INTEGRATED NITROGEN MANAGEMENT IN Bt. COTTON (*Gossypium hirsutum* L.)

A
THESIS
SUBMITTED TO THE
SARDARKRUSHINAGAR DANTIWADA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE

OF

MASTER OF SCIENCE
(Agriculture)

IN

AGRONOMY

BY

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OCTOBER–2014

[Reg. No. 04-AGRMA-01041-2012]

ABSTRACT

INTEGRATED NITROGEN MANAGEMENT IN Bt. COTTON (*Gossypium hirsutum* L.)

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ABSTRACT

A field experiment was conducted during *kharif* 2013-14 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the, "Integrated nitrogen management in Bt. Cotton (*Gossypium hirsutum* L.). The soil of the experimental field was loamy sand in texture, low in organic carbon (0.21%) and available nitrogen (158 kg/ha), medium in available phosphorus (39.29 kg/ha) and high in available potash (294 kg/ha) with 7.8 soil pH.

The experiment was laid out in randomized block design (RBD) with three replications. There were twelve treatments comprising of application of nutrients through different sources in combination *viz*., T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer, T_2: 125% RDN through

inorganic fertilizer, T_3: 100% RDN through inorganic fertilizer + 25 kg $MgSO_4$/ha, T_4: 25% RDN through inorganic fertilizer + 75% RDN through castor cake, T_5: 50% RDN through inorganic fertilizer + 50% RDN through castor cake, T_6: 75% RDN through inorganic fertilizer + 25% RDN through castor cake, T_7: 25% RDN through inorganic fertilizer + 75% RDN through castor cake + *Azotobacter,* T_8: 50% RDN through inorganic fertilizer+ 50% RDN through castor cake + *Azotobacter,* T_9: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter,* T_{10}: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB, T_{11}: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha and T_{12}: 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}). The crop was sown keeping 120 cm inter and 60 cm intra row spacing.

The results of the experiment revealed that application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) appreciably recorded significantly higher plant height at different intervals, number of monopodial and sympodial branches per plant over remaining treatments.

Integration of inorganic fertilizer, organic manures and biofertilizers i.e. application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) remarkably produced significantly higher number of bolls per plant at different interval, weight of seeds per boll (g), 100 seeds weight (g), weight of seed cotton per boll (g) and seed cotton yield per plant (g) over other treatments. Significantly higher seed cotton and stalk yields (kg/ha) were recorded under application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}).

Among the different integrated nitrogen management practices, an application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded significantly higher oil yield (652 kg/ha) and total nitrogen uptake (143.6 kg/ha) by stalk and cotton seed. While, number of seeds per boll, harvest index, oil content of cotton seed, lint index, ginning percentage, mean fibre length and nitrogen content in cotton were not significantly influenced by different integrated nitrogen management treatments.

From the economic point of view, maximum net return (₹111707/ha) and benefit cost ratio (3.25) were received with application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}).

Based on the results obtained from the present study, it is concluded that *kharif* Bt. Cotton may be fertilized with 75% recommended dose of N (180 kg/ha) through inorganic fertilizer + 25% RDN (60 kg/ha) through castor cake along with seed inoculation with *Azotobacter* and PSB for securing higher profitable seed cotton yield grown on loamy sand soil of North Gujarat.

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ACKNOWLEDGEMENT

This memorable occasion provides me an unique privilege to express my deep sense of gratitude and indebtedness to my honorable Major Advisor ***Dr. D. M. Patel****, Associate Professor, Department of Agronomy, C.P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar for his invaluable guidance and constant encouragement with constructive suggestions throughout the course of this investigation as well as the preparation of this manuscript.*

My grateful thanks go to the members of my advisory committee ***Dr. B. B. Patel****, Professor, Department of Agricultural Chemistry & Soil Science,* ***Dr. B. S. Patel****, Research Scientist, AICRP on IFS,* ***Dr. J. K. Patel****, Professor and Head, Department of Computer Science.*

I am highly appreciative to ***Dr. M. R. Prajapati*** *Principal, C. P. College of Agriculture, and Sardarkrushinagar for their encouragement and providing necessary facilities.*

I gratified to ***Dr. J. C. Patel****, Professor and Head, Department of Agronomy, C. P. College of Agriculture, SDAU, Sardarkrushinagar, for enormous help and constructive criticism throughout my academic career.*

I heartly express my special thanks to ***Dr. B. J. Patel, Dr. G. N. Patel, Shri. M.G. Chaudhary, Dr. B. M. Patel*** *and all the staff members of Department of Agronomy, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, for their valuable help and co-operation during the course of my study.*

I am happy to extend my gratitude and sincere thanks to ***Shri A. M. Mali*** *for his ever willing co-operation, encouragement and care.*

The limited world of words hampers me to express the feeling of my indebtedness towards my friends whose love and affection always makes me feel at home here in the S. D. Agricultural University. I would like to thank my seniors ***Kunjal, Jinkal, Hitesh*** *and* ***Manthan*** *for their direct and indirect help to assist me to reach this pinnacle.*

It is my pleasant duty to acknowledge most gratefully invaluable and unbelievable help received with joyful company from my friends gallery ***Niral, Tushar, Pratik, Mohan, Raju, Hardik, Nitin, Jay, Vipul, Mukesh, Nimesh, Thakkr, Dhamo, Narsih, Jetshi, Dhaval,*** *during the course of this study.*

It is my pleasant duty to acknowledge most gratefully invaluable and unbelievable help received with joyful company from my juniors ***Ankur, Smit, Adil, Jago, Sanjay*** *and* *thanks to my all friends, who have inspired me in all respects during this study and I remain indebted forever to them.*

At this inexplicable moment of joy, words are inadequate in the available lexicon to express my gratitude and respect towards my family who took pains to bring me up to this stage, without their love, sacrifice, extra-ordinary patience, inspiration and blessings this work would not have taken final shape. My heart takes breath when I realize the painstaking efforts taken up by my "Family Members" for making me post graduate of the noble profession. Words are just not sufficient to express my feeling for their love, blessing, affection and encouragement given to me by my parents ***Shri. Govindbhai*** *and* ***Smt. Bhagavatiben*** *and I solemnized to dedicate this thesis to them and vis-à-vis offers this as a humble tribute to science. my heartly lovable brother* ***Umang****.*

I special thanks to my beloved fiancee ***Miranki*** *who is deeply sited in my heart and always encourage every time.*

Having expressed these thoughts, I am at once aware that such an acknowledgement in no way projects the depth or extent my gratitude to the few mentioned and whole of unmentioned help extenders. To all who deserves such thanks, I apologize for the omission and the inadequacy of these written words.

Last but far from the least, I bow my head in extreme regards to the almighty "JAY GOGA", "MAA UMIYA" and "JAI RANGILA HANUMAN" whose blessings enabled me to reach this destination.

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ABBREVIATIONS USED

&	:	And
@	:	At the rate of
+	:	Plus
%	:	Per cent
ANOVA	:	Analysis of Variance
BCR	:	Benefit Cost Ratio
BG	:	Boll Gaurd
^{0}C	:	Degree Celsius
CAB	:	Cotton Advisory Board
C.D.	:	Critical Difference
CIRCOT	:	Central Institute for Research on Cotton Technology
cm	:	Centimeter
C.V.	:	Coefficient of variance
DAP	:	Diammonium Phosphate
DAS	:	Days after sowing
d. f.	:	Degrees of freedom
dSm^{-1}	:	DeciSimens per meter
EC	:	Electrical Conductivity
et al.	:	*et allii* ; and others
etc.	:	Etcetera

$FeSO_4$	:	Ferrus Sulphate
Fig.	:	Figure
FYM	:	Farm Yard Manure
g	:	Gram
G.Cot.Hy.6	:	Gujarat Cotton Hybrid 6
GDP	:	Gross Domestic Productivity
GP	:	Ginning percentage
hr.	:	Hour
INM	:	Integrated Nitrogen Management
i.e.	:	That is
K_2O	:	Potash
K	:	Potassium
kg ha^{-1}	:	Kilogram per hectare
Lit.	:	Litre
m	:	Metre
mm	:	Millimeter
$MgSO_4$	:	Magnesium Sulphate
M.S.S.	:	Mean Sum of Square
Max	:	Maximum
Min	:	Minimum
NMR	:	Nuclear Magnetic Resonance
N_20	:	Nitrogen
No.	:	Number

NS	:	Non significant
PB	:	Pair of bullock
P_2O_5	:	Phosphorous
PSB	:	Phosphorus Solubilizing Bacteria
pH	:	Pucciness de Hydrogen
ppm	:	Parts per million
q	:	Quintal
RDF	:	Recommonded Dose of Fertilizer
RDN	:	Recommonded Dose of Nitrogen
RH	:	Relative Humidity
₹	:	Rupees
ha	:	Hectare
S.Em.	:	Standard Error of mean
Viz.,	:	Namely
RBD	:	Randomized Block Design

INTRODUCTION

I. INTRODUCTION

Cotton known as "King of the Fibre" is one of the most ancient and major cash crops next to food grains in India and plays a vital role in Indian economy. In addition, as an industrial crop, it supports millions of people directly or indirectly by providing huge employment through cultivation, processing and trade. Cotton remains incomparable to the other fibre crops as far as fibre quality is concerned. Due to this significant importance cotton is also known as "White Gold". Cotton industry in India is the largest organized and broad-based industry which accounts for about 4.0 per cent of GDP, 14.0 per cent of manufacturing value added and 13.5 per cent to total export earnings.

Bt. cotton (*Gossypium hirsutum* L.) is a genetically modified cotton seeds which contain the Bt. toxin. Bt. cotton was first planted in India in 2002 and following its success, the area under this crop and the number of farmers who adopted this technology increased significantly from year to year. Bt. cotton hybrids targeting at cotton bollworm substantially brought down the cost of cultivation and has been a boon as the technology is eco-friendly and acceptable to farmers.

Bt. cotton is grown in almost all the tropical and sub tropical countries like India, USA, Mexico, Iran, Egypt, Pakistan, Turkey, Brazil, Sudan, Uganda and China across the world out of which United States, China and India contribute 80.00 per cent of total production in the world. India ranks first in area (34%) and second in production (21%) of cotton in the world. Gujarat, Maharashtra, Haryana, Punjab, Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu are the major cotton growing states which contribute about 90.00 per cent of the national cotton production. Based on Bt. cotton cultivation, India is divided into three major zones *viz.,* North zone (Punjab, Haryana and Rajasthan), Central zone (Madhya Pradesh, Maharashtra and Gujarat) and South zone (Andhra Pradesh, Karnataka and Tamil Nadu). These zones differ from each other in soil type, topography, irrigation facility and specific cultural operations.

In India, cotton is planted in about 115.53 lakh hectares of land and it occupies second position in production with 375 lakh bales (each of 170 kg) among all cotton producing countries in the world *i.e.,* next to China (CCI, 2013-14). Average productivity of cotton in India is 552 kg/ha which is low as compared to world average of 733 kg/ha (CCI, 2013-14). Gujarat is the second largest cotton growing state with an area of 26.91 lakh hectares with production of 116 lakh bales. The average productivity of cotton in Gujarat is 733 kg/ha which is higher than the national average (CCI, 2013-14). Looking to the world average productivity of this crop, there is huge scope to increase productivity of cotton per unit area in Gujarat by adopting improved agro techniques. The major cotton growing districts in Gujarat are Surendranagar, Baroda, Bharuch, Ahmedabad and Sabarkantha.

Nitrogen is one of the most important determinant of plant growth and crop yield. Fertility analysis of Indian soils indicated that the soils are deficient in nitrogen (Patel, 2007). Plants lacking in N show stunted growth and yellowish leaves. It is an essential component of the proteins that build cell material and plant tissue. In addition, it is necessary for the function of other essential biochemical agents, including chlorophyll, many enzymes (which help organisms to carry out biochemical processes and assimilate nutrients) and nucleic acids such as DNA, RNA (which are involved in reproduction).

Nitrogen is major plant nutrient which controls new growth, nutrient uptake and prevents abscission of squares and bolls. Application of nitrogen increases monopodial and sympodial branches per plant, plant height, harvested bolls per plant and seed cotton yield. High nitrogen availability may shift the balance between vegetative and reproductive growth toward excessive vegetative development, thus delaying crop maturity and reducing lint yield (Howard *et al*., 2001). It improves the quality of lint *viz.,* ginning per cent, lint index, fibre length, bundle strength and fibre fineness. Hence, judicious use of nitrogen is a key for higher and better quality production.

But on other hand, due to continuous use of high dose of inorganic fertilizers, adoption of intensive cropping and lesser use of organic manures, the soil health is being deteriorated day by day which decline ultimately the soil productivity. Therefore, it is an urgent and prime need to add adequate amount of organic manure in the soil which can maintain the soil health. It supplies primary, secondary and micro nutrients to plants and supply organic matter to the soil also improves biological and physical properties of the soil.

