Sawan *et al.* (2006) noted that cotton seed yield as well as seed index significantly increased as much as 13.0% due to raising the N rates from 95.2 to 142.8 kg N/ha. Seed oil content slightly decreased with increase in amount of N applied but oil yield significantly increased 45.5 kg/ha which was attributed to significant increase in cotton seed yield.

The split application of N in which 25% at sowing + 25% at first irrigation + 50% at flowering with one hoeing at 3 weeks and earthing up at 6 weeks treatment gave maximum number of sympodial branches/plant and bolls/plant compared to other treatments (Anjum *et al*., 2007).

Kumbhar *et al*. (2008) observed that application of 150 kg N/ha gave significantly the highest number of monopodial and sympodial branches/plant. Hallikeri *et al.* (2010) recorded that number of opened bolls and boll weight was significantly influenced by increase in level of N from 80 to 120 kg N/ha.

Application at different rates of N (0, 100, 200 and 300 kg/ha) enhanced boll number and boll weight. Among different rates of nitrogen, 200kg/ha gave more effective result to obtain the highest bolls number, boll weight and seed cotton yield (Rashidi *et al*., 2011).

Prakash *et al.* (2010) observed that with increase in N levels number of sympodial branches/plant increasing. It was also recorded that N application @ 90kg/ha significantly increased seed cotton yield .Experiment at Faisalabad on different levels of nitrogen *i.e.* 0, 60, 120 and 180 kg/ha revealed that application of 120kg/ha significantly increased the boll weight as well as seed cotton yield (Saleem *et al*., 2010).

Patel *et al.* (2011) revealed that application of 200 kg N/ha and 160 kg N/ha gave significantly higher seed cotton yield than 120 kg N/ha. Modhvadia *et al.* (2012) recorded that application of nitrogen @ 240 kg/ha resulted in significantly higher number of bolls/plant and boll weight.

Alitabar *et al.* (2013) observed that application of nitrogen @ 225 kg N/ha produced maximum seed cotton yield, number of bolls per plant.A field experiment on different levels of nitrogen (180, 240 and 300 kg N/ha) in *Bt* cotton revealed significant increase in seed cotton yield due to different levels of nitrogen applied to *Bt*-cotton. Significantly higher seed

cotton yield was produced under nitrogen applied @ 300 kg/ha, but it was remained at par with 240 kg N/ha (Usadadiya *et al.*, 2013).

2.1.3Fiber quality

Hussain *et al.*(2000) reported that nitrogen rate had no effect on fiber uniformity. Excess application of N than the required for optimum crop performance can reduce fiber quality.Das *et al*. (2006) reported that quality parameters *viz.*, ginning percent, lint index, fiber length, bundle strength and fiber fineness were not affected significantly by N management practices.

A field experiment by Kumbhar *et al*. (2008)oneffect of different nitrogen levels (50, 100, 150 kg N/ha) on cotton showed that application of 150 kg N/ha gave significantly higher ginning out turn.

2.1.4 Nutrient uptake

Nalyaini *et al*. (2010) reported that uptake of N was significantly enhanced by 10.9, 54.8 and 33.9% at 50, 75 and 100% RDN level, respectively. Mahadevappa *et al.* (2018) observed that among different nitrogen levels, significantly higher nitrogen uptake (107 kg/ha) was found with application of nitrogen at 225 kg/ha and it did not differ significantly with 150 kg N/ha (100 kg/ha). These treatments were significantly superior over lower levels of nitrogen application.

2.1.5 Economics

Application of 180 kg N/ha resulted in significantly higher gross returns, net returns and B:C ratio (1,46,222, ` 97,765 per ha and 3.01, respectively) of Bt cotton over other nitrogen levels (Manjunatha *et al*. 2017).Significantly higher net returns were obtained at higher levels of nitrogen application over no nitrogen application (Mahadevappa *et al.* 2018).

2.2 Effect of growth regulators on

2.2.1 Growth and development

Reddy *et al.* (1990) stated that foliar application with mepiquat chloride resulted in more compact plants of cotton with a ratioof reproductive to vegetative dry matter larger than one. Mahmoud *et al.* (1994) found that Cycocel and Alar decreased plant height with application rates of 500 and 5,000 ppm, respectively, when applied at-early growth stages, while late application increased plant height and leaf abscission, but decreased number of leaves per plant.

Reddy *et al*. (1996) found that mepiquat chloride inhibits biosynthesis of gibberellic acid. Therefore, cell elongation, foliar area and growth are decreased. Crozat and Kasemsap (1997) reported that mepiquat chloride application at early flowering significantly decreased vegetative growth and shortened crop duration of cotton.

Mert and Caliskan (1998) reported that mepiquat chloride reduced plant height. El-Shahawy (1999) studied the effect of foliar application with Pix on cotton and reported that it decreased plant height as compared with control.

Mepiquat chloride acts as an anti-gibberellic acid compound, thus decreasing cell elongation and usually reducing number of main stem nodes (Pettigrew and Johnson, 2005).Insituations where excess moisture and nitrogen were problems, mepiquat chloride effectively reduced plant height in most instances (Nuti *et al.,* 2006).

Pix which is commonly used as growth retardant, when applied as foliar spray reduced the vegetative growth of plant, leaves became coarser and dark green in color (Muhammad *et al.,* 2007). Wilson *et al.* (2007) reported reduction in plant height, main stem nodes in response to mepiquat chloride as compared to the control.

Bogianiand Rosolem (2009) stated that mepiquat chloride plant growth regulator applied at 0, 7.5, 15 and 22.5 g/haof the active ingredient reduced the growth of cotton plants, and this effect was intensified by increasing the dosage.

2.2.2 Yield attributes and yield

Yao *et al.* (1990) found various aspects of the use of Pix *i.e.* high solar radiation can be synchronized with the optimal boll setting period, thus contributing to the total yield increase. Koraddi *et al.*(1993) found that application of 60 ml Cycocel/ha at 90, 105, and 120 days after sowing increased mean yield of cotton plants.

Pipolo *et al.* (1993) found that single and double applications of 25 g/ha of Cycocel resulted in yield increases of 11.5% and 11.6%, respectively. These treatments also enhanced earliness and seed weight.

Boman and Westerman (1994) found that application of mepiquat chloride consistently reduced plant height by as much as 5.7 inches. Reddy *et al*. (1996) observed that treating cotton plants with mepiquat chloride @ 7.65, 15.3, 30.6 and 61.2 g/haat first square stage recorded reduced total leaf area by 1% and net photosynthetic rates by 25% as compared with control. The activity of ribulose-biphosphate carboxylase was decreased by mepiquat chloride suggesting partial loss of photosynthetic capacity which was responsible for reduced growth.

Mert and Caliskan (1998) reported that mepiquat chloride increased seed cotton weight per boll as compared with control. El-Shahawy (1999) studied the effect of foliar application with Pix on cotton and reported that it increased number of sympodia, number of bolls, percent boll retention, earliness, seed index, lint %, boll weight and yield of seed cotton.

Compared with the untreated control, application of mepiquat chloride improved leaf photosynthetic rate and increased lint yield (Zhao and Oosterhuis, 1999). Nuti *et al.* (2000) stated that mepiquat chloride is thought to causes a shift in partitioning of photo-assimilates

from vegetative to reproductive growth. Redistribution of assimilates between vegetative and reproductive growth may be one means by which yields can be increased.

Siddique *et al*. (2002) observed that foliar spraying with mepiquat chloride significantly increased the yield. Abro *et al.* (2004) reported that naphthalene delay maturing and increased number of bolls and seed cotton yield.

Kumar *et al*. (2006) observed that NAA (20ppm) at 90 DAS recorded significantly higher number of bolls per plant, boll weight and seed cotton yield followed by mepiquat chloride (50ppm) sprayed at 90 DAS over the untreated control.Wilson *et al.* (2007) reported reduction in number of effective sympodia and total bolls per plant in response to growth hormones as compared to the control.

Plant growth regulators such as Pix increased seed cotton yield (Gencsoylu, 2009). However, there are also some findings supporting that Pix decreased seed cotton yield (O'Berry *et al.,* 2009). Ali *et al*. (2012) found that foliar spraying with mepiquat chloride significantly increased yield of cotton as compared with untreated treatment.

2.2.3Fiber quality

Livingston *et al*. (1992) found increased fiber strength by 1.5 to 2.8 g/tex with mepiquat chloride. Boman and Westerman(1994) stated that application of mepiquat chloride increased fiber strength by 3.8%. Several workers (Mert and Caliskan, 1998; Karthikeyan and Jayakumar, 2001) have reported that mepiquat chloride did not significantly affect fiber qualities, but micronaire increased with mepiquat chloride application (Mekki, 1999). Sawan *et al.* (1997) and Sawan (2013) reported that Cycocel and Alar did not affect cotton fiber quality.

2.2.4 Nutrient uptake

Yaseen *et al.* (2006) suggested that with the combined application of $CaC_2$and N fertilizer in cotton, N uptake was increased up to 31.5% over the application of N fertilizer alone.

CHAPTER-III

MATERIALS AND METHODS

The present investigation on "Growth behaviour of *Bt* cotton as influence by mepiquat chloride under varying nitrogen levels" was carried out during *Kharif* season of 2018. The details of materials used and the experimental techniques adopted during the course of investigation are described below:

3.1 Experimental site and location

The study was conducted at National Seed Production Area of Choaudhary Charan Singh Haryana Agricultural University, Hisar, during *kharif* season of 2018. Hisar is situated in the sub-tropics at longitude 75º46'E, latitude 29º10'N and altitude of 215.2 m above mean sea level in Haryana state of India.