(4) intro

The use of oil cakes as manure is well known in India. Oil cakes are quick acting concentrated organic manure and their effect can be observed within a week or 10 days after application. Castor cake contains 4.5% N, 1.8% P_2O_5 and 1.3% K_2O. Castor cake is excellent organic manure due to availability of nitrogen and phosphorus to the plant during early crop growth period. Beside this, it protects the crop from termites and soil borne diseases.

The major attraction of using biofertilizers in integrated nutrient management system is to convert the unavailable nutrient to available form which is readily available and easily accessible by the plants. Biofertilizers improves soil physical properties and sustain soil fertility by providing nutrients in available forms. It also enhances plant growth due to release of hormones, vitamins and auxins.

Azotobacter is non-symbiotic aerobic free living nitrogen fixing soil bacteria. Population varies in soil but rarely exceeds 10^2 - 10^3 / g soil. The effective strain used in *Azotobacter* culture fixes about 15 - 20 kg atmospheric nitrogen per hectare. The cells of *Azotobacter* remain free in soil or in vicinity of the root system and fix part of the atmospheric nitrogen. *Azotobacter* cultures are useful for the cereals and cash crops *viz.*, wheat, paddy, pearlmillet, sorghum, maize, mustard, cotton, cumin, banana, sugarcane, tobacco, castor, vegetables etc. About 10 to 15% increase of crop yield can be achieved with the use of these cultures.

Phosphate solubilizing bacteria is one of the commercial P solubilizing biofertilizers prepared by incorporating *Bacillus megatherium* var.

phosphaticum. Most of the cultivable soil being alkaline in nature contains less available phosphorus. Use of effective strain of PSB will increase the level of available P_2O_5 in the soil. About 10 to 15% increase in crop yield can be achieved with the use of this culture. Phosphate solubilizing bacteria are useful for all crops *viz.*, cereals, cash crops, leguminous crops, horticultural crops, vegetables etc.

Looking to the above facts, an experiment entitled **"Integrated nitrogen management in Bt. cotton (*Gossypium hirsutum* L.)"** was conducted at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during the *kharif* 2013 with the following objectives;

OBJECTIVES

1. To study the effect of castor cake, biofertilizers and inorganic fertilizers on growth, yield and quality of Bt. cotton.
2. To find out the best combination of organic and inorganic fertilizers for Bt. cotton.
3. To work out the economics of different treatments.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

In the present study efforts were made to develop production technologies for Bt. cotton with respect to integrated nitrogen management and their effects on growth, yield and fibre quality. Literatures and results of the previous investigations carried out on these aspects in Bt. cotton are very limited and meagre. Attempts are made to present a brief summary of work carried out in India and abroad related to the integrated nitrogen management which have been highlighted and reviewed under the following sub headings.

2.1 EFFECT ON GROWTH ATTRIBUTES

2.1.1 Effect of nitrogen (inorganic source)

Hallikeri *et al.*, (2010) carried out an experiment at Agricultural Research Station, Dharwad during 2005-06 and 2006-07 under irrigated conditions on medium deep black soil. They reported that an application of 160 kg N/ha produced significantly higher plant height (73.6 cm), no. of monopodial branches/plant (3.09) and no. of sympodial branches/plant (15.31) than lower levels of nitrogen (80 and 120 kg/ha) in cotton crop.

A field experiment was carried out on mix red and black calcareous soil at Regional Station, Central Institute for Cotton Research, Coimbatore during *kharif* 2003-04 and 2004-05. They observed that increase in plant height and no. of sympodial branches/plant with the increase in nitrogen level 0, 60, 90 and 120 kg N/ha (Prakash *et al.*, 2010).

Sunitha *et al.,* (2010) conducted an experiment at the Agricultural College Farm, Bapatla during the *kharif* season of 2006-2007. They noted that maximum plant height observed with application of 240 kg N ha^{-1}. However, in case of Bunny Bt and non-Bt Bunny hybrids, effect of N levels were found non-significant with respect to number of monopodial and sympodial branches per plant.

Bibi *et al.*, (2011) conducted an experiment during crop season 2010 at Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan with four levels of nitrogen and six cultivars. They reported that application of N @ 150 kg/ha significantly increased plant height (24.49%) and sympodia per plant (87.12%) over control (0 kg N/ha).

Emara and El-Gammaal (2012) carried out a field experiment at Sakha Agricultural Research Station, Egypt, during 2009 and 2010. They indicated that application of nitrogen 60 kg/fed increased plant height at harvest and no. of sympodia/plant in cotton crop.

Modhvadia *et al.*, (2012) carried out an experiment at Cotton Research Station, Junagadh Agricultural University, Junagadh during *kharif* 2006-07 and 2007-08 to study the effect of nitrogen on yield of Bt.cotton under irrigated condition on medium black clay soil. The results showed that application of 240 kg N/ha produced significantly higher plant height (160.98 cm), plant spread (102.55 cm), no. of monopodial branches/plant (4.55) and no. of sympodial branches/plant (25.91) than lower levels of nitrogen (120 and 200 kg/ha) in cotton crop.

A field experiment was conducted on clay loam soil during 2008 at the Gharakhil Agricultural Research Institute, Mazandaran. An application of 225 kg N ha^{-1} gave maximum plant height (84.88 cm), while application of 150 kg N ha^{-1} gave maximum sympodial branches (7.51) per plant (Alitabar *et al.*, 2013).

2.1.2 Effect of Biofertilizers

Pandey *et al.*, (1989) observed that establishment of *Azotobacter chroococum* in rhizosphere resulted in significant increase in plant height, number of monopodial and sympodial branches per plant of cotton crop.

2.1.3 Integrated effect of inorganic fertilizer, castor cake and biofertilizer

Bodake and Rana (2008) carried out an experiment to study the effect of deoiled seed cake of jatropha (*Jatropha curcas* L.) and castor (*Ricinus communis* L.) as a source of nutrient alone and in various combination with inorganic sources in spring sunflower (*Helianthus annuus* L.) – maize (*Zea mays* L.) sequence at Indian Agricultural Research Institute, New Delhi during 2007 and 2008 on sandy loam soil. They reported that application of 75% RDF + 25% RDN through castor cake gave maximum plant height (183.8 cm) at harvest in spring sunflower.

2.2 EFFECT ON YIELD ATTRIBUTES AND YIELD

2.2.1 Effect of nitrogen (inorganic source)

Sagarka *et al.*, (2002) carried out an experiment on cotton crop during 1994-95 and 1995-96 on clayey soil at the Instructional Farm, College of Agriculture, Gujarat Agricultural University, Junagadh. They reported that application of 160 kg N/ha recorded significantly larger boll size, number of square, green bolls, picked bolls per plant, seed cotton yield and stalk yield over 80 and 120 kg N/ha.

Clawson *et al.,* (2006) reported that application of higher dose of N (225 kg/ha) decreased seed cotton yield (2962 kg/ha) over lower N level (150 kg/ha) which recorded seed cotton yield of 3263 kg/ha.

A field experiment was conducted by Sawan *et al*., (2006) on clay loam soil at the Agricultural Research Center, Ministry of Agriculture in Giza, Egypt during 1999-2000. They showed that number of bolls/plant, boll weight, seed index and seed cotton yield significantly increased with application of nitrogen @143 kg/ha.

Das and Reddy (2009) conducted an experiment on cotton crop at Agricultural Research Station, Adilabad during *kharif* 2006 on vertisol soil. They reported that application of 150 kg N/ha gave significantly higher kapas yield (2818 kg/ha) and stalk yield (10097 kg/ha) as compared to 90 and 120 kg N/ha.

A field experiment was conducted at Regional Station, Punjab Agricultural University, Bhatinda during *kharif* 2006-2007 to evaluate the nitrogen levels for obtaining higher yield potential of newly developed Bt cotton hybrids *viz.,* Ankur 651 Bt and Ankur 2534 Bt. They reported significantly higher seed cotton yield with 150 kg N/ha which was at par with 175 kg N/ha but significantly higher than 200 kg N/ha (Butter *et al*., 2010).

Hallikeri *et al.*, (2010) carried out an experiment at Agricultural Research Station, Dharwad during 2005-06 and 2006-07 under irrigated conditions on medium deep black soil. They observed that application of 160 kg N/ha produced significantly higher no. of bolls/plant (30.5), boll weight (5.26 g), seed cotton yield (2412 kg/ha) and total dry matter (254.9 g/plant) than lower levels of nitrogen (80 and 120 kg/ha) in cotton crop.

A field experiment was carried out on mix red and black calcareous soil at Regional Station, Central Institute for Cotton Research, Coimbatore during *kharif* 2003-04 and 2004-05. Linear response of N was observed with respect to bolls/plant and seed cotton yield consisting of four N levels *viz.,* 0, 60, 90 and 120 kg/ha (Prakash *et al.*, 2010).

Sunitha *et al.*, (2010) conducted an experiment at the Agricultural College Farm, Bapatla during the *kharif* season of 2006-2007. They reported that application of 240 kg N ha^{-1} noted significantly higher yield and yield attributes of cotton as compared to other levels of nitrogen.

Bibi *et al.*, (2011) conducted an experiment during 2010 at Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan with four levels of nitrogen and found that application of 150 kg N/ha significantly increased bolls per plant (78.43%), boll weight (13.51%) and seed cotton yield (62.39%) over control.

Emara and El-Gammaal (2012) carried out a field experiment at Sakha Agricultural Research Station, Egypt during 2009 and 2010. They indicated that application of nitrogen @ 60 kg/fed increased no. of opened boll/plant, boll weight and seed cotton yield.

Modhvadia *et al.*, (2012) carried out an experiment at Cotton Research Station, Junagadh Agricultural University, Junagadh during *kharif* 2006-07 and 2007-08 to study the effect of nitrogen on yield of Bt. cotton under irrigated condition on medium black clay soil. An application of 240 kg N/ha produced significantly higher no. of bolls/plant (103.35), boll weight (6.77 g), no. of seeds/boll (28.39), seed cotton yield (4027 kg/ha) and stalk yield (5589 kg/ha) over 120 and 200 kg N/ha.

A field experiment was conducted on clay loam soil during 2008 at the Gharakhil Agricultural Research Institute, Mazandaran. An application of 225 kg N ha^{-1} produced maximum yield (1731.06 kg ha^{-1}), number of node and boll as compared to 0, 75 and 150 kg N ha^{-1} (Alitabar *et al.*, 2013).

2.2.2 Effect of Biofertilizers

Kundu and Gaur (1980) observed a synergetic interaction between *Azotobacter* and phosphate solubilizing bacteria when inoculated together in cotton. In combined inoculation treatment, population of both the organisms was enhanced in addition to increase in yield of cotton.

Pandey *et. al.*, (1989) observed that establishment of *Azotobacter chroococcum* in rhizosphere resulted in significant increase in seed cotton yield and yield attributing parameters.

An experiment was conducted to test effect of *azotobacter* and PSB during 2002-03 at Akola on cotton under rainfed condition. Seed inoculation with *Azotobacte*r and PSB biofertilizers recorded higher seed cotton yield (12.5%) over control (AICCIP, 2003a).

A field experiment was conducted at the Indian Agricultural Research Institute, New Delhi during 2001 and 2002 to assess the effect of different nitrogen sources on cotton (*Gossypium hirsutum* L.) productivity. The results indicated that considerable improvement in yield attributes and seed cotton yield (2.33 t/ha) with application of 30 kg N/ha through *Azotobacter* remained at par with application of 60 kg N/ha through fertilizer (Das *et al.*, 2006).

Ismail *et al.*, (2011) conducted an experiment on vertisol soil at Experimental Farm of Marathwada Agricultural University, Parbhani during *kharif* season of 2010-11. They reported that dual inoculation of *Azotobacter* and PSB recorded significantly higher cotton yield over single inoculation of biofertilizer. However, inoculation with single biofertilizer either *azotobacter* or PSB was found superior over control but remained at par with each other.

2.2.3 Effect of $MgSO_4$

A field experiment was carried out during 1997-98 at Cotton Research Station, Banswara. They reported that foliar spray of $MgSO_4$ and $FeSO_4$ were found superior in managing the leaf reddening and secured higher yield in G.Cot.Hy.6. It was found that the combined spray of 1.5% DAP + 1 % $MgSO_4$ gave significantly higher seed cotton yield (16.27 q/ha) followed by 0.5% $MgSO_4$ + 0.5% $FeS0_4$ (15.80 q/ha). It also significantly increased boll weight per plant (AICCIP, 1999a).

A field experiment was carried out during 1997-98 at Cotton Research Station, Dharwad showed that spray of $MgSO_4$ (1%) or Lihocin 2000 ppm alone registered the highest seed cotton yield in hybrid DHB 105 (AICCIP., 1999b).

An experiment was conducted at Maharastra Agricultural University, Nanded during 2002-03, to study the effect of spraying of micro nutrients on seed cotton yield and quality of cotton crop (Hy. NHH. 44). The results showed that spraying of $MgS0_4$ @ 0.2% at 45 and 75 DAS recorded higher seed cotton yield (13.66%) over control (AICCIP., 2003b).