3.2 Weather and Climate

Hisar has semi-arid climate with very hot summer (temperature rises up to 45˚C or more) and extremely cool winter (temperature falls up to 1-2˚C or less than this). During summer season as well as winter season, the mean monthly temperature shows a wide range of fluctuation in minimum and maximum temperature. In December and January months, minimum temperature may fall to 0˚C. Average annual rainfall of Hisar is 450 mm out of the total rainfall, around 80% is received in south-west monsoon during July to September.

The weekly weather data recorded in Agro-Meteorology Observatory, CCS HAU, Hisar during the crop season are presented in Table 3.1 and Fig. 3.1.

The perusal of data in Table 3.1 indicates that the mean weekly maximum and minimum temperature ranged from 43.8 to 27.2^{o}C and 29.6 to 9.4^{o}C, respectively during the crop growing period. The weekly mean relative humidity during the same period ranged from 48 to 98% in morning hours and 17 to 80% in evening hours.

3.3 Soil analysis

Representative soil samples up to the depth of 0-15 cm from the experimental field were randomly collected at the start of the experiment from the five places to determine pH, organic carbon and NPK content of the soil. The composite samples were subjected to the analysis of physio-chemical properties of soil. The results of sample analysis along with method used for determination are presented in Table 3.2.

Table-3.1 Mean weekly meteorological data during the crop growing season 2018 recorded at experimental area, CCSHAU, Hisar

Meteorological Week	Temperature (^{o}C)		Relative Humidity (%)		Sun Shine hours	Rainfall (mm)
	Max.	Mini.	Morning	Evening		
16	37.6	19.4	56	31	8.3	0.0
17	39.3	20.6	52	27	8.5	0.0
18	39.4	25.2	57	30	6.8	0.0
19	39.1	22.3	57	24	7.5	0.0
20	39.7	23.3	63	40	4.7	0.0
21	42.5	22.8	48	21	8.6	0.0
22	43.8	26.4	66	36	6.6	0.0
23	41.7	28.6	77	43	5.6	2.2
24	39.7	29.6	68	46	1.6	0.0
25	39.4	26.4	61	35	6.7	0.0
26	35.1	26.5	81	71	4.1	56.7
27	35.3	26.7	82	60	6.3	39.1
28	37.6	27.9	82	61	6.0	14.2
29	33.9	26.3	94	81	4.6	11.7
30	33.4	26.3	95	79	2.9	93.5
31	36.1	26.5	80	54	6.1	0.0
32	36.6	26.6	78	58	4.7	0.0
33	32.7	26.2	92	73	3.5	22.1
34	35.6	27.2	90	62	6.8	0.6
35	36.1	26.9	89	66	5.2	0.8
36	35.1	26.2	90	64	4.9	3.0
37	34.4	23.5	90	64	7.6	29.2
38	33.7	23.3	93	76	6.6	44.6
39	30.8	21.6	98	69	5.1	32.0
40	34.4	20.0	90	40	7.9	0.0
41	32.5	15.2	86	43	6.8	0.0
42	33.4	16.5	72	30	7.1	0.0
43	31.4	14.4	84	36	7.1	0.0
44	31.0	15.4	92	44	2.1	0.0
45	27.4	10.1	90	41	3.3	0.0
46	27.5	12.7	91	53	3.5	0.0
47	27.4	10.9	87	44	5.8	0.0
48	27.2	9.4	93	47	5.5	0.0

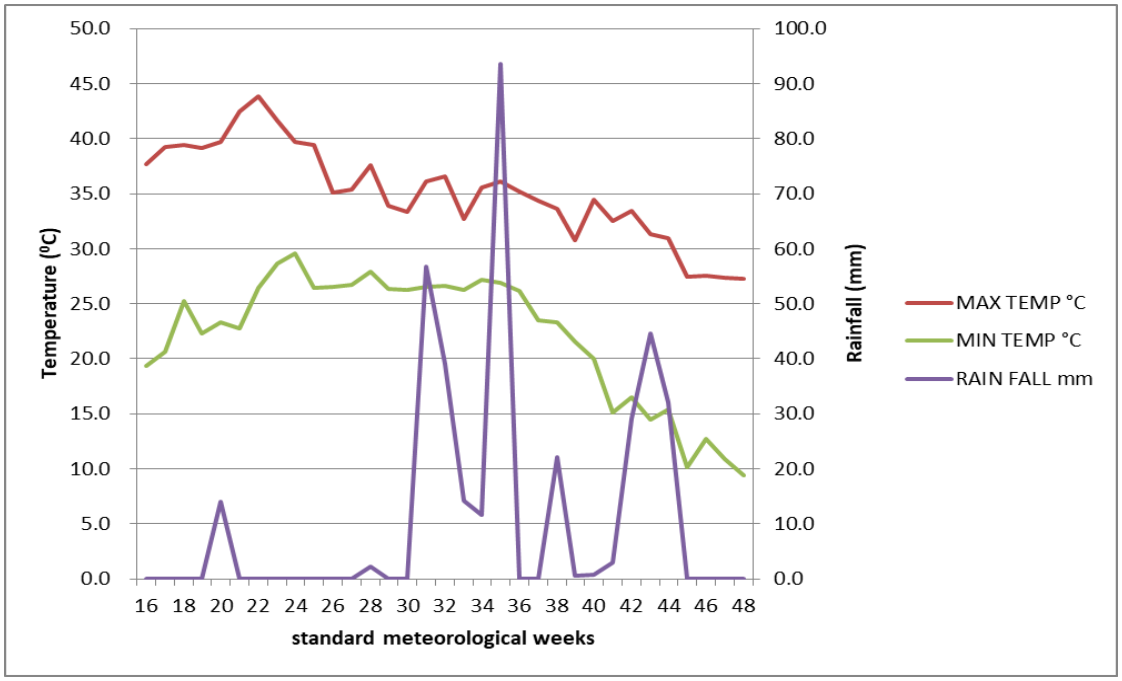

Fig.3.1 Mean weekly values of meteorological parameters during crop season 2018

Table-3.2 Physico-chemical analysis of experimental field soil before crop sowing

Soil property	**Values**	**Method of determination**
Sand (%) Silt (%) Clay (%)	73.8 15.9 10.3	International pipette method(Piper, 1966)
pH	7.9	Glass electrode pH meter (Jackson, 1973)
Electrical conductivity (dS/m)	0.23	Solubridge conductivity meter 1:2 soil-water suspension (Richards, 1954)
Organic carbon (%)	0.44	Walkley and Black rapid titration method (Jackson, 1973)
Available nitrogen (kg/ha)	125	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg/ha)	13	Olsen method (Olsen *et al.*, 1954)
Available potassium (kg/ha)	280	Flame photometer method (Richards, 1954)

3.4 Cropping history of experimental field

The cropping history of the experimental field is presented in Table 3.3.

Table-3.3 Cropping history of experimental field

Year	**Crop season**	
	Kharif	***Rabi***
2016-17	Mung+Bajra+Cotton	Fallow
2017-18	Mung+Cotton	Fallow
2018-19	Experimental crop	-

3.5 Experimental details

3.5.1 Treatments:

Nitrogen dose-

N_1: 100% RDN*

N_2: 125% RDN

N_3: 150%RDN

Growth retardant-

G_1: Control

G_2: Mepiquat chloride application 20g *a.i.*/ha at 60 DAS

G3: Mepiquat chloride application 20g *a.i.*/ha at 60 DAS and 75 DAS

Genotype: RCH 650

3.6 Layout details

No. of treatments: **9**

No. of replications: **3**

Total no. of plots: **27**

Design of treatment:**Factorial randomized block design**

Plot size: 6x4.5

(RDN=Recommended dose of nitrogen)