AICCIP, (2004) conducted an experiment on farmers' field in rainfed cotton at Nanded during 2003-04. The results showed that spraying of micro-nutrients $MgSO_4$ @ 0.2% at 45 and 75 DAS increased seed cotton yield to the tune of 10.62% over farmers' practice.

AICCIP, (2005) conducted an experiment on farmers' field on cotton crop during *kharif* 2004-2005. They reported that spraying of micronutrients $MgSO_4$ @ 0.2% at 45 and 75 DAS on seed cotton yield of hybrid HH- 316. The seed cotton yield increased ranging from 2.73% to 14.08% over no spraying of micronutrient $MgSO_4$ @ 0.2% at 45 and 75 DAS. The average increase in seed cotton yield was 10.27% over control.

2.2.4 Integrated effect of inorganic fertilizer, castor cake and biofertilizer

An experiment was conducted at Agronomy Instructional Farm, Sardarkrushinagar on loamy sand soil during 2000 to 2005 to study the effect of different treatments of integrated nutrient management under cotton-late sown wheat cropping sequence. They observed that application of 75% RDN through organic sources (37.5% N from castor cake and 37.5% N from FYM) and 25% RDN through inorganic fertilizer in cotton crop (Anon., 2006).

Bodake and Rana (2008) carried out an experiment at Indian Agricultural Research Institute, New Delhi during 2007 and 2008 on sandy loam soil. They reported that application of 50% RDN through inorganic fertilizer and 50% RDN through castor cake gave significantly higher 1000 seeds weight and seed yield in spring sunflower.

A field experiment was carried out during 2011 at Cotton Research Station, Akola (Maharashtra). They reported that application of castor cake @ 500 kg/ha + seed treatment with *Azotobacter* + PSB @ 25 g/kg seed gave significantly the highest seed cotton yield of 1838 kg/ha (AICCIP, 2012).

2.3 EFFECT ON QUALITY PARAMETERS

2.3.1 Effect of nitrogen (inorganic source)

Kummar (1981) reported that fiber length of hybrid cotton (DCH-32) reduced with application of N beyond 225 kg ha^{-1}. However, other quality parameters like fiber strength, fineness and maturity co-efficient were not affected by N increments.

A field experiment was conducted at Indian Agricultural Research Institute, New Delhi during 2001 and 2002 to assess the effect of different nitrogen sources on cotton crop (*Gossypium hirsutum* L.). Different sources of nitrogen did not exert any significant effect on various quality parameters *viz.*, ginning percentage, lint index, fibre length, bundle strength and fibre fineness of cotton with the application of 60 kg N/ha through fertilizer (Das *et al.*, 2006).

Field experiments were conducted on clay loam soil at the Agricultural Research Centre, Ministry of Agriculture in Giza, Egypt using the cotton cultivar "Giza 86" (*Gossypium barbadense* L) during 1999-2000. Seed oil content was slightly decreased with application of 143 kg N/ha, but oil yield per hectare significantly increased, which is attributed to the significant increase in cotton seed yield (Sawan *et al.*, 2006).

Mahavishnan *et al.* (2008) carried out an experiment on sandy loam soil during *kharif* and *rabi* seasons of 2002-03 and 2003-04. They found that lint index, seed index, fibre length, fibre fineness, bundle strength and maturity coefficient were remained unaffected due to various N management practices in cotton.

Hallikeri *et al.*, (2010) carried out an experiment at Agricultural Research Station, Dharwad during 2005-06 and 2006-07 under irrigated conditions on medium deep black soil and indicated that significantly higher fibre span length (30.7 mm) and uniformity percentage (46.96) recorded with 120 kg N/ha.

2.3.2 Effect of Biofertilizers

Pandey *et al.,* (1989) observed that establishment of *Azotobacter chroococcum* in rhizosphere resulted in significant increase in lint index and ginning percent but fibre quality was not improved with *Azotobacter*.

A field experiment was conducted at Indian Agricultural Research Institute, New Delhi during 2001 and 2002 to study effect of different nitrogen sources on cotton crop (*Gossypium hirsutum* L.). They noted that various quality parameters *viz.,* ginning percentage, lint index, fibre length, bundle strength and fibre fineness were not affected significantly with application of 30 kg N/ha through *Azotobacter* (Das *et al.*, 2006).

2.4 EFFECT ON NITROGEN CONTENT AND UPTAKE

2.4.1 Effect of nitrogen (inorganic source)

Wanjura and Sundaraman (1976) reported that N concentration in vegetative parts increased with increased N levels (90 to 180 kg ha^{-1}). They further showed that N content in reproductive parts (seeds) increased between peak bloom and maturity. While in vegetative parts it decreased with advancement of growth.

Das and Reddy (2009) conducted an experiment on cotton crop during *kharif* 2006 on vertisol soil at Agricultural Research Station, Adilabad. They reported that application of 150 kg N/ha recorded significantly higher total nitrogen uptake (34.25 kg/ha) compared to 90 kg N/ha (17.44 kg/ha).

2.4.2 Effect of Biofertilizers

A field experiment was conducted at Indian Agricultural Research Institute, New Delhi during 2001 and 2002 to assess the effect of different nitrogen sources on cotton (*Gossypium hirsutum* L.). The results indicated considerable increase in NPK uptake by cotton with the application of 30 kg

N/ha through *Azotobacter* inoculation being at par with application 60 kg N/ha through fertilizer (Das *et al.*, 2006).

2.4.3 Integrated effect of inorganic fertilizer, castor cake and biofertilizer

Bodake and Rana (2008) carried out an experiment at Indian Agricultural Research Institute, New Delhi during 2007 and 2008 and reported that application of 100% RDF gave maximum total nitrogen uptake (102.4 kg/ha) which was significantly superior to rest of the treatments except 75% RDF + 25% RDN through jatropha cake, 75% RDF + 25% RDN through Castor cake and 75% RDF + 25% RDN through FYM.

2.5 EFFECT ON ECONOMICS

2.5.1 Effect of nitrogen (inorganic source)

Das and Reddy (2009) conducted an experiment on cotton crop during *kharif* 2006 on vertisol soil at Agricultural Research Station, Adilabad. They reported that application of 150 kg N/ha gave maximum profit.

2.5.2 Integrated effect of inorganic fertilizer, castor cake and biofertilizer

An application of 25% RDN through organic sources and 75% RDN through inorganic sources recorded the highest gross realization, net realization and BCR in cotton crop (Anon., 2006).

Bodake and Rana (2008) reported that application of 50% RDF + 50% RDN through castor cake gave maximum net return in spring sunflower.

MATERIALS AND METHODS

III. MATERIALS AND METHODS

The detail of the materials used and experimental techniques adopted during the course of the present investigation are described in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was carried out on Plot No. B-8 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District Banaskantha (North Gujarat) during *kharif* season of 2013-14.

3.2 CLIMATIC AND WEATHER CONDITIONS

Geographically, Sardarkrushinagar is situated at 24° - 19' North latitude and 72° - 19' East longitude with an elevation of 154.52 metre above the mean sea level. It is located in the North Gujarat Agro-climatic Zone.

This zone is characterized by semi arid climate with extreme cold winter and hot and dry windy summer. Generally, monsoon commences in the middle of June and retreats by the middle of September. Most of the precipitation is received from South-West monsoon, concentrating in the months of July and August. The seasonal rain fall is 1021.9 mm with 35 rainy days in 2013.

The winter season is fairly cold and dry starts from the end of October and continues till the end of February. The minimum temperature of the year is reached in the months of December and January. The temperature starts rising from February and reaches the maximum in the months of April and May. The wind velocity is very high during summer.

Weekly average meteorological data on maximum and minimum temperature, relative humidity, sunshine hours, wind velocity and evaporation pertaining to the period of this investigation recorded at the Meteorological Observatory of the Department of Agricultural Meteorology, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar are presented in Table 3.1 and graphically depicted in Fig. 3.1. It could be seen from the meteorological data that weather conditions are suitable for satisfactory growth and development of cotton crop.

3.3 PHYSICO-CHEMICAL PROPERTIES OF SOIL

To ascertain physico-chemical characteristics of soil, soil samples were collected from different spots of the experimental field for the depth of 0-15 cm and 15-30 cm. A composite soil sample for each depth were prepared and analyzed. The general physic-chemical characteristics of the soils of the experimental field as well as the methods followed for the soil analysis are given in Table 3.2.

The soil analysis indicated that the soils of the experimental field are loamy sand in texture, low in organic carbon (0.21%) and available nitrogen (158 kg/ha), medium in available phosphorus (39.29 kg/ha) and high in available potash (294 kg/ha).

Table 3.1 : Standard week wise meteorological data recorded during crop season of the year 2013-14

Month and Year	Std. Week	Temperature (°C)		Relative humidity (%)		Wind velocity (km/hr)	Bright sunshine (hr/day)	Rainfall (mm)	Evapo-ration (mm/day)
		Max.	Min.	I	II				
June 2013	23	39.6	27.5	71	40	10.8	8.8	1.3	10.7
	24	36.1	25.4	87	50	11.4	5.5	98.5	7.6
	25	34.6	26.1	89	51	9.0	6.5	76.0	7.1
	26	35.6	27.2	80	50	14.3	4.1	0.0	8.4
July 2013	27	33.1	26.0	91	75	8.3	1.0	10.9	4.5
	28	32.5	24.9	97	73	8.2	1.3	101.3	2.4
	29	33.7	27.5	88	66	8.2	2.8	0.0	4.8
	30	32.1	25.9	93	82	6.4	1.4	211.4	2.4
	31	31.3	25.2	96	86	5.9	0.7	43.4	2.1
August 2013	32	30.7	25.5	93	76	7.2	0.8	9.3	4.0
	33	30.6	26.0	93	84	7.0	0.1	80.8	3.0
	34	31.8	25.9	87	63	6.8	1.0	0.0	5.0
	35	32.7	25.8	87	65	8.3	4.5	0.0	6.6
September 2013	36	34.2	25.8	86	56	8.6	8.3	0.0	7.6
	37	37.2	27.1	90	46	5.6	8.4	0.0	8.2
	38	37.7	26.5	84	51	5.7	7.6	5.4	7.3
	39	29.3	25.3	94	90	9.9	0.5	383.6	3.1
October 2013	40	32.9	26.1	89	62	3.0	7.4	10.3	5.1
	41	32.7	25.8	88	68	3.4	7.5	51.6	5.1
	42	35.5	23.1	83	40	2.3	9.9	0.0	5.8
	43	35.1	20.1	69	28	4.6	10.4	0.0	6.4
	44	33.5	19.0	79	32	2.8	9.7	0.0	4.5
November 2013	45	32.2	16.8	83	36	8.8	7.9	0.0	4.5
	46	30.0	12.5	70	33	4.3	9.3	0.0	3.9
	47	31.2	12.3	80	32	4.0	9.7	0.0	4.3
	48	31.3	13.6	87	37	3.1	9.4	0.0	4.1
December 2013	49	30.0	12.4	94	34	3.9	9.4	0.0	4.2
	50	29.8	11.0	92	31	3.1	8.2	0.0	3.6
	51	26.7	10.4	95	31	6.8	9.1	0.0	3.1
	52	25.2	10.0	95	34	13.7	8.4	0.0	3.5
January 2014	01	25.0	8.6	90.1	54.4	19.0	7.8	0.0	3.9
	02	24.5	6.8	82.0	58.9	11.7	8.6	0.0	3.6
	03	24.8	8.7	88.8	53.7	8.9	7.7	0.0	3.6
	04	26.3	9.6	87.8	54.3	8.3	7.7	0.0	3.7
	05	30.5	10.5	85.1	56.3	5.0	9.2	0.0	4.0
February 2014	06	27.2	11.1	89.3	53.9	3.9	9.4	0.0	4.7
	07	26.8	10.1	81.2	46.0	13.9	9.0	0.0	5.0
	08	28.9	13.2	72.2	37.0	11.3	8.5	0.0	5.7
	09	25.0	8.6	90.1	54.4	19.0	7.8	0.0	3.9