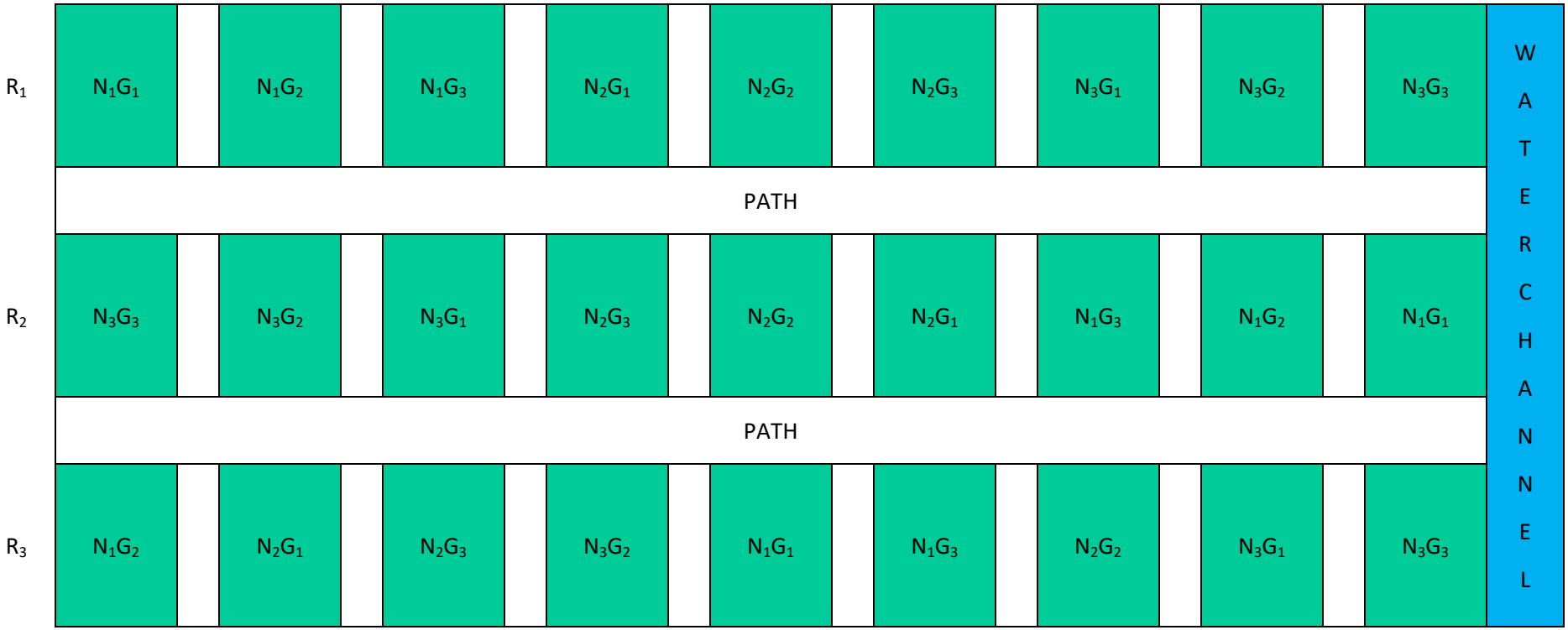

Fig.3.2 LAYOUT OF FIELD EXPERIMENT

3.7 Cultural operations

All the intercultural operations were carried out as per the package of practices of raising cotton crop recommended by the CCS Haryana Agricultural University.

3.7.1 Preparatory tillage

A primary harrowing tillage operation with the tractor drawn disc harrow was done. Pre sowing irrigation was applied in whole field. When the field attained proper moisture condition, a fine seed bed was prepared by giving one harrowing and ploughing with the tractor drawn cultivator followed by planking.

3.7.2 Sowing and spacing

Genotype RCH 650 sown on 16th April 2018 by dibbling method, by putting two seeds per hillat a depth of 3-5 cm. Row to row distance 45 cm, plant to plant distance for RCH 650 is 90 cm.

3.7.3 Fertilizer application

Recommended dose of fertilizer for RCH 650 is 175 kg N, 60 kg P_2O_5, 60 kg K_2O and 25 kg $ZnSO_4$ per hectare.One third of N and full dose of P, K and $ZnSO_4$ was applied at the time of seed bed preparation. Remaining dose of N was applied after 1st irrigation and at flowering stage.

3.7.4 Gap filling and thinning

Soon after germination gap filling was done. Thinning was done after 30 days of sowing to maintain one plant per hill.

3.7.5 Irrigation

Only two irrigations were applied at 57 DAS and 127 DAS.

3.7.6 Hoeing and weeding

1st Hoeing was done before first irrigation and after that hoeing was done after every irrigation to keep the field free from weeds. One hand weeding and pre-emergence application of pendimathalin @ 1.5 kg/ha was applied.

3.7.7 Pickings

Two hand pickings were done, 1st picking was done on 23rd octomberand 2nd was on 19th November.

Table-3.4 Details of cultural practices

Cultural operation	Date	Details
Pre-sowing irrigation	11/04/18	One pre-sowing irrigation was applied.
Seed bed preparation	16/04/18	One harrowing and ploughing with cultivator followed by planking were done.
Sowing date	16/04/18	Sowing was done by dibbling method.
Fertilizer application	16/04/18 18/06/18 20/07/18	Full dose of P, K and $ZnSO_4$ was applied at the time of seed bed preparation. dose of N was applied as per treatments.
Thinning	24/04/18	Thinning was done after 30 days of sowing.
Weeding and hoeing	19/04/18 04/05/18 28/05/18 18/06/18 28/08/18	Pre-emergence application of herbicide (pendimethalin), one hand weeding and three hoeing was done.
Irrigation	13/06/18 22/08/18	Two irrigation were applied at 57 and 127 DAS.
Growth regulator	15/06/18 30/06/18	Spray of mepiquat chloride @ 20g *a.i.*/ha.
Plant protection	22/07/18	Spray of thaimethoxam for the control of insects.
Harvesting and picking	23/10/18 19/11/18	Two hand picking were done.

3.8 Observations recorded

In each plot, five plants were randomly selected and tagged for the recording of different observations till maturity of the crop.

3.8.1 Growth studies

3.8.1.1 Plant height

Height of five tagged plants in each plot was measured periodically at 45, 75, 105, 135 days after sowing and at maturity. It was measured from the main stem to the tip of fully opened leaf at the top and expressed in cm.

3.8.1.2 Dry matter

Two plants per plot were uprooted at ground level. For the measurement of dry matter accumulation at 45, 75, 105, 135 DAS and at maturity, the samples were first dried in air and then oven dried at a temperature of 70°C till constant weight was obtained. Dry weight was recorded on per plant basis and expressed in g/plant.

3.8.1.3 Leaf area index

Leaf area index (LAI) was recorded at 45, 75, 105 and 135 DAS by uprooting two plants per plot at ground level and leaves of these plants were used for the measurement of leaf area by using LI-3000 Leaf Area Meter, LICOR Ltd., Nebraska, USA.

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

3.8.2 Phenological Studies

3.8.2.1 Days to squaring

When first Square of a size visible with naked eye appeared on 50 % of plants, number of days from planting was recorded. Average number of days taken to squaring was calculated.

3.8.2.2 Days to 50% flowering

It is the number of days when 50% of plants initiate of flowering. Days were noted after the sowing from each individual plant when 50% plants initiated flowering.

3.8.2.3 Days to 50% boll opening

It is the number of days when 50% of plants initiates boll opening. Days were noted after the sowing from individual plant when 50% plantsinitiated boll opening.

3.8.2.4 Days to maturity

When the bolls crack open and the fluffy white cotton is exposed or when the cotton is ready to be picked and days were noted from the sowing to first picking.

3.8.3 Yield attributes and yield

3.8.3.1 Number of bolls/m^2

Total number of bolls harvested per m^2 was recorded in each plot from five tagged plants.

3.8.3.2 Boll weight (g)

Five fully opened bolls from tagged plants in each plot were picked randomly and weighed and recorded as average boll weight per plant in grams.

3.8.3.3 Number of monopodial branch

Monopodial branches were counted from the five tagged plants in each plot at maturity stage and mean was calculated and expressed as per plant basis.

3.8.3.4 Number of sympodial branch

The sympodial branches are known as fruit bearing branches and counted from the five tagged plants in each plot at maturity stage and expressed as average sympodial branches per plant.

3.8.3.5 Seed index

Weight of 100 cotton seeds randomly taken after ginning from each plot and expressed in grams.

3.8.3.6 Seed cotton yield (kg/ha)

Total seed cotton harvested from all the picking (two) per plot and seed cotton yield in kg/ha was computed on the basis of net seed cotton yield per plot.

3.8.4 Fiber quality parameters

3.8.4.1 Ginning out turn (GOT)

500 g sample of seed cotton was taken from each plot and then ginned to get lint and cotton seed.It was calculated by using following formula.

$$\text{GOT (\%)} = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$$

3.8.4.2 Micronairevalue

It measures the fiber weight in 10^{-6} g/inch length of fiber. Fineness denotes the size of cross-sectional diameter of the fibre. A sample of 100gram lint was taken and measure micronaire value by using Precitronic Digital Mic Tester at CICR, Sirsa.

3.8.5 Plant analysis

The oven dried samples taken at harvest were ground, and 0.2 g for stalk and 0.1 g for seed of each ground sample was digested in di-acid mixture of H_2SO_4 and $HClO_4$ (9:1) for N, P and K estimation. After digestion, a known volume was made with distilled water and filtered through Whatman filter paper No. 42. All the estimation in aliquot was made according to following procedure.

3.8.5.1 Nitrogen content and uptake at harvest

Per cent nitrogen content was determined by Nessler's Reagent Method as described by Jackson (1973). The nitrogen uptake at harvest was calculated as under:

$$\text{N uptake by seed (kg/ha)} = \frac{\text{SeedN content (\%) x seed yield (kg/ha)}}{100}$$

$$\text{N uptake by stalk (kg/ha)} = \frac{\text{StalkN content (\%) x stalk yield (kg/ha)}}{100}$$

3.8.5.2.Phosphorous content and uptake at harvest

Per cent phosphorous content was determined by Vanadomolybdo Phosphoric Acid Yellow Colour Method. The P uptake at harvest was calculated as under:

$$\text{P uptake by seed (kg/ha)} = \frac{\text{Seed P content (\%) x seed yield (kg/ha)}}{100}$$

$$\text{P uptake by stalk (kg/ha)} = \frac{\text{Stalk P content (\%) x stalk yield (kg/ha)}}{100}$$

3.8.5.3.Potassium content and uptake at harvest

Percent potassium content was determined by Flame Photometric Method. The K uptake at harvest was calculated as under:

$$\text{K uptake by seed (kg/ha)} = \frac{\text{Seed K content (\%) x seed yield (kg/ha)}}{100}$$

$$\text{K uptake by stalk (kg/ha)} = \frac{\text{StalkK content (\%) x stalk yield (kg/ha)}}{100}$$

3.9 Soil analysis

The composite soil samples from 0 – 15 cm depth were analysed before sowing and after harvesting for determining the available nitrogen, phosphorus and potassium.

3.10Economics of treatments

The expenditure incurred on individual treatment was worked out from the detail assessment of the fixed and variable costs involved such as land preparation, seed, fertilizer, plant protection, chemicals, herbicides, growth regulator and labour engaged in different operations. Gross income for all treatments was calculated separately. Thereafter, net returns were calculated after subtracting expenditure incurred on the individual treatment from the gross expenditure of the same treatment.

The benefit: cost ratio was calculated as follows.

$$B:C = \frac{\text{Gross return (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

3.9 Statistical analysis

Data used in the study are the mean values of the replicated observations. For the statistical analysis of the data, online computer programme OPSTAT (http://hau.ernet.in/ sheoranop/) was used.

CHAPTER-IV

EXPERIMENTAL RESULTS

Theseresults obtained from the observations recorded for plant growth parameters, phenological parameters, yield and yield attributes, and fiber quality traits in the field experiment entitled "Growth behaviour of *Bt*(*Bacillus thuringiensis*) cotton as influenced by mepiquat chloride under varying nitrogen levels" are described in this chapter with the help of appropriate tables and figures.

4.1 Growth studies

4.1.1 Plant height (cm)

At 45 DAS plant height was significantly higher with 150% RDN as compared to lower two levels. While at 75, 105, 135 DAS and at maturity plant height was not affected by different levels of nitrogen.

Application of mepiquat chloride was imposed from 60 DAS, hence its effect was seen from 75 DAS onwards. Mepiquat chloride had significant effect on the plant height at different growth stages. At 75 DAS, significantly higher plant height was recorded in control as compared to other two treatments with mepiquat chloride application. The same trend was observed at 105, 135 DAS and at harvest.

Table- 4.1 Effect of different nitrogen levels and mepiquat chloride on plant height (cm) of *Bt* cotton hybrid

Treatments	Days after sowing				
	45	75	105	135	Maturity
Nitrogen levels					
N_1 (100% RDN)	40.6	82.2	116.8	143.1	144.0
N_2 (125% RDN)	40.6	82	117.4	141.2	154.5
N_3 (150% RDN)	43.4	84.5	125.7	152.9	154.7
SEm±	**0.6**	**2.5**	**2.7**	**8.3**	**10.3**
CD at 5%	**2.0**	**NS**	**NS**	**NS**	**NS**
Mepiquat chloride					
G_1 (Control)	42.2	102.8	176.1	209	210.8
G_2 (MC@ 20g a.i./ha at 60 DAS)	40.5	72.3	97.5	126.4	128.4
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	42.0	73.5	86.3	101.8	114.1
SEm±	**0.68**	**2.5**	**2.7**	**8.3**	**10.3**
CD at 5%	**NS**	**7.5**	**8.2**	**25.1**	**30.6**

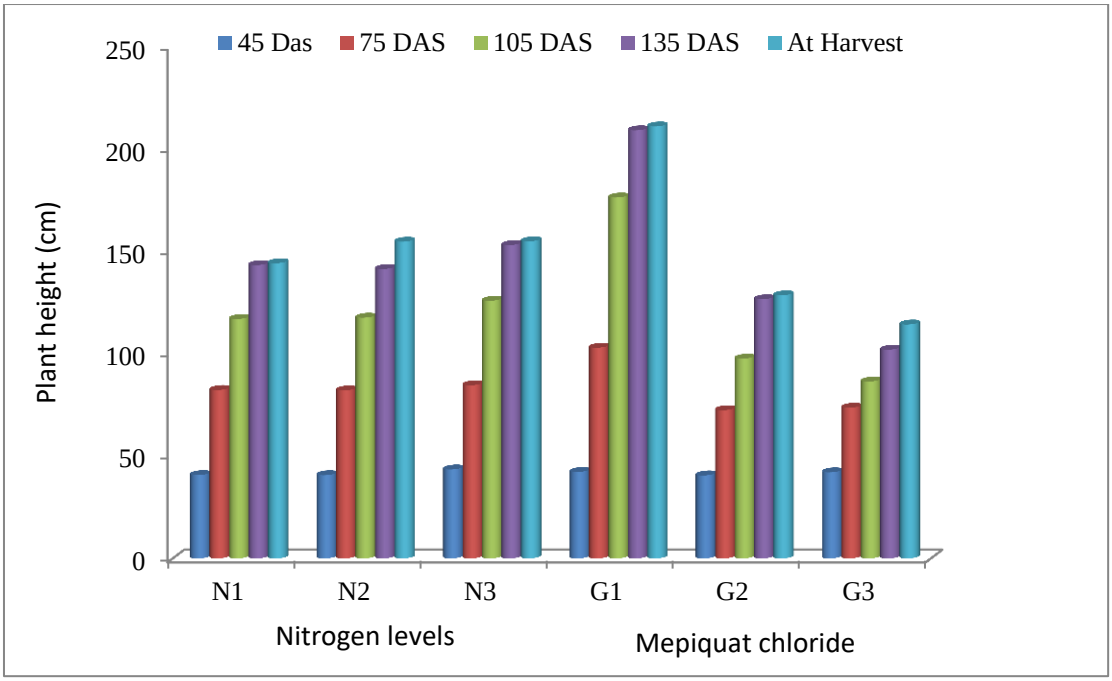

Fig- 4.1 Effect of different nitrogen levels and mepiquat chloride on plant height (cm) of *Bt* cotton hybrid

4.1.2 Dry matter (g/plant)

Table 4.2 revealed that there was continuous increase in dry matter accumulation upto maturity. Total dry matter accumulation was not affected with different levels of nitrogen at 45 and 75 DAS. But at 105 DAS and at maturity, accumulation of dry matter was significantly higher with 150% RDN compared to 100% RDN and at par with 125% RDN. At 135 DAS dry matter accumulation was significantly higher with 150% RDN compare to other two levels.At 135 DAS increase in dry matter with 125% RDN over 100% RDN was also significant.

Effect of mepiquat chloride on dry matter started from 75 DAS onwards. Total dry matter accumulation was significantly higher with control over two spray of mepiquat chloride at 60 and 75 DAS and single spray at 60 DAS. At 105, 135 DAS and at maturity reduction in dry matter with two foliar application of mepiquat chloride was significant over its application only once at 60 DAS.

Table-4.2 Effect of different nitrogen levels and mepiquat chloride on dry matter (g/plant) of *Bt* cotton hybrid

Treatments	Days after sowing				
	45	**75**	**105**	**135**	**Maturity**
Nitrogen levels					
N_1 (100% RDN)	6.7	39.7	83.2	127.1	269.9
N_2 (125% RDN)	6.6	42.9	101.9	144.8	277.6
N_3 (150% RDN)	6.0	41.5	108.1	170	343.1
SEm±	**0.2**	**1.8**	**2.7**	**5.1**	**18.9**
CD at 5%	**NS**	**NS**	**8.2**	**15.4**	**57.4**
Mepiquat chloride					
G_1 (Control)	6.4	70.8	159.2	240.6	542.2
G_2 (MC@ 20g a.i./ha at 60 DAS)	6.6	26.0	72.3	109.2	205.1
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	6.3	27.2	61.7	92.1	143.3
SEm±	**0.2**	**1.8**	**2.7**	**5.1**	**18.9**
CD at 5%	**NS**	**5.3**	**8.2**	**15.4**	**57.4**

4.1.3 Leaf area index

Table-4.3 revealed the effect of different nitrogen levels and mepiquat chloride dose on LAI of cotton. LAI increased from 45 DAS to 135 DAS. At 45 DAS different nitrogen levels did not show any effect on LAI. While at 75 DAS significantly higher LAI was recorded with 150% RDN compared to other two levels. The same trend was noticed at 105, 135 DAS and at harvest.

Table 4.3 Effect of different nitrogen levels and mepiquat chloride on leaf area index

Treatments	Days after sowing				Maturity
	45	**75**	**105**	**135**	
Nitrogen levels					
N_1 (100% RDN)	0.2	0.8	1.1	1.5	0.4
N_2 (125% RDN)	0.1	0.7	1.6	1.6	0.5
N_3 (150% RDN)	0.2	0.9	1.7	1.7	0.5
SEm±	**0.2**	**0.1**	**0.03**	**0.04**	**0.003**
CD at 5%	**NS**	**0.1**	**0.1**	**0.1**	**0.01**
Mepiquat chloride dose					
G_1 (Control)	0.1	1.5	2.2	2.4	0.5
G_2 (MC@ 20g a.i./ha at 60 DAS)	0.2	0.7	1.2	1.3	0.4
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	0.2	0.2	0.9	1.1	0.4
SEm±	**0.16**	**0.07**	**0.03**	**0.04**	**0.003**
CD at 5%	**NS**	**0.09**	**0.1**	**0.1**	**0.01**

Effect of mepiquat chloride on LAI started from 75 DAS onwards because first application of mepiquat chloride was made 60 DAS. Significantly higher LAI was recorded with control as compared to other two treatments at 60 DAS and 75 DAS. Same trend was recorded at 105, 135 DAS and at maturity.