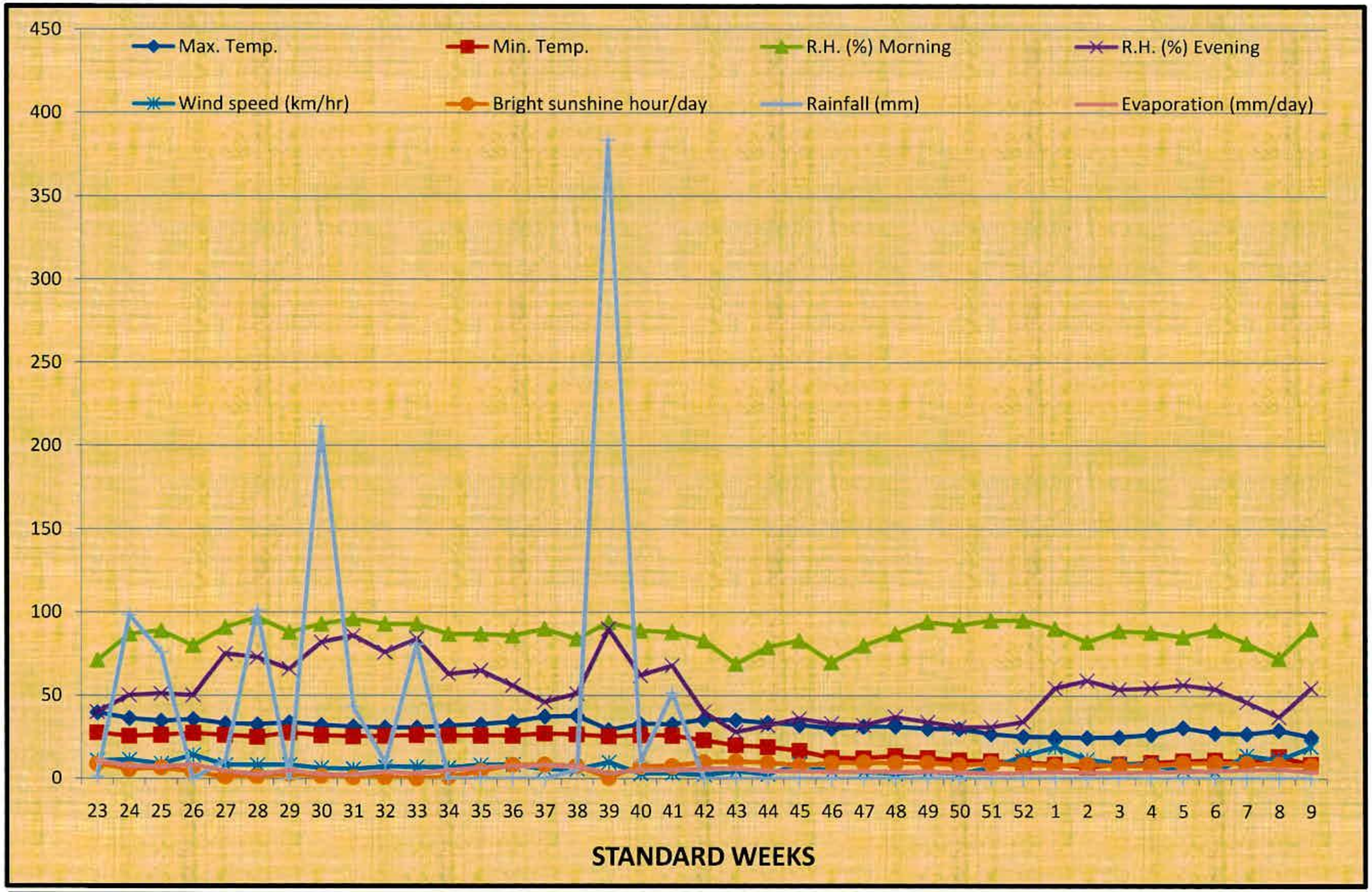


Fig. 3.1: Weather chart for the period of investigation (2013-14)

Table 3.2: Physico-chemical properties of the experimental soil

Sr. No.	Properties		Values at soil depth 0-15 cm	Values at soil depth 15-30 cm	Method employed
[A]	**PHYSICAL PROPERTIES :**				
	(a)	Sand (%)	85.01	85.34	International Pipette method (Piper, 1966)
	(b)	Silt (%)	7.55	7.47	
	(c)	Clay (%)	7.09	6.93	
	(d)	Textural class	Loamy sand		
[B]	**CHEMICAL PROPERTIES :**				
	(a)	Soil pH (1 : 2.5, Soil : Water ratio)	7.8	7.7	Potentiometric method (Jackson, 1973)
	(b)	Electrical conductivity (dS/m)	0.11	0.12	Schofield method (Jackson, 1973)
	(c)	Organic carbon (%)	0.21	0.15	Walkley and Black's method (Jackson, 1973)
	(d)	Available N (kg/ha)	158	149.0	Alkaline Potassium Permanganate method (Jackson, 1973)
	(e)	Available P_2O_5 (kg/ha)	39.29	40.31	Olsen's method (Olsen *et al.,* 1954)
	(f)	Available K_2O (kg/ha)	294	288	Flame Photometer method (Jackson, 1973)

3.4 CROPPING HISTORY

Details regarding the cropping history of the experimental field with respect to crops taken and fertilizers applied during the previous three years are presented in Table 3.3.

Table 3.3: Cropping history of the experimental field (B-8)

Year	Season	Crop	Nutrients applied (kg/ha)		
			N	P_2O_5	K_2O
2011-12	*Kharif*	Cluster bean	20	40	00
	Rabi	Fallow	-	-	-
	Summer	Pearlmillet	120	60	00
2012-13	*Kharif*	Cluster bean	20	40	00
	Rabi	Fenugreek	20	40	00
	Summer	Fallow	-	-	-
2013-14	*Kharif*	Cotton	As per treatments		
	Rabi	Continue			

3.5 SALIENT FEATURES OF THE VARIETIES

The cotton variety G.Cot.Hy.-6 was released in 1980 for irrigated tract and recognized as a quality hybrid even today. This was converted to BG-II under same programme in 2011. The new Bt. cotton variety G.Cot.Hy.-6 (BG-II) was high yielding (1981 kg/ha) than its non Bt. counter part by 31.4%. G.Cot.Hy.-6 (BG-II) was developed by Main Cotton Research Station, Surat. The characters of G.Cot.Hy.-6 (BG-II) variety are given in Table 3.4.

Table 3.4: Salient features of the variety G.Cot.Hy.6 (BG II)

Sr. No.	Particulars	
1.	Leaf colour	Dark green
2.	Leaf hairiness	Hairy
3.	Leaf appearance	Cup shape
4.	Leaf shape	Palmate (normal)
5.	Plant stem hairiness	Medium
6.	Plant height	Tall
7.	Plant growth habit	Spread
8.	Dract type	Normal
9.	Number of monopodial branches/plant (average)	4-5
10.	Number of sympodial branches/plant (average)	21-22
11.	Days to 50 per cent flowering (50 % of plants with at least one open flower)	50-52
12.	Days to maturity	170-200
13.	Flower : Petal colour	Cream
14.	Flower : Petal spot	Absent
15.	Flower : Pollen colour	Yellow
16.	Boll bearing habit	Solitary
17.	Boll shape	Ovate
18.	Boll surface	Smooth
19.	Boll prominence of pit	Pointed
20.	Seed cotton yield / boll (g)	3.5-4.5
21.	Fibre length (mm)	Long (28.5-29)
22.	Fibre fineness (μg/inch) (Micronire value)	Fine (3.5-4.0)
23.	Fibre strength (g/tex)	Medium (21.5-22)
24.	Maturity ratio	Fine (0.80-0.83)
25.	Uniformity percentage	Excellent (48-50)
26.	Short fibre index	Long (11.6-13.4)
27.	Average seed cotton yield (q/ha)	25-35

3.6 EXPERIMENTAL DETAILS

The field experiment was conducted on "**Integrated Nitrogen Management in Bt. cotton** (*Gossypium hirsutum* L.)" was carried out during *kharif* season of 2013-14. The details of experiment are described as under.

3.6.1 Treatments

T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer

T_2: 125% RDN through inorganic fertilizer

T_3: 100% RDN through inorganic fertilizer + 25 kg $MgSO_4$/ha

T_4: 25% RDN through inorganic fertilizer + 75% RDN through castor cake

T_5: 50% RDN through inorganic fertilizer + 50% RDN through castor cake

T_6: 75% RDN through inorganic fertilizer + 25% RDN through castor cake

T_7: 25% RDN through inorganic fertilizer + 75% RDN through castor cake + *Azotobacter*

T_8: 50% RDN through inorganic fertilizer+ 50% RDN through castor cake + *Azotobacter*

T_9: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter*

T_{10}: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB

T_{11}: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha

T_{12}: 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB

3.6.2 Design of the experiment

Randomized Block Design was employed in present investigation. The treatments were replicated three times and were assigned randomly to each plot in the replication.

Table 3.5: Experimental details

1.	Replications	:	3 (Three)
2.	Treatments	:	12 (Twelve)
3.	Total plots	:	36 (Thirty six)
4.	Plot size	:	Gross plot : 7.2 m x 6.0 m
			Net plot : 6.0 m x 4.8 m
5.	Method of sowing	:	Dibbling
6.	Spacing	:	120 cm x 60 cm
7.	Crop and Variety	:	Bt. cotton G.Cot.Hy.-6 (BG-II)
8.	Seed rate	:	2.5 kg/ha
9.	Recommended dose of fertilizer	:	240 + 40 + 00 NPK kg/ha

3.7 CULTURAL OPERATIONS

The calendar of cultural operations carried out during the course of investigation is presented in Table 3.6.

3.7.1 Preparation of land and layout

The experimental field was throughly cross cultivated with a tractor drawn cultivator. Residues and stubbles of the previous crop were removed from the experimental plots. Finally land was prepared by harrowing and planking. Layout of the experiment was prepared according to design of the experiment. Treatments were allotted to the experimental plots by randomly as depicted in Fig. 3.2.

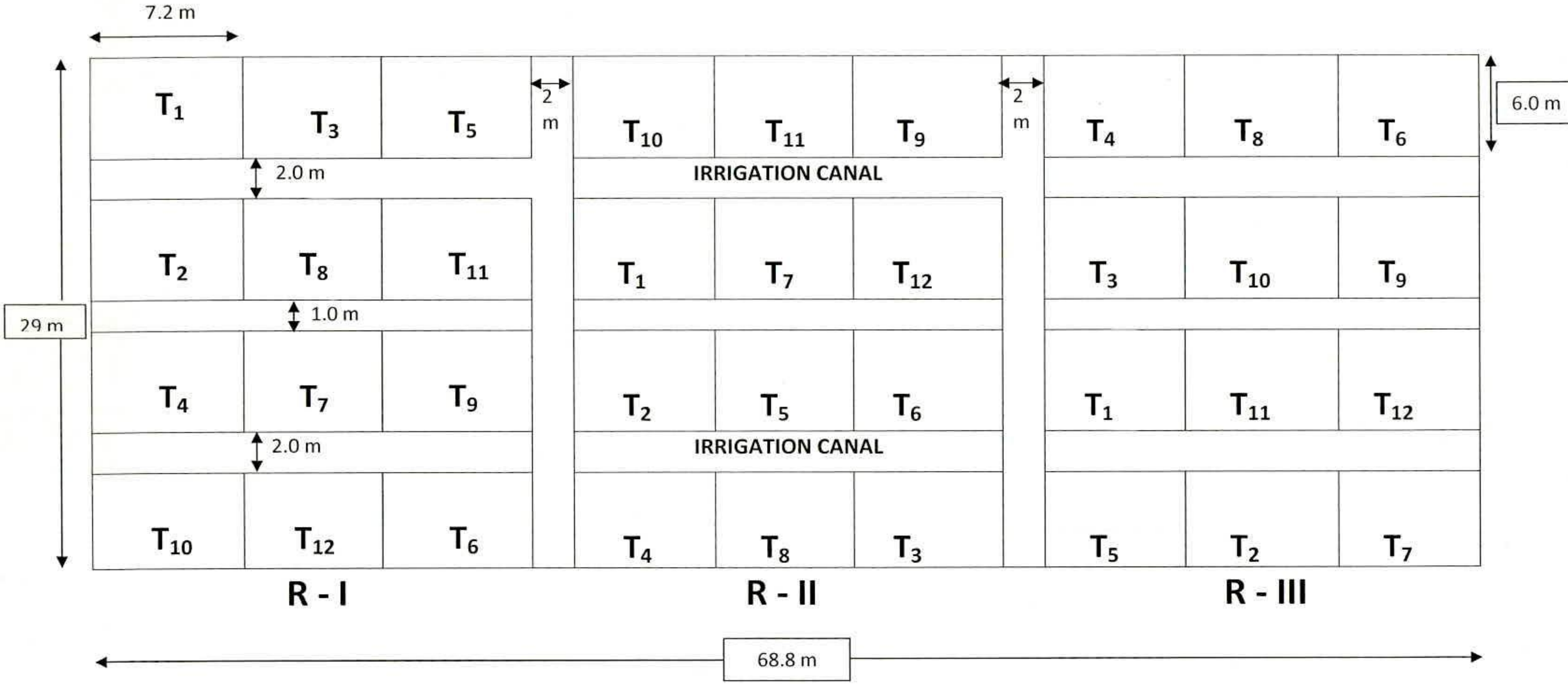
3.7.2 Application of manure and fertilizers

Application of castor cake (powder form) was done at 15 days before sowing of cotton crop as per treatments and thoroughly incorporated into the soil. At the time of sowing one fourth of recommended dose of nitrogen (60 kg/ha) in the form of urea was applied as basal dose as per treatments and 40 kg P_2O_5/ha was applied before sowing in previously opened furrows as a common dose. Remaining dose of nitrogen was top dressed in three equal splits at 30, 60 and 90 DAS from urea after irrigation or rainfall through ring method as per treatments.