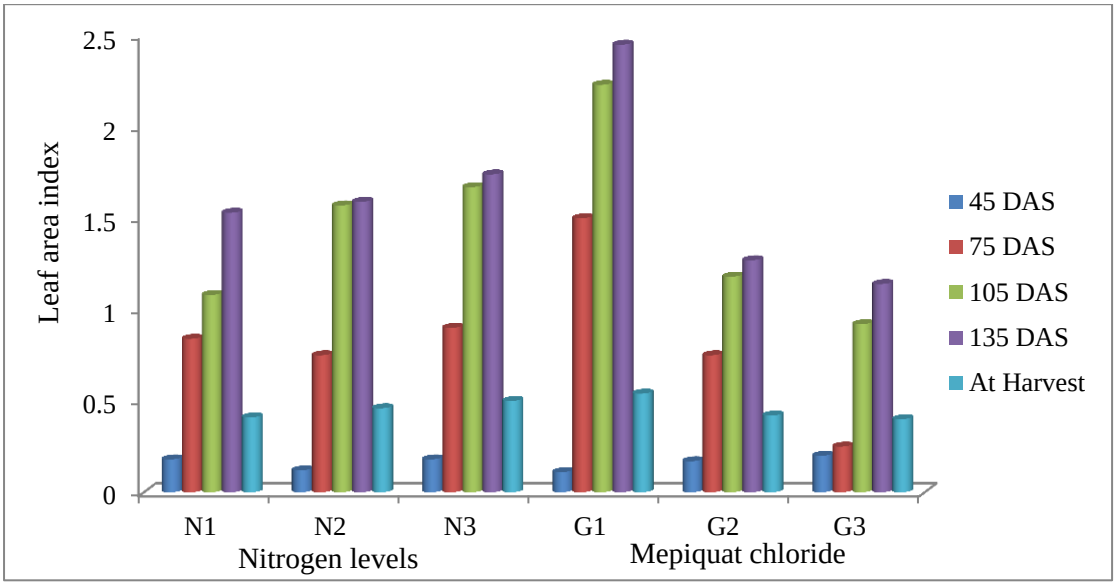

Fig-4.2 Effect of different nitrogen levels and mepiquat chloride on leaf area index

4.1.4 Number of sympodia and monopodia per plant

Sympodia and monopodia per plant did not vary due to different levels of nitrogen.Spraying of mepiquat chloride twice at 60 and 75 DAS resulted in significantly higher number of sympodia per plant over single spray (60 DAS) which in turn resulted in significantly more number of sympodiaas compared to control. While monopodia per plant did not vary due to mepiquat chloride.

Table 4.4 Effect of different nitrogen levels and mepiquat chloride on sympodia and monopodia per plant of *Bt* cotton hybrid

Treatment	No. of Sympodia/plant	No. of Monopodia/plant
Nitrogen levels		
N_1 (100% RDN)	21.0	2.2
N_2 (125% RDN)	20.8	2.2
N_3 (150% RDN)	22.6	2.6
SEm±	**1.2**	**0.2**
CD at 5%	**NS**	**NS**
Mepiquat chloride dose		
G_1 (Control)	17.3	2.3
G_2 (MC@ 20g a.i./ha at 60 DAS)	21.6	2.3
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	25.6	2.1
SEm±	**1.2**	**0.2**
CD at 5%	**3.6**	**NS**

4.1.5 Plant population

Table 4.5 shows that plant population was not affected with different nitrogen levels and mepiquat chloride.

Table 4.5: Effect of different nitrogen levels and mepiquat chloride on plant population (no. of plants/ha) of *Bt* cotton hybrid

Treatments	Plant population at harvest
Nitrogen levels	
N_1 (100% RDN)	21543
N_2 (125% RDN)	20740
N_3 (150% RDN)	21049
SEm±	238
CD at 5%	**NS**
Mepiquat chloride	
G_1 (Control)	21049
G_2 (MC@ 20g a.i./ha at 60 DAS)	21234
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	21049
SEm±	238
CD at 5%	**NS**

4.2 Phenology studies

Number of days required to complete different four phenological stages *i.e.* squaring, 50% flowering, 50% boll opening and maturity was presented in table 4.6

Days to squaring was significantly earlier with 100% RDN compared to other two levels of nitrogen. While it not effected with mepiquat chloride.

The 50% flowering wassignificantly earlier with 150% RDNthan 100% RDN and 125% RDN, which were at par with each other. Spraying of mepiquat chloride twice at 60 and 75 DAS showed significantly earlier flowering than single spray which registered earlier 50% flowering as compared to control.

Days to 50% boll opening was significantly delayed with 150% RDN compared to other two levels of nitrogen. Spraying of mepiquat chloride twice at 60 and 75 DAS resulted in significantlylesser number days to 50% boll opening than single spray and control.

Number of days required to maturity under different levels of nitrogen and mepiquat chloride followed similar trend of days to flowering and days to 50% boll opening.

Table 4.6 Effect of different nitrogen levels and mepiquat chloride on phenological stages of *Bt* cotton hybrid

Treatments	Days to squaring	Days to 50% flowering	Days to 50% boll opening	Days to maturity
Nitrogen levels				
N_1 (100% RDN)	50	81	108	174
N_2 (125% RDN)	52	80	109	177
N_3 (150% RDN)	53	80	111	179
SEm±	**0.3**	**0.3**	**0.3**	**0.3**
CD at 5%	**1.0**	**0.9**	**1.0**	**1.0**
Mepiquat chloride				
G_1 (Control)	51	84	112	182
G_2 (MC@ 20g a.i./ha at 60 DAS)	52	80	109	176
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	51	77	106	171
SEm±	**0.3**	**0.3**	**0.3**	**0.3**
CD at 5%	**1.0**	**0.9**	**1.0**	**1.0**

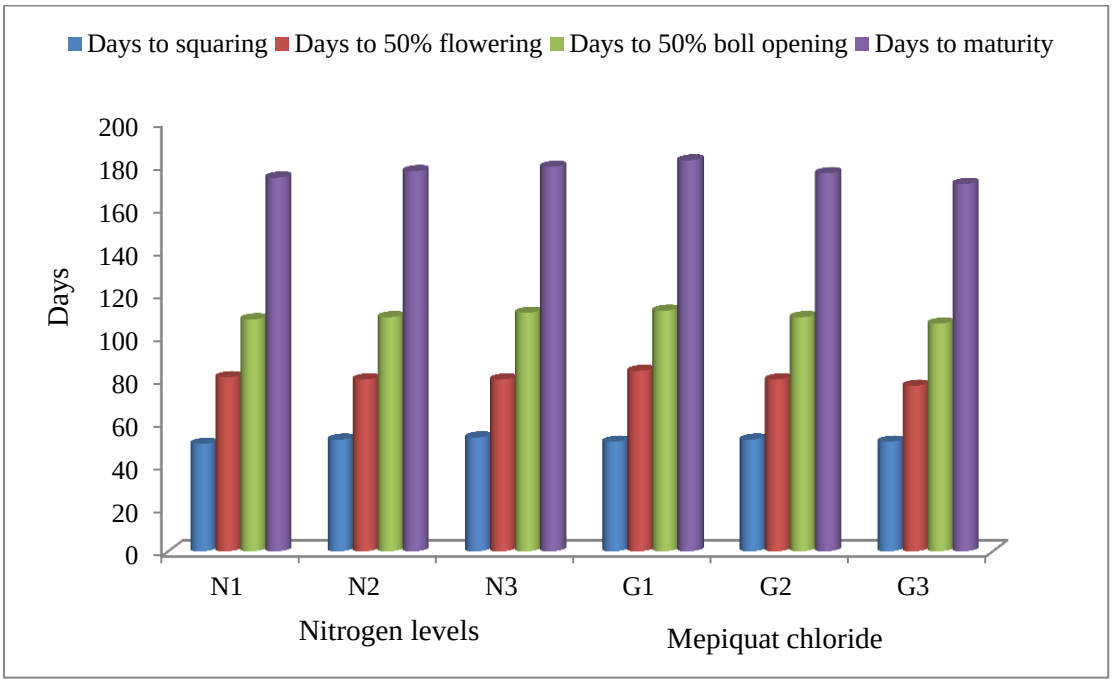

Fig-4.3 Effect of different nitrogen levels and mepiquat chloride on phenological stages of *Bt* cotton hybrid

4.3 Yield attributes and yield

Seed cotton yield, numbers of bolls/m^2 and boll weight were not affected with different levels of nitrogen. But seed index was significantlyhigher with 100% RDN compared to 125% and 150% RDN, which are at par with each other.

Significantly higher seed cotton yield was produced by twice spray of mepiquat chloride followed by single spray and control. The same trend was observed for seed index. Also number of bolls/m^2 was significantly higher with twice spray of mepiquat chloride than control, but at par with single spray. Boll weight was not affected with mepiquat chloride application.

Table-4.7 Effect of different nitrogen levels and mepiquat chloride on yield attributes and yield of *Bt* cotton hybrid

Treatment	Seed cotton Yield(kg/ha)	No of bolls/m^2	Boll wt(g)	Seed index (g)
Nitrogen levels				
N_1 (100% RDN)	3421	56	4.49	11.4
N_2 (125% RDN)	3440	57	4.51	10.38
N_3 (150% RDN)	3450	57	4.63	10.42
SEm±	**25**	3	**0.1**	**0.04**
CD at 5%	**NS**	NS	**NS**	**0.11**
Mepiquat chloride				
G_1 (Control)	3338	50.9	4.52	9.4
G_2 (MC@ 20g a.i./ha at 60 DAS)	3442	58.6	4.61	11
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	3531	61.1	4.5	11.8
SEm±	**25**	**3**	**0.1**	**0.04**
CD at 5%	**75.57**	**7.8**	**NS**	**0.11**