In present investigation, castor cake was used as one of the source of nitrogen. It contains 4.5% N and 1.7% P_2O_5, so phosphorus is added in treatments that received castor cake. Therefore, to equate quantity of P_2O_5 in all treatments, phosphorus added through castor cake in respective treatment was deducted from 40 kg P_2O_5/ha and there by 40 kg P_2O_5/ha was maintained in all the treatments. Phosphorus was applied from single super phosphate. *Azotobacter* and PSB were applied @ 25 g/ kg seed.

3.7.3 Sowing of crop

Seeds of Bt. cotton were sown by maintaining 120 cm distance between two rows and 60 cm between two plants by hand dibbling.



Design : Randomized block design

Plot size : Gross : 7.2 m X 6.0 m

Net : 4.8 m X 3.6 m

Fig. 3.2 Layout plan of the field experiment

PLAT- I : GENERAL VIEW OF EXPERIMENTAL SITE

3.7.4 Gap filling

For maintaining optimum plant population, gap filling was carried out at 10 DAS.

3.7.5 Irrigation

Rainfall was received at the time of sowing, so irrigation was not applied after dibbling of seeds. First irrigation was given 10 days after sowing immediately after the gap filling. Remaining irrigations were given as per crop need during crop life period. Total 8 irrigations were given to cotton crop.

3.7.6 Plant protection measures

Recommended plant protection measures were followed to control termite, sucking pests and bacterial diseases in Bt. cotton varieties as shown in Table 3.6.

Table 3.6: A calendar of cultural operations

Sr. No	Field operations		Date
[A]	PRE-SOWING OPERATIONS		
	1	Cultivation by tractor drawn cultivator	23-05-2013
	2	Harrowing	24-05-2013
	3	Planking	24-05-2013
	4	Field layout	25-05-2013
	5	Castor cake application	29-05-2013
	6	Preparation of beds and irrigation channels	11-06-2013

Conti.....

Conti.....

[B]	POST SOWING OPERATIONS			
	7	Sowing		13-06-2013
	8	Basal application of fertilizers		13-06-2013
	9	Gap filling		23-06-2013
	10	Top dressing of fertilizer (N)	1	12-07-2013
			2	12-08-2013
			3	13-09-2013
	11	Irrigation	1	23-06-2013
			2	21-08-2013
			3	11-09-2013
			4	21-09-2013
			5	16-10-2013
			6	1-11-2013
			7	26-11-2013
			8	18-12-2013
	12	Application of pre-emergence herbicide		
		Pendimethalin @1 kg/ha	1	15-06-2013
	13	Hand weeding	1	18-07-2013
			2	01-08-2013
	14	Interculturing	1	13-07-2013
			2	23-08-2013
	15 a. Plant Protection measures for the control of termite			
		Chlorpyriphos 20 EC @ 2 ml/l	1	10-07-2013
			2	08-08-2013
			3	10-09-2013

		4	22-09-2013
16 b. Plant Protection measures for the control of sucking pests			
	Dimethoate 30 EC	1	04-09-2013
		2	03-10-2013
17. Plant Protection measures for the control of disease			
	Mancozeb and Carbendazin	1	05-10-2013
		2	18-10-2013
18	Picking of seed cotton	1	11-10-2013
		2	16-11-2013
		3	31-12-2013
		4	27-01-2014
		5	15-02-2014
19	Removal of cotton stalks		16-02-2014

3.7.7 Weeding and interculturing

Pendimethalin @ 1.0 kg/ha was applied as pre-emergence to eliminate early crop weed competition. Two hand weedings at 35 and 50 DAS as well as two intercultivations at 30 and 70 DAS were also carried out to keep the plots free from weeds.

3.7.8 Picking

Fully brusted bolls of border line plants were picked up first and were kept separately. The brusted bolls of five tagged plants were picked up separately for recording post harvest observations and their seed cotton yield was added to final net plot yield .The brusted bolls from each net plot were picked up simultaneously and produce kept separately treatment wise. After completation of final picking, net plot wise entire produce was sun dried along with produce of selected five plants and recorded for each plot as per treatments. After last picking, stalks of each net plot were uprooted and left in field for sun drying and weight were recorded as per treatments.

3.8 BIOMETRIC OBSERVATIONS

The details of various growth parameters, yield attributes, yield and quality parameters are given in Table 3.7.

Details of techniques followed for recording the observations are described as under.

3.8.1 Growth parameters

3.8.1.1 Plant population

Plant population at 30 DAS and at harvest was recorded by counting the number of plants in each net plot.

3.8.1.2 Plant height (cm)

The height of five randomly tagged plants from each net plot was measured at 30, 60, 90 and 120 DAS. The height was measured from the ground level to the tip of main shoot in cm. The average height of five plants was calculated and recorded separately for each treatment.

3.8.1.3 Number of monopodial branches per plant

Number of monopodial branches bearing at least one functional sympodial branch were counted from five selected tagged plants at 60 and 90 DAS. Average of five plants was taken as number of monopodial branches per plant for each treatment.

Table 3.7: Biometric observations recorded during investigation

Sr. No.	Characters	Sample size	Time of recording
[A]	**Growth attributes:**		
1.	Plant population	Net plot	30 DAS and at harvest
2.	Plant height (cm)	5 plants from net plot	30, 60, 90 and 120 DAS
3.	Number of monopodial branches per plant	5 plants from net plot	60 and 90 DAS
4.	Number of sympodial branches per plant	5 plants from net plot	60, 90 and 120 DAS
[B]	**Yield attributes and yield:**		
1	Number of bolls per plant	5 plants from net plot	120,150 ,180 DAS and last picking
2	Weight of seed cotton per boll (g)	5 bolls from net plot	At harvest
3	Weight of seed per boll (g)	5 bolls from net plot	At harvest
4	Number of cotton seed per boll	5 bolls from net plot	At harvest
5	100 seeds weight (g)	100 seeds from net plot	After harvest
6	Seed cotton yield per plant (g)	5 plants from net plot	After harvest
7	Seed cotton yield (kg/ha)	Net plot	After harvest
8	Stalk yield (kg/ha)	Net plot	After harvest
9	Harvest index	-	After harvest
[C]	**Quality parameters:**		
1	Lint index	100 g seed cotton	After harvest
2	Oil content in cotton seed (%)	100 g cotton seed	After harvest
3	Oil yield (kg/ha)	-	After harvest
4	Ginning percentage	100 g seed cotton	After harvest
5	Mean fibre length	100 g lint	After harvest

3.8.1.4 Number of sympodial branches per plant

Number of fruiting branches arising from the main stem were counted from five selected tagged plants at 60, 90 and 120 DAS. Mean of five plants was expressed as number of sympodials per plant for each treatment.

3.8.2 Yield and yield attributes

3.8.2.1 Number of bolls per plant

The number of brusted bolls were counted and collected from previously tagged five plants and average value per plant was worked out and recorded for each treatment at every picking time.

3.8.2.2 Weight of seed cotton per boll (g)

Five fully opened bolls were picked randomly from each net plot and weighed. Average weight of seed cotton per boll was worked out by dividing the total weight of seed cotton with five. Mean weight of seed cotton per boll was calculated and recorded as weight of seed cotton per boll in gram for each plot.

3.8.2.3 Weight of seed per boll (g)

Five fully opened bolls were picked randomly from each net plot and separated the cotton seed from each boll. Average cotton seed weight was worked out by dividing the weight of five bolls cotton seed with five. Mean weight of cotton seed per boll was calculated and recorded as cotton seed weight in gram for each treatment.

3.8.2.4 Number of seeds per boll

Five fully opened bolls were picked randomly from each net plot and separately counted number of seeds from each boll and accordingly recorded for each plot.

3.8.2.5 100 seeds weight (g)

100 seed weight was obtained by weighting of 100 seeds from each net plot on Electronic Balance.

3.8.2.6 Seed cotton yield per plant (g)

Seed cotton was harvested from five tagged plants and weighted. Mean seed cotton yield per plant was calculated and expressed in gram per plant for each plot.

3.8.2.7 Seed cotton yield per hectare (kg/ha)

Seed cotton yield of five pickings from each net plot was recorded and summed up treatment wise. Seed cotton obtained from other observations like boll weight, seed cotton yield per plant, fibre quality parameters was also added and recorded as net plot yield which were converted in to hectare basis.

3.8.2.8 Stalk yield per hectare (kg/ha)

After the last picking from net plots, the stalks from net plots were pulled out and dried under the sun. Thereafter, the weight of dry stalks per net plot was recorded in kg for each treatment and converted in to hectare basis.

3.8.2.9 Harvest index

The harvest index was calculated by using following formula

$$\text{H.I. (\%)} = \frac{\text{Seed cotton yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.8.3 Quality parameters

Sample preparation

Seed cotton was randomly picked from each treatment from net plot area at the time of harvesting and cleaned for ginning. Cleaned and ginned lint samples of 100 g was packed and labeled as per treatments for quality testing.

Various conventional instruments are integrated into a single compact operating system by using the state of the art technology in optics, mechanics and electronics. HVI system provides measurement of fibre length (mm). Cotton samples were tested for fibre quality parameters from CIRCOT unit of Mumbai with HVI instrument (in ICC mode) by the method adopted from ASTM D-5867 procedure (Sundaram *et al.*, 2002).

3.8.3.1 Lint index

Lint index represents the absolute weight of lint produced per 100 seeds. This was computed with the help of formula suggested by Sikka and Joshi (1960)

$$\text{L.I.} = \frac{\text{Weight of 100 seeds X Ginning percentage}}{\text{100 – Ginning percentage}}$$

3.8.3.2 Oil content in cotton seed (%)

The oil content in cotton seed was determined by Nuclear Magnetic Resonance (NMR) Spectrophotometer as per method suggested by Tiwari *et al*. (1974) and expressed in percentage.

3.8.3.3 Oil yield (kg/ha)

Oil yield was calculated by using the following formula:

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content (\%)} \times \text{Seed cotton yield (kg ha}^{-1}\text{)}}{100}$$

3.8.3.4 Ginning percentage

A random sample of approximately 150 g of seed cotton from five selected plants was used to calculate ginning percentage (GP). The sample was ginned on electrically operated laboratory modified cloy gin designed by the Central Institute for Research on Cotton Technology (CIRCOT), Mumbai. After ginning of seed cotton of selected plants, ginning percentage was calculated as per the following formula:

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

Ginning percentage is the ratio of weight of lint to that of seed cotton expressed as percentage.

3.8.3.5 Mean fibre length (mm)

It is the distance spanned by a specified per cent of the fibres in the test beard. 2.5 per cent span length is the distance from the clamp on a fibre beard to a point up to which only 2.5 per cent of the fibres extend (Sundaram *et al.*, 2002). It was expressed as fibre length in mm.

3.9 CHEMICAL STUDIES

The previously prepared oven dried plant samples were used for chemical analysis.

3.9.1 Estimation of nitrogen content (%)

Nitrogen content in stem, leaf, reproductive parts of cotton and seed cotton at harvest was estimated by Modified Micro Kjeldhal method and expressed in percentage.

3.9.2 Uptake of nitrogen

The total uptake of nitrogen by the plant and seed was calculated by using the formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%) X Biological yield (kg ha}^{-1}\text{)}}{100}$$

3.10 ECONOMICS

3.10.1 Gross and net realization (₹/ha)

The gross and net realization in terms of rupees per hectare was worked out based on seed cotton yield and stalk yield for each treatment considering prevailing market price. The cost of cultivation of the crop under each treatment was worked out by considering the expenses incurred for all cultural operations as well as cost of various inputs. The net realization was obtained by deducting the cost of cultivation from the gross realization per hectare for respective treatment.

3.10.2 Benefit cost ratio

The Benefit: Cost Ratio (BCR) was calculated as ratio of gross return to total cost of cultivation by using following formula:

$$\text{BCR} = \frac{\text{Gross return (₹/ha)}}{\text{Total cost of cultivation (₹/ha)}}$$

3.11 STATISTICAL ANALYSIS

The observations recorded for growth and yield attributes, yield and quality parameters were put to the statistical analysis in accordance with analysis of variance techniques as suggested by Panse and Sukhatme (1967) for randomized block design.

The critical differences for comparing treatment means were worked out at 5 per cent level of significance. To elucidate effects, summary table along with critical difference at 5 per cent were prepared and are given in chapter "Experimental Results" and their analysis of variances are given in the appendices I to VII.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The experiment entitled, **"Integrated nitrogen management in Bt. cotton (*Gossypium hirsutum* L.)"** conducted at the Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (North Gujarat) during *kharif* 2013-14 at Agronomy Instructional Farm, Sardarkrushinagar and the results are presented in this chapter along with statistical inferences and also illustrated graphically wherever necessary. The data pertaining to various parameters of growth, yield and quality were subjected to statistical analysis and analysis of variance has been given in appendices.

4. 1 EFFECT ON GROWTH ATTRIBUTES

4.1.1 Plant population

The data pertaining to plant population at 30 DAS and at the time of last picking were statistically analysed and presented in Table 4.1.

The data indicated that plant population per plot at 30 DAS and at the time of last picking (at harvest) was not significantly influenced due to different nitrogen management treatments which indicated that no adverse effect of inorganic fertilizer, castor cake and biofertilizers were observed on germination of cotton seed as well as on survival of cotton plants.

4.1.2 Plant height

The data recorded on plant height of cotton at 30, 60, 90 and 120 DAS are presented in Table 4.2 and graphically illustrated in Fig 4.1.

Table 4.1: Plant population at 30 DAS and at harvest of cotton as influenced by different integrated nitrogen management treatments

Treatments	Mean plant population (Net plot area)	
	30 DAS	At harvest
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	23.0	22.3
T_2: 125% RDN through inorganic fertilizer	22.7	21.3
T_3: 100% RDN + 25 kg $MgSO_4$/ha	24.0	23.0
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	21.7	21.0
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	22.0	21.0
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	22.3	21.3
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	21.7	21.0
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	21.7	21.3
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	23.7	22.7
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	22.3	22.0
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	24.0	23.3
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	22.7	22.3
S.Em. ±	0.69	0.63
C.D. (P = 0.05)	NS	NS
C.V. (%)	5.30	5.02

4.1.2.1 Plant height at 30 DAS

A perusal of data on plant height as influenced significantly at 30 DAS presented in Table 4.2 indicated that higher plant height of 33.3 cm was observed with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) but it was found statistically at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) having the plant height of 31.3 cm and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) having the plant height of 32.3 cm. The lowest plant height (20.5 cm) was noted with treatment T_1 (100% RDN through inorganic fertilizer) which was statistically at par with treatments T_2, T_3, T_4 and T_6.

4.1.2.2 Plant height at 60 DAS

The mean data on plant height as influenced significantly at 60 DAS presented in Table 4.2 revealed that the highest plant height of 78.6 cm was observed with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) at 60 DAS but it was found at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) having the plant height of 71.5 cm and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) having the plant height of 75.8 cm. The lowest plant height (60.1 cm) was noted with treatment T_1 (100% RDN through inorganic fertilizer) which was statistically at par with treatments T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9.

4.1.2.3 Plant height at 90 DAS

Plant height influenced significantly at 90 DAS treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) registered maximum plant height of 140.1 cm but it was found statistically at par with treatments T_9 (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter*) having the plant height of 125.1 cm, T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) having the plant height of 130.3 cm and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) having the plant height of 138.3 cm, While the lowest plant height (109.7 cm) was noted with treatment T_1 (100% RDN through inorganic fertilizer) which was statistically at par with treatments T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10}.

4.1.2.4 Plant height at 120 DAS

The mean data (Table 4.2) indicated that integrated nitrogen management treatments significantly influenced the plant height at 120 DAS. Significantly higher plant height of 162.3 cm was observed with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB), but it was found statistically at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) having the plant height of 151.1 cm and T_{11} (75% RDN through inorganic

Table 4.2: Plant height of cotton at different growth stages as influenced by different integrated nitrogen management treatments

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	120 DAS
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	20.5	60.1	109.7	121.7
T_2: 125% RDN through inorganic fertilizer	23.7	62.7	113.3	131.4
T_3: 100% RDN + 25 kg $MgSO_4$/ha	24.3	63.7	117.1	133.5
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	22.0	60.8	112.2	123.2
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	28.5	64.9	121.4	136.1
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	24.3	64.7	119.5	135.9
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	24.8	63.9	118.2	133.5
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	28.7	66.4	122.5	137.9
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	28.9	68.4	125.1	142.4
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	31.3	71.5	130.3	151.1
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	32.3	75.8	138.3	156.3
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	33.3	78.6	140.1	162.3
S.Em. ±	1.30	3.18	5.71	6.52
C.D. (P = 0.05)	3.83	9.34	16.74	19.12
C.V. (%)	8.41	8.26	8.08	8.13

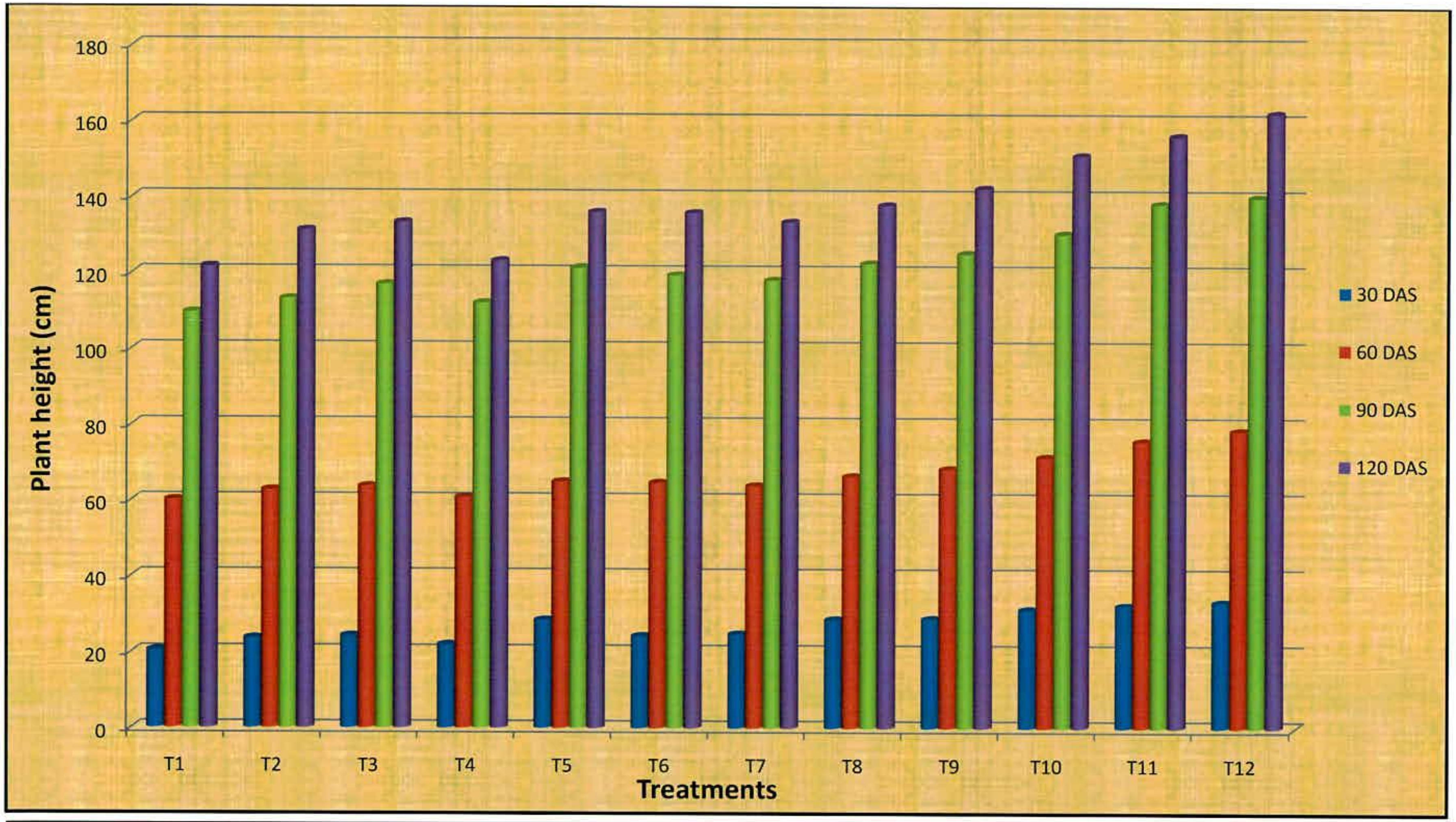


Fig. 4.1: Plant height at different growth stages as influenced by different integrated nitrogen management treatments

fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) having the plant height of 156.3 cm. The lowest plant height (121.7 cm) was noted with treatment T_1 (100% RDN through inorganic fertilizer) which was statistically at par with treatments T_2, T_3, T_4, T_5, T_6, T_7 and T_8.

4.1.3 Number of monopodial branches per plant

The data recorded on mean number of monopodial branches per plant at 60 and 90 DAS of cotton as influenced significantly by different integrated nitrogen management treatments are presented in Table 4.3 and graphically illustrated in Fig. 4.2.

The results indicated that maximum monopodial branches per plant of 3.4 and 4.6 was observed with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) at 60 and 90 DAS, respectively being at par with treatments T_9 (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter*), T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) in case of monopodial branches at 60 DAS; whereas it was found at par with treatments T_{10} and T_{11} in case of number of monopodial branches per plant at 90 DAS. Minimum monopodial branches per plant of 2.5 and 3.4 were observed with treatment T_1 (100% RDN through inorganic fertilizer) at 60 and 90 DAS,

Table 4.3: Monopodial branches per plant at 60 and 90 DAS as influenced by different integrated nitrogen management treatments

Treatments	Number of monopodial branches per plant	
	60 DAS	90 DAS
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	2.5	3.4
T_2: 125% RDN through inorganic fertilizer	2.6	3.6
T_3: 100% RDN + 25 kg $MgSO_4$/ha	2.5	3.5
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	2.5	3.4
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	2.9	3.8
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	2.8	3.7
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	2.7	3.7
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	2.9	3.9
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	3.0	3.9
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	3.1	4.1
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	3.2	4.3
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	3.4	4.6
S.Em. ±	0.16	0.19
C.D. (P = 0.05)	0.47	0.58
C.V. (%)	9.81	9.01

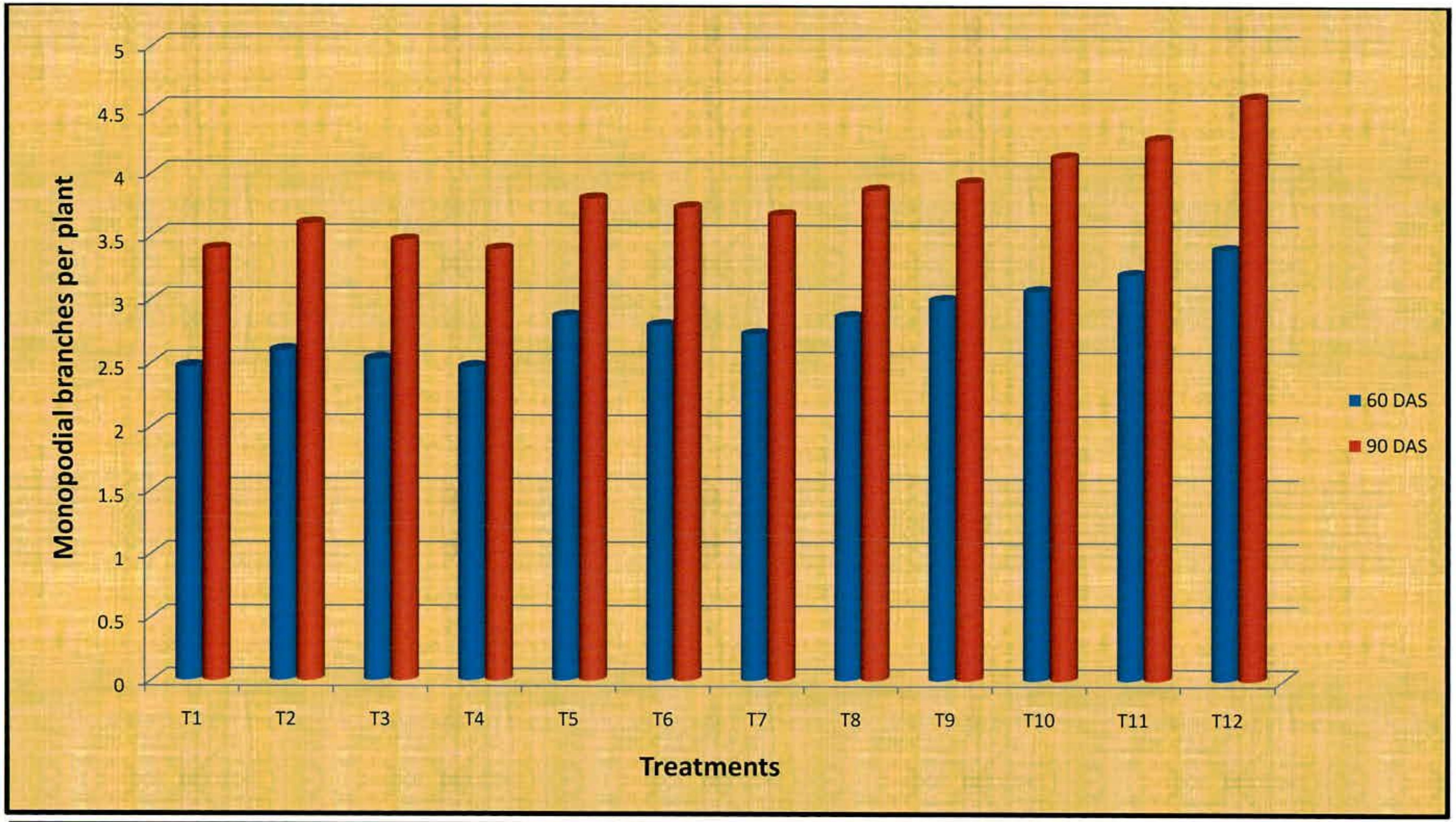


Fig. 4.2: Monopodial branches per plant at 60 and 90 DAS as influenced by different integrated nitrogen management treatments

respectively. It was found at par with treatments T_2 to T_8 at 60 DAS and T_2 to T_9 in case of 90 DAS.