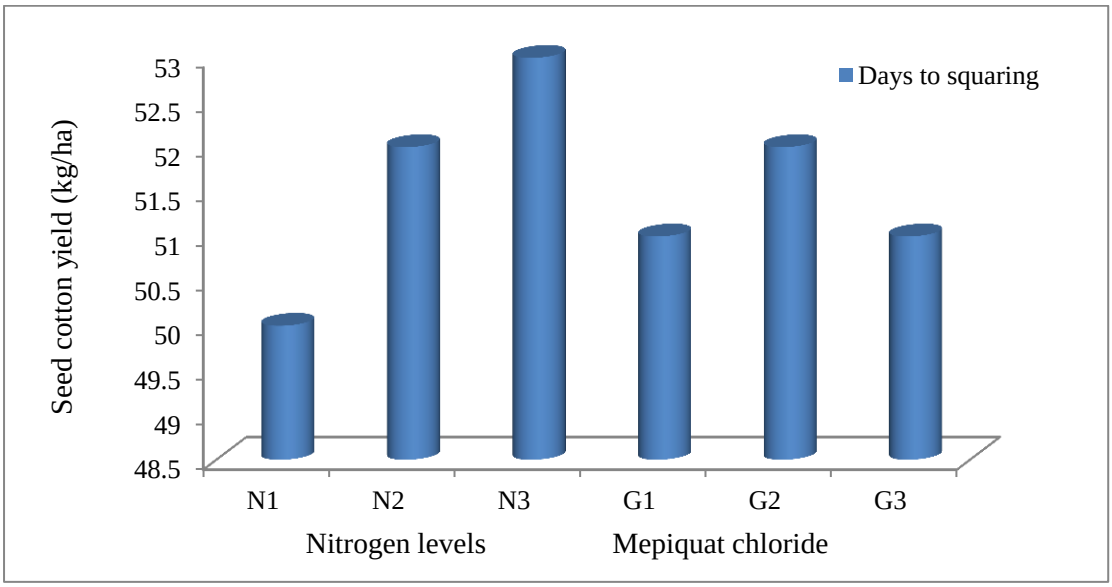

Fig 4.4 Effect of different nitrogen levels and mepiquat chloride on Seed cotton yield (kg/ha)

4.4 Quality parameters

Ginning out turn was not affected with different levels of nitrogen. But mepiquat chloride significantly reduced the ginning out turn. Significantly higher ginning out turn was recorded in control compared to other two treatments of mepiquat chloride. While ginning out turn was at par with twice and single application of mepiquat chloride.

Span length significantly differed with different levels of nitrogen and mepiquat chloride. Application of 100% RDNresulted in significantly higher span length followed by 150% and 125% RDN. Span length was significantly higher in control and with single application of mepiquat chloride as compared to twice spray.

Micronaire value was significantly influenced by different levels of nitrogen and mepiquat chloride. Significantly higher value of micronaire was observed with 125% RDN followed by 150% and 100% RDN. With mepiquat chloride, significantly higher value of micronaire was recorded in control followed by twice spray of mepiquat chloride and single spray.

Table-4.8 Effect of different nitrogen levels and mepiquat chloride on quality parameters of *Bt* cotton hybrid

Treatments	**Ginning out turn (%)**	**Span length (mm)**	**Micronaire value (10^{-6}g/inch)**
Nitrogen levels			
N_1 (100% RDN)	34.0	28.8	4.3
N_2 (125% RDN)	34.8	28.5	4.4
N_3 (150% RDN)	34.2	28.6	4.4
SEm±	0.7	0.03	0.01
CD at 5%	NS	0.08	0.05
Mepiquat chloride			
G_1 (Control)	36.2	28.7	4.5
G_2 (MC@ 20g a.i./ha at 60 DAS)	33.7	28.7	4.2
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	33.1	28.5	4.4
SEm±	0.7	0.03	0.01
CD at 5%	1.8	0.08	0.05

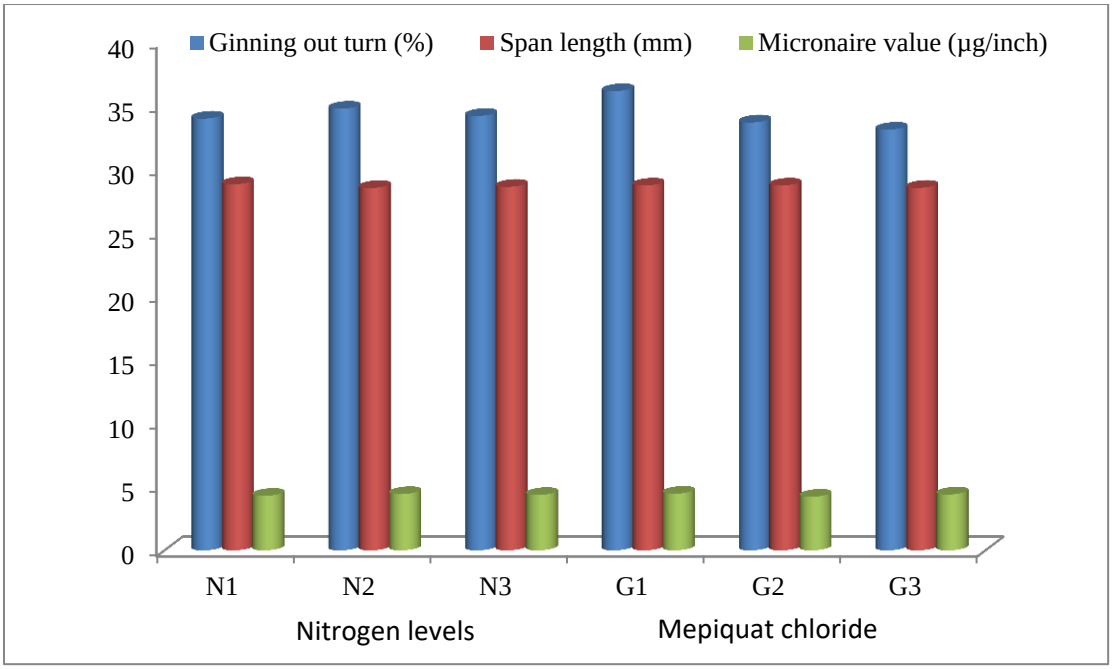

Fig- 4.5 Effect of different nitrogen levels and mepiquat chloride on quality parameters of *Bt* cotton hybrid

4.5 Nutrient status

Nutrient status of soil was not affected due to different levels of nitrogen and mepiquat chloride (Table 4.9).

N uptake was significantly affected with different levels of nitrogen. Highest uptake was with 150% RDN, which was significantly higher than lower levels. With mepiquat chloride, maximum N uptake was in control, which was significantly higher than twice and single spray of mepiquat chloride.

There was no difference observed in P uptake due to different levels of nitrogen. But with mepiquat chloride significant variation was observed. Significantly higher P uptake was recorded in control as compared to other two treatments of mepiquat chloride (Table 4.10).

For K uptake, significant differencewere observed between different levels of nitrogen and mepiquat chloride. Uptake of K with 150% RDN was significantly higher than lower two levels of nitrogen. Uptake with 100% and 125% RDN at par with each other. Significantly higher uptake of K was recorded in control as compared to foliar application of mepiquat chloride once or twice(Table 4.10)

Table- 4.9 Effect of different nitrogen levels and mepiquat chloride on N P K (kg/ha) status in soil after crop harvest

Treatment	After harvest		
	N	P	K
Nitrogen levels			
N_1 (100% RDN)	122	11.5	267
N_2 (125% RDN)	121	11.3	272
N_3 (150% RDN)	120	11.3	270
SEm±	0.6	0.5	2.8
CD at 5%	NS	NS	NS
Mepiquat chloride dose			
G_1 (Control)	121	11	271
G_2 (MC@ 20g a.i./ha at 60 DAS)	122	12	266
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	121	11	273
SEm±	0.6	0.5	2.8
CD at 5%	NS	NS	NS
Initial soil status	125	13	280

Table- 4.10 Effect of different nitrogen levels and mepiquat chloride on N P K (kg/ha) uptake of *Bt* cotton hybrid

Treatments	N	P	K
Nitrogen levels			
N_1 (100% RDN)	263	116	317
N_2 (125% RDN)	293	115	330
N_3 (150% RDN)	341	136	407
SEm±	12.3	6.4	17.5
CD at 5%	37.2	NS	52.8
Mepiquat chloride			
G_1 (Control)	477	213	609
G_2 (MC@ 20g a.i./ha at 60 DAS)	227	85	247
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	194	70	197
SEm±	12.3	6.4	17.5
CD at 5%	37.2	19.5	52.8

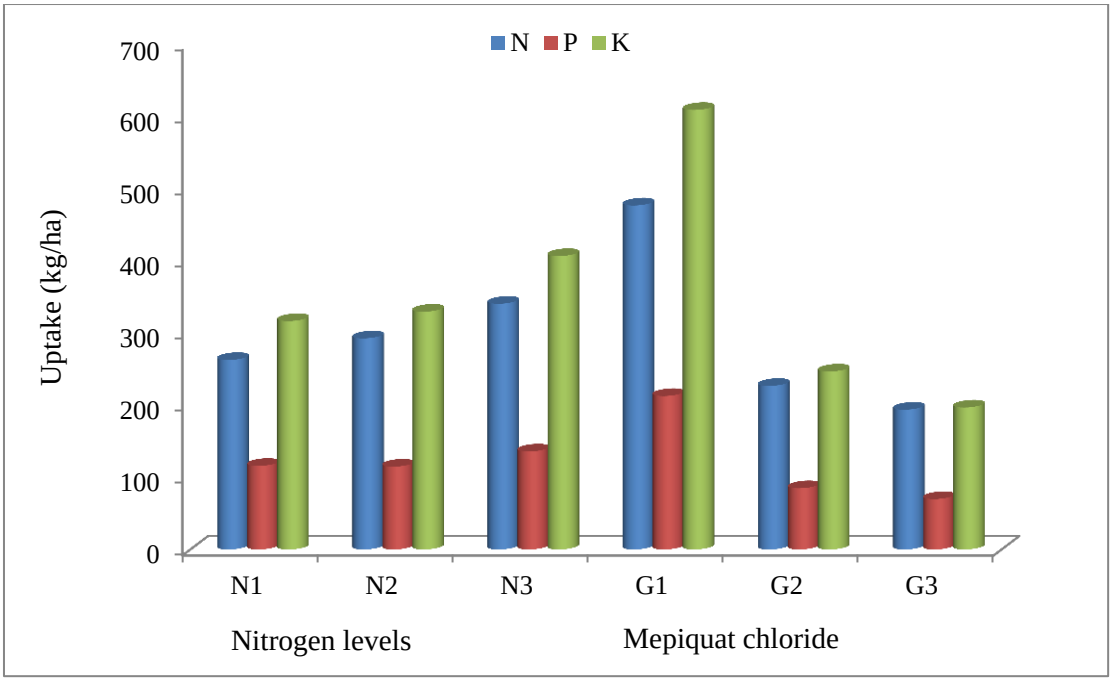

Fig- 4.6 Effect of different nitrogen levels and mepiquat chloride on N P K (kg/ha) uptake of *Bt* cotton hybrid

4.6 Economics

Crop planted with 150% RDNincurred more cost of cultivation than 100% and 125% RDN. But gross return was also higher with 150% RDN because of high seed cotton yield compared to other levels. The B:C was higher with 150% RDN.