4.1.4 Number of sympodial branches per plant

Data pertaining to mean number of sympodial branches per plant at 60, 90 and 120 DAS of cotton as influenced by different integrated nitrogen management treatments are presented in Table 4.4 and graphically represented in Fig. 4.3.

4.1.4.1 Sympodial branches per plant at 60 DAS

An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded significantly higher number of sympodial branches per plant (8.7) at 60 DAS but it was found statistically at par with treatments T_9 (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter*) having the sympodial branches per plant (7.8), T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) having the sympodial branches per plant (8.3) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) having the sympodial branches per plant of 8.4 at 60 DAS. Minimum sympodial branches per plant (6.4) were observed with treatment T_1 (100% RDN through inorganic fertilizer) which was at par with treatments T_2, T_3, T_4 and T_7.

4.1.4.1 Sympodial branches per plant at 90 DAS

The data (Table 4.4) showed that application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded higher mean number of sympodial branches per plant (17.4) at 90 DAS, but it was found statistically at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) having the sympodial branches per plant (16.2) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) having the sympodial branches per plant of 16.9, While minimum sympodial branches per plant (12.5) were observed with treatment T_1 (100% RDN through inorganic fertilizer) which was found statistically at par with treatments T_2 to T_9.

4.1.4.1 Sympodial branches per plant at 120 DAS

Different integrated nitrogen management treatments significantly influenced sympodial branches per plant at 120 DAS (Table 4.4). An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded higher mean number of sympodial branches per plant (26.8) at 120 DAS, but it was found statistically at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) having the sympodial branches per plant (24.8) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) having the

Table 4.4: Sympodial branches per plant at 60, 90 and 120 DAS as influenced by different integrated nitrogen management treatments

Treatments	Number of sympodial branches per plant		
	60 DAS	90 DAS	120 DAS
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	6.4	12.5	19.6
T_2: 125% RDN through inorganic fertilizer	6.9	14.1	21.5
T_3: 100% RDN + 25 kg $MgSO_4$/ha	6.8	13.7	21.4
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	6.6	12.9	20.5
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	7.5	14.7	22.6
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	7.5	14.3	22.5
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	7.3	14.2	22.2
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	7.5	14.8	22.7
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	7.8	14.9	22.7
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	8.3	16.2	24.8
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	8.4	16.9	25.7
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	8.7	17.4	26.8
S.Em. ±	0.34	0.81	1.22
C.D. (P = 0.05)	1.02	2.40	3.59
C.V. (%)	8.09	9.63	9.31

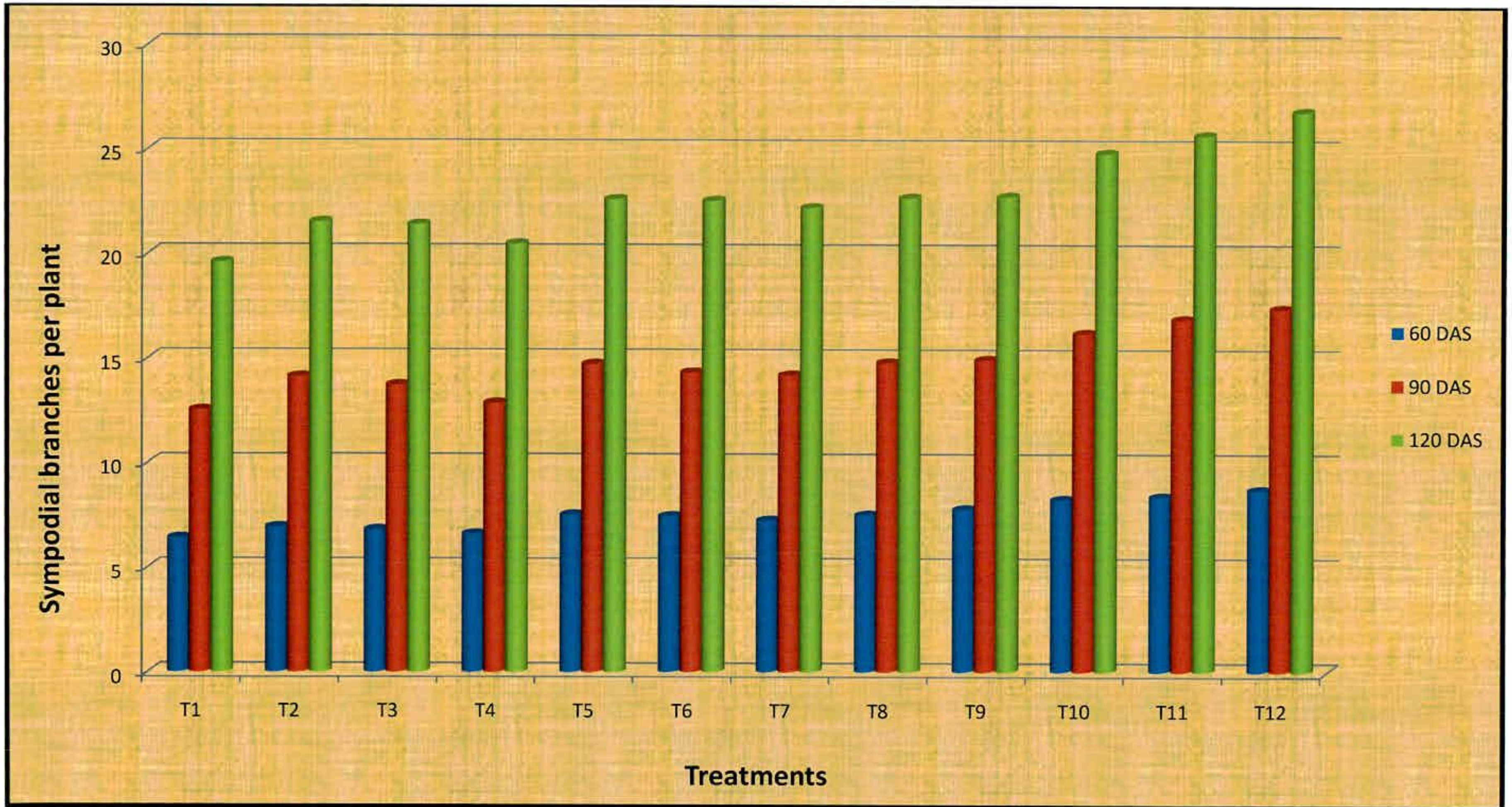


Fig. 4.3: Sympodial branches per plant at 60, 90 and 120 DAS as influenced different integrated nitrogen management treatments

sympodial branches per plant of 25.7. Minimum sympodial branches per plant (19.6) were observed with treatment T_1 (100% RDN through inorganic fertilizer) which was found statistically at par with treatments T_2 to T_9.

4. 2 EFFECT ON YIELD ATTRIBUTES AND YIELD

4.2.1 Number of bolls per plant

Data recorded on number of bolls per plant at 120,150, 180 DAS and at last picking as influenced by different nitrogen management treatments are presented in Table 4.5 and also graphically depicted in Fig. 4.4.

The results showed that significantly higher number of bolls per plant of 22.3, 45.6, 55.3 and 59.7 recorded with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) at 120, 150, 180 DAS and at last picking, respectively but it was found statistically at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha). Treatment T_{10} registered 19.3, 41.3, 50.3 and 52.0 and T_{11} recorded 20.6, 44.0, 53.6 and 57.0 number of bolls per plant at 120, 150, 180 DAS and at last picking, respectively. While minimum number of bolls per plant (14.3, 33.3, 42.3 and 45.6) were observed with treatment T_1 (100% RDN through inorganic fertilizer) at 120, 150, 180 DAS and at last picking, respectively. However, treatment T_1 was found statistically at par with treatments T_2, T_3, T_4, T_6 and T_7 at 120 DAS; treatments T_2 to T_8 at 150 DAS; treatments T_2 to T_9 at 180 DAS and treatments T_2 to T_{10} at last picking.

Table 4.5: Number of bolls per plant as influenced by different integrated nitrogen management treatments

Treatments	No. of bolls per plant			
	120 DAS	150 DAS	180 DAS	Last picking
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	14.3	33.3	42.3	45.7
T_2: 125% RDN through inorganic fertilizer	16.3	35.0	43.3	47.7
T_3: 100% RDN + 25 kg $MgSO_4$/ha	17.0	36.3	43.3	48.7
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	15.3	33.7	42.7	46.3
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	18.0	37.3	47.3	50.3
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	17.7	37.0	46.3	50.0
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	17.0	36.3	45.0	48.7
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	18.3	38.0	47.7	51.0
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	18.7	39.3	48.0	51.3
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	19.3	41.3	50.3	52.0
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	20.7	44.0	53.7	57.0
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	22.3	45.7	55.3	59.7
S.Em. ±	1.18	1.96	2.41	2.62
C.D. (P = 0.05)	3.47	5.75	7.07	7.71
C.V. (%)	11.44	8.91	8.86	8.98

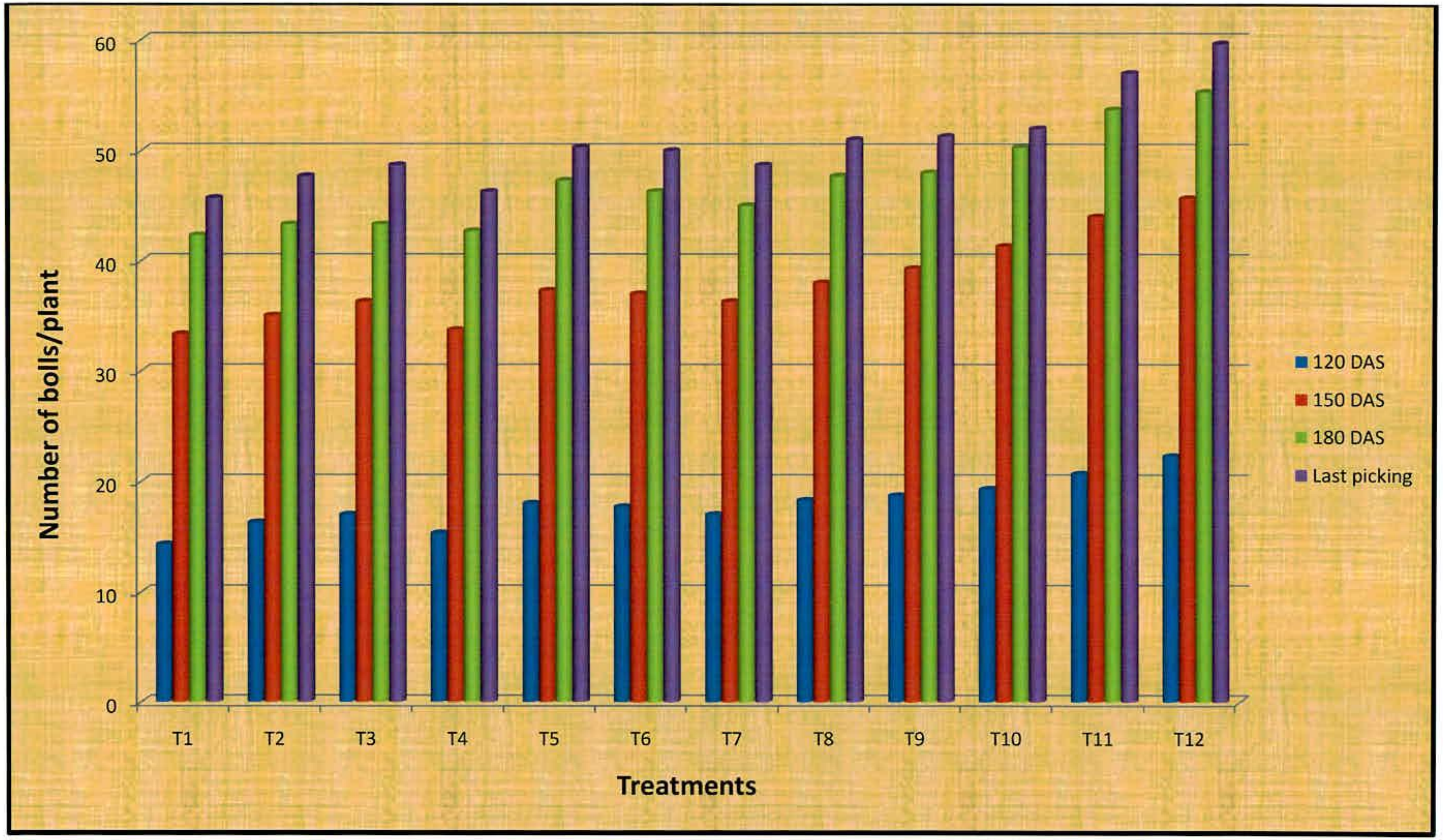


Fig. 4.4: Number of bolls per plant at different growth stages as influenced by different integrated nitrogen management treatments

4.2.2 Weight of seeds per boll

The weight of seeds per boll as influenced significantly by different nitrogen management treatments are tabulated in Table 4.6 and also graphically represented in Fig. 4.5.