Among the mepiquat chloride application higher cost of cultivation and gross return were observed with twice spray of mepiquat chloride followed by single spray and control. SimilarlyB:C was high in twice spray compared to control.

Table- 4.11 Effect of different nitrogen levels and mepiquat chloride dose on economics of *Bt* cotton hybrid

Treatments	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C
Nitrogen levels				
N_1 (100% RDN)	79108	144318	65210	1.8
N_2 (125% RDN)	88475	190320	101845	2.1
N_3 (150% RDN)	91217	199850	108663	2.2
Mepiquat chloride				
G_1 (Control)	88538	166902	88364	1.8
G_2 (MC@ 20g a.i./ha at 60 DAS)	89964	182437	92473	2.1
G_3 (MC@ 20g a.i./ha at 60 and 75 DAS)	91298	187138	95850	2.1

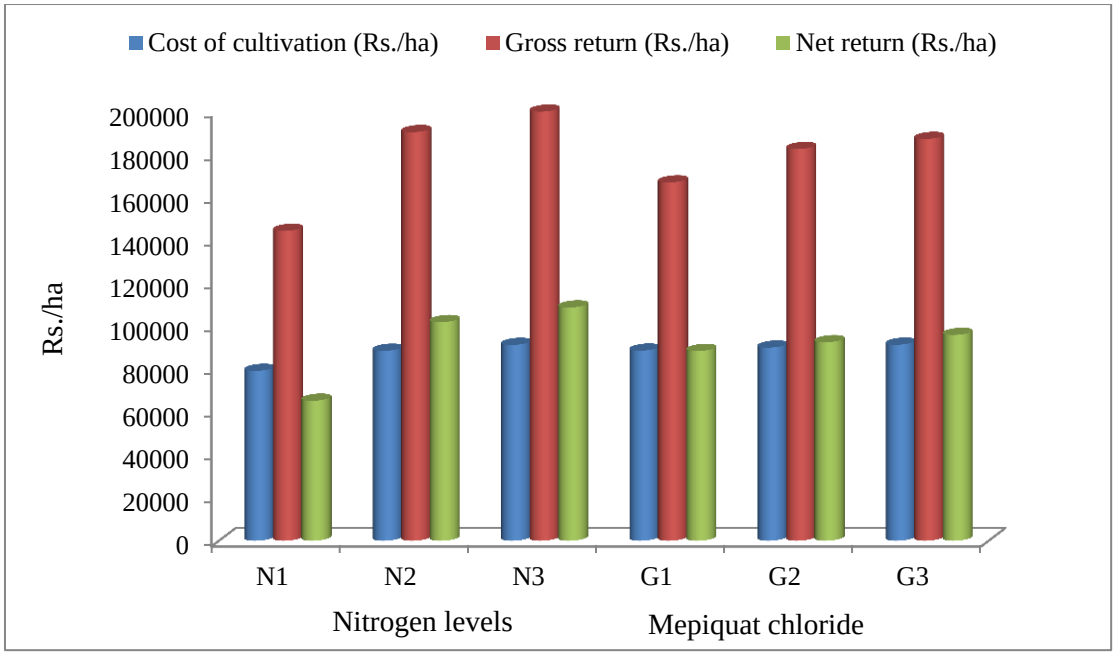

Fig-- 4.7 Effect of different nitrogen levels and mepiquat chloride on economics of *Bt* cotton hybrid

CHAPTER-V

DISCUSSION

The result of study conducted on "Growth behaviour of *Bt* (*Bacillus thuringiensis*) cotton as influenced by mepiquat chloride under varying nitrogen levels" presented in previous chapter are discussed with available literature and interpreted in this chapter in light of scientific evidences to establish cause and effect relationship.

5.1 Growth studies

Plant height was not affected with different levels of nitrogen except at 45 DAS (table 4.1). Mepiquat chloride significantly influenced the plant height from 75 DASupto maturity. The plant height significantly reduced with mepiquat chloride and it might be due to the interference of this chemical as growth regulator in gibberellic acid biosynthetic pathway. The reduced amount of gibberellins in the plant system affects the growth and decreases plant height. The present results corroborate with the findings of Reddy *et al*. (1992) and Brar *et al*. (2000).

At 45 and 75 DAS no difference in dry matter was observed with different levels of nitrogen (table 4.2). But at 105, 135 DAS and at maturity significantly higher dry matter were recorded with 150% RDN than 125%, 100% RDN of nitrogen level. Total dry matter production per plant depends on accumulation of dry matter in different plant parts *viz.*, leaf, stem and reproductive parts. Beneficial effects of nitrogen on cell division and elongation, formation of nucleotides and co-enzymes resulted in increased meristematic activity and photosynthetic area and hence more production and accumulation of photosynthates, which reflected in higher dry matter production. This study was supported by Reddy and Reddy (2012). The total dry matter produced at 75 DAS upto harvest was significantly higher with control, when compared with single spray of mepiquat chloride at 60 DAS and two sprays at 60 and 75 DAS respectively. At 45 DAS, no such differences were noticed because mepiquat chloride was sprayed at 60 DAS or at 60 and 75 DAS. During early growth stage mainly leaves contribute maximum to dry matter but at latter stages, contribution of stem and reproductive part is maximum. Meredith and Wells (1989) also showed the same results.

Higher number of sympodia and monopodia per plant were recorded with 150% RDN (table 4.4). This might be due to higher dry matter accumulation, leaf area index and better canopy development with 150% RDN than lower nitrogen levels. Manjunatha *et al.* (2017) observed similar result in his experiment. Spraying of mepiquat chloride twice at 60 and 75 DAS resulted in higher number of sympodia per plant (25.57/plant) followed by single spray (21.66/plant) compared to control (17.35/plant). Number of sympodia per plant is very important morphological character because it is directly related to the yield of crop. Mepiquat

chloride application provided seat for more number of nodes and internodes where sympodial branches emerged resulting in greater number of sympodia. The experiment of Pothiraj *et al*. (1995) gave similar results.The monopodia per plant did not vary due to different doses of mepiquat chloride (Table 4.4). Desilva (1971) and Brar *et al*. (2000) also observed no variation in monopodia per plant due to growth regulator.

5.2 Phenological studies

There were significant differencesin phenological growth observed with different levels of nitrogen. Higher dose of nitrogen *i.e* 150% RDN significantly delayed the duration of each phenological stage compared to 100% RDF. It might be due to more vegetative growth which delays the maturity *i.e.,* it has taken more number of days to reach boll development stage at higher levels of nitrogen application. Similar results were reported by Dong *et al.,* (2012) and Munir *et al.,* (2015).

Earliness in phenological stages was significantly enhanced by mepiquat chloride application. Increased earliness may be related to mepiquat chloride effect on biomass partitioning (inhibiting growth of branches and stems, expanding leaves, and extending stem internodes and petioles), which led to the development of a more compact canopy structure, this provided an improved microclimate, especially better light conditions, that resulted in earlier maturity. Similar findings were recorded by Oosterhuis *et al*., (2000).

5.3 Yield attributes and yield

Number of bolls/m^2 was higher at 150% and 125% RDN than 100% RDN. This might be due to prevention of abscission of squares and bolls. This study agrees with those obtained by Ali and El-Sayed (2001).

Number of bolls/m^2 were significantly higher with spraying mepiquat chloride twice at 60 and 75 DAS compared to control. These was due to reduction in the abscission of buds and bolls. Mepiquat chloride completely counteracts the effect of abscisic acid and thus reduced the shedding of reproductive structures over control. Similar results were observed by Joseph and Johnson (2006).

Higher boll weight were recorded with 150% and 125% RDN over 100% RDN. It might be due to the fact that increased nitrogen fertilizer rate increased leaf photosynthetic rate which might have resulted higher accumulation of metabolites and impacted on boll weight. Similar findings were recorded by Sawan *et al.* (2006).

There was no difference observed in weight of boll due to mepiquat chloride application. Higher seed cotton yield (3450 kg/ha) was obtained with application of nitrogen at 150% RDN. 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 increased number of bolls per plant, dry matter accumulation per plant and its subsequent translocation towards sink.

Seed cotton yield was significantly higher (3531kg/ha) with two sprays of mepiquat chloride at 60and 75 DAS when compared to single spray 60 DAS (3442 kg/ha) and control (3338 kg/ha). Theseed cotton yield depends on the accumulation and partitioning of photo assimilates in reproductive parts of the plant. Higher seed cotton yield might be due to relatively higher number of sympodia per plant, better partitioning of photo assimilates towards reproductive structures. Norton *et al.* (2005) and Zakaria *et al.* (2006) reported the similar effect of growth regulators in increasing the seed yield of cotton.

Application of mepiquat chloride significantly increased seed index compared with the control. It has been reported that bolls on cotton treated with mepiquat chloride have larger photosynthetically supplied sinks for carbohydrates and other metabolites than untreated bolls . Similar results were obtained by Hayes *et al*. (1995).

5.4 Quality parameters

Span length was reduced with higher levels of nitrogen but it too small to affect the quality of fiber. This study was supported by Hussain *et al*. (2000). Span length not affected with mepiquat chloride, but two sprays of mepiquat chloride application decreased span length. Similar pattern in span length was recorded by Mekki (1999).

Ginning out turn was notaffected with increasing application rate of N from 100% to 150% RDN. This study was supported by Hussain *et al*. (2000). Ginning out turn decreased with mepiquat chloride application. It might be due to high seed cotton yield with mepiquat chloride. Mekki (1999) observed the same effect of mepiquat chloride on ginning out turn.

Maximum micronaire value recorded with 125% RDN which was close to 150% RDN. This showed that excess application of N can reduce fiber quality. Twice application of mepiquat chloride gave almost similar micronaire value to control. Very low effect of mepiquat chloride on micronaire value was observed. This study was supported by Karthikeyan and Jayakumar (2001).

5.5 Nutrient status

There was no significant difference observed in N P K status in soil due to different nitrogen levels and mepiquat chloride application.

Among nitrogen levels, significantly higher N P K uptake was found with application of nitrogen at 150% RDNover 125% RDN and 100%RDN. The increased uptake of nutrient might be due to more nitrogen availability in the soil as higher levels of application increased plant height, boll number, boll weight anddry matter production. Similar findings were recorded by Modhvadia *et al.*(2012).Higher uptake of N P K was recorded with control compared to spraying of mepiquat chloride. It might be due to more vegetative and plant height growth, which enhanced the requirement of nutrient.

5.6 Economics

Highest gross and net returns were recorded with 150% RDF level of nitrogen followed by 125% RDN and 100% RDN. It was mainly due to higher seed cotton yield. Higher returns due to increased yield levels at higher application of nitrogen was reported by Hallikeri (2008).

Among spraying of mepiquat chloride, higher gross returns and net returns were recorded with two sprays of mepiquat chloride (Rs. 1,87,138/ha and 95,850/ha respectively) followed by single spray (Rs 1,82,457/ha and Rs 92,473/ha respectively) and control (Rs 1,66,902/ha and Rs 88,364/ha respectively). This was mainly because of higher seed cotton yield with growth regulator application. The B:C was also greater with growth regulator compared to control.

CHAPTER-VI

SUMMARY AND CONCLUSIONS

Present investigation entitled, "Growth behaviour of *Bt* cotton as influenced by mepiquat chloride under varying nitrogen levels" was conducted at Cotton Research area of CCS HAU, Hisar, during *kharif* season of 2018.Soil tested low in available nitrogen and medium in available phosphorus and potassium. The experiment was laid out in factorial randomized block design with three levels of nitrogen (100%, 125% and 150% RDN) and three levels of mepiquat chloride spray (control, single spray at 60 DAS and two spray at 60, 75 DAS). Total nine treatment combinations were tested in three replications. All recommended cultural practices and plant protection measures were followed throughout the crop season. The findings of the present investigation are summarized below.

6.1 Effect of nitrogen levels

6.1.1 Plant height gradually increased from 45 DAS to harvest. Higher plant height was recorded with 150% RDN, which was at par with other two levels.

6.1.2 Initially at 45 and 75 DAS different nitrogen levels did not affect the dry matter accumulation, but from 105 DAS onwards significantly higher dry matter accumulation was recorded with 150% RDN compared to 100% and 125% RDN.

6.1.3 Leaf area index increased from 45 DAS to 135 DAS and decreased at harvest. Except at 45 DAS, significantly higherleaf area index was recorded with 150% RDN compared to lower two levels.

6.1.4 Numbers of sympodial and monopodial branches per plant and also the plant population at harvest were not influenced with different levels of nitrogen.

6.1.5 Duration for different phenological stages *i.e* days to squaring, 50% flowering, 50% boll opening and for maturity as compared to higher levels was significantly reduced with 100% RDN.

6.1.6 Seed cotton yield and boll weight were not affected with different levels of nitrogen. But weight of 100 seed was significantly higher with 100% RDF.

6.1.7 Among the different quality parameters significantly longest fiber length was recorded with 100% RDN, while the micronaire value was high with 125% RDN.

6.1.8 There was no effect of different nitrogen levels on nutrient status of soil, while maximum uptake of NPK was obtained with 150% RDN.

6.1.9 150% RDNresulted in the maximum gross return with highest B:C ratio.

6.2 Effect of mepiquat chloride

6.2.1 Plant height was significantly reduced with mepiquat chloride spray as compared to control, at all growth stages except at 45 DAS.

6.2.2 Two sprays of mepiquat chloride significantly reduced the dry matter accumulation compared to single spray and control at 105 and 135 DAS and at maturity.

6.2.3 Leaf area index was significantly higher in control as compare to mepiquat chloride treatment for all growth stages except at 45 DAS.

6.2.4 Sympodia per plant was significantly higher with two sprays of mepiquat chloride followed by single spray over control. But monopodia per plant was not affected with mepiquat chloride.

6.2.5 Plant population was not affected with mepiquat chloride treatment.

6.2.6 All the phenological stages were except days to squaring completed significantly earlier with two sprays of mepiquat chloride as compared to single spray and control.

6.2.7 Two sprays of mepiquat chloride at 60 and 75 DAS retained maximum number of bolls, which significantly enhanced the seed cotton yield as compared to single spray and control.

6.2.8 Boll weight was not affected with mepiquat chloride spray, but weight of 100 seeds was significantly higher with two sprays of mepiquat chloride over single spray and control.

6.2.9 Ginning out turn and span length were significantly higher in control as compared to foliar application of mepiquat chloride.

6.2.10 Nutrient status of soil after crop harvest was not affected with mepiquat chloride, but NPK uptake by plant was significantly higher in control plot as compared to mepiquat chloride treated plot.

6.2.11 Maximum gross return and B:C was recorded with two sprays of mepiquat chloride.

CONCLUSIONS

Seed cotton yield with 150% RDN (3450 kg/ha) was at par with 100% RDN (3421 kg/ha). Higher seed cotton yield and income can be obtained with recommended dose of nitrogen along with application of mepiquat chloride twice at 60 and 75 DAS.

Two sprays of mepiquat chloride (20g *a.i.*/ha) at 60 and 75 DAS gave higher seed cotton yield (3531kg/ha) and income (both gross and net).

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ABSTRACT

Title of Thesis	:	**Growth behaviour of *Bt* (*Bacillus thuringiensis*)cotton as influenced by mepiquat chloride under varying nitrogen levels**
Name of Degree holder	:	Sadhana Kumari
Admission number	:	2017A11M
Title of Degree	:	Master of Science in Agronomy
Name of Major Advisor	:	**Dr. S. K. Thakral** Professor, Department of Agronomy CCS Haryana Agricultural University, Hisar-125004
Degree awarding University	:	Chaudhary Charan Singh Haryana Agricultural University, Hisar -125004, Haryana
Year of award of Degree	:	2019
Major Subject	:	Agronomy
Total number of pages in Thesis	:	36+v
Number of words in Abstract	:	270

Key words: Cotton, Mepiquat chloride, Nitrogen, Yield, Economics

The field experiment was conducted at Cotton Research area of CCS Haryana Agricultural University, Hisar, during *kharif* 2018. The experiment comprisedof three levels of nitrogen (100%, 125% and 150% RDN) and three spray of mepiquat chloride (control, single spray at 60 DAS and two sprays at 60 and 75 DAS) was conducted in factorial randomized complete block design with three replication. Results reveal that plant height was statistically higher with 150% RDN at 45 DAS, while with mepiquat chloride spray it was significantly higher in control from 75 DAS uptoharvest. Initially dry matter accumulation and LAT were affected with different levels of nitrogen but after 105 days of sowing it was significantly higher with 150% RDN. Significantly higher dry matter accumulation and LAI were recorded in control over mepiquat chloride spray. Number of sympodia and monopodia per plant and plant population was not affected with different levels of nitrogen and mepiquat chloride. Different phenological stages were delayed by 3 to 4 days with application of 150% RDN, while twice spray of mepiquat chloride resulted in 6 to 7 days earlier completion of these stages. Seed cotton yield, number of bolls per m^2 and boll weight were not affected with different levels of nitrogen but two sprays of mepiquat chloride @ 20 g/ha at 60 and 75 DAS enhanced these parameters. Ginning out turn was statistically at par with different levels of nitrogen. 100% RDN has shown maximum span length with lowest micronaire value. While all the quality parameters was significantly higher in control over the spray of mepiquat chloride. Total uptake of primary nutrients (except phosphorus) differ significantly with treatments.

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I hereby, declare that all the information provided in the resume is true to the best of my knowledge.

(SADHANA KUMARI)

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I also undertake that, patent, if any arising out of the research work conducted during the programme shall be filed by me only with due permission of the competent authority of CCS HAU, Hisar.

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