The results revealed that significantly higher weight of seed per boll of 3.87 g was produced with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and was found at par with treatments T_5 (50% RDN through inorganic fertilizer + 50% RDN through castor cake), T_8 (50% RDN through inorganic fertilizer + 50% RDN through castor cake + *Azotobacter*), T_9 (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter*), T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha). The lowest weight of seed per boll of 2.86 g was recorded with use of 100% RDN through inorganic fertilizer (T_1) which remained at par with treatments T_2 to T_7.

4.2.3 Number of seeds per boll

The data on number of seeds per boll presented in Table 4.6 indicated that different integrated nitrogen management treatments tried in this experiment did not have significant effect on number of seeds per boll.

4.2.4 100 seeds weight

Data regarding significant effect of different integrated nitrogen management treatments on 100 seeds weight of cotton are furnished in Table 4.6 and graphically illustrated in Fig. 4.5.

An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded higher 100 seeds weight (11.3 g) being at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha). While lower 100 seeds weight of 7.4 was noted with treatment T_1 (100% RDN through inorganic fertilizer) being at par with treatments T_2, T_3, T_4 and T_7.

4.2.5 Weight of seed cotton per boll

The mean data on weight of seed cotton per boll as influenced by different nitrogen management treatments are furnished in Table 4.7 and graphically illustrated in Fig. 4.6.

The results indicated that application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded significantly higher weight of seed cotton per boll of 5.33 g over treatments T_1, T_2, T_3 and T_4. However, it failed to prove its superiority over treatments T_5, T_6, T_7, T_8, T_9, T_{10} and T_{11}. Application of 100% recommended dose of nitrogen

Table 4.6: Weight of seed per boll, number of seeds per boll and 100 seed weight of influenced by different integrated nitrogen management treatments

Treatments	Wt. of seeds per boll (g)	No. of seeds per boll	100 seeds weight (g)
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	2.87	30.9	7.9
T_2: 125% RDN through inorganic fertilizer	3.20	32.7	8.9
T_3: 100% RDN + 25 kg $MgSO_4$/ha	3.13	31.5	8.8
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	3.00	31.7	8.3
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	3.33	33.1	9.4
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	3.20	32.6	9.3
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	3.13	32.3	9.3
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	3.47	33.3	9.5
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	3.60	33.7	9.8
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	3.73	34.3	11.2
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	3.80	35.4	11.2
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	3.87	35.9	11.3
S.Em. ±	0.19	1.55	0.47
C.D. (P = 0.05)	0.58	NS	1.39
C.V. (%)	10.30	8.15	8.63

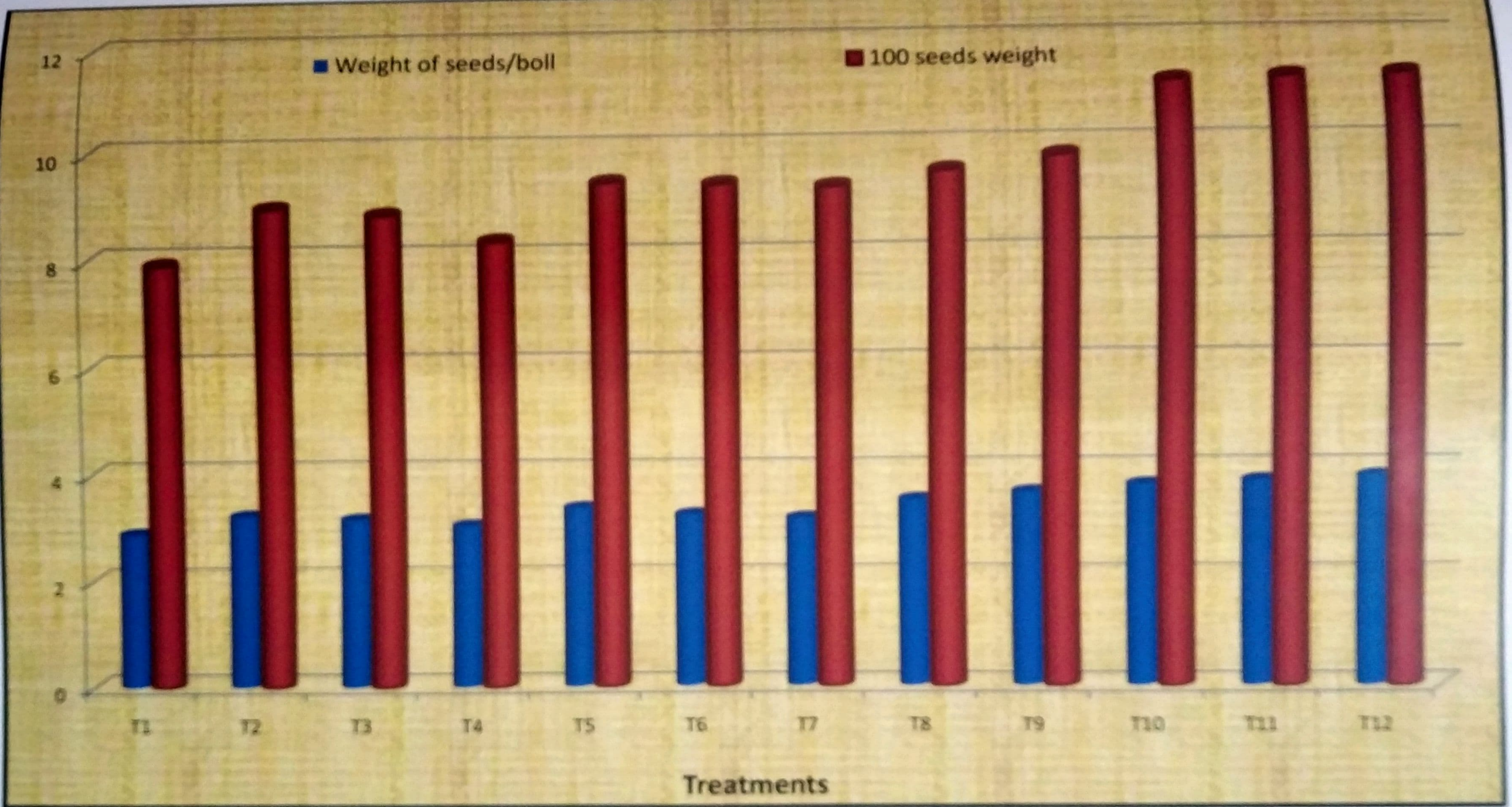


Fig. 4.5: Weight of seeds/boll and 100 seed weight as influenced by different integrated nitrogen management treatments

recorded lower weight of seed cotton per boll (3.80 g) but remained on same bar with treatments T_2, T_3, T_4 and T_7.

4.2.6 Seed cotton yield per plant

The mean data on seed cotton yield per plant as influenced by different nitrogen management treatments are furnished in Table 4.7 and graphically illustrated in Fig. 4.7.

A perusal of data revealed that significantly higher seed cotton yield per plant (165.6 g) was recorded with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB), but it was at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha). Treatments T_{10} and T_{11} registered seed cotton yield of 152.3 g and 162.7 g, respectively. The results further showed that lower seed cotton yield per plant (123.6 g) was noted with treatment T_1 (100% RDN through inorganic fertilizer) but found at par with treatments T_2 to T_8.

Table 4.7: Weight of seed cotton per boll and seed cotton yield per plant as influenced by different integrated nitrogen management treatments

Treatments	Weight of seed cotton per boll (g)	Seed cotton yield per plant (g)
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	3.80	123.7
T_2: 125% RDN through inorganic fertilizer	4.67	132.7
T_3: 100% RDN + 25 kg $MgSO_4$/ha	4.27	131.0
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	4.13	128.0
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	5.00	139.7
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	4.73	137.0
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	4.67	134.7
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	5.07	140.3
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	5.07	143.0
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	5.13	152.3
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	5.20	162.7
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	5.33	165.7
S.Em. ±	0.30	6.55
C.D. (P = 0.05)	0.88	19.23
C.V. (%)	10.97	8.06

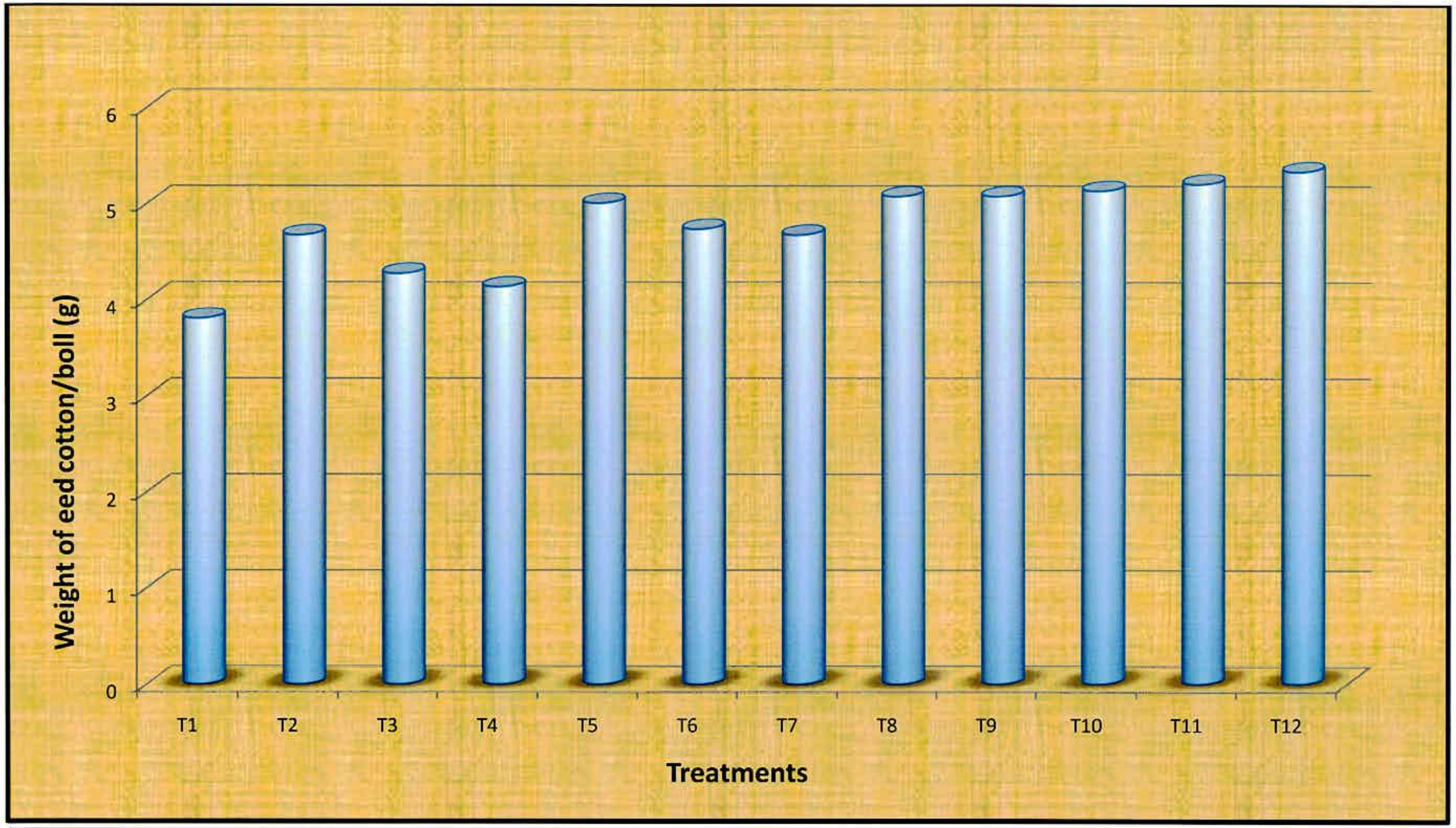


Fig. 4.6: Weight of seed cotton per boll as influenced by different integrated nitrogen management treatments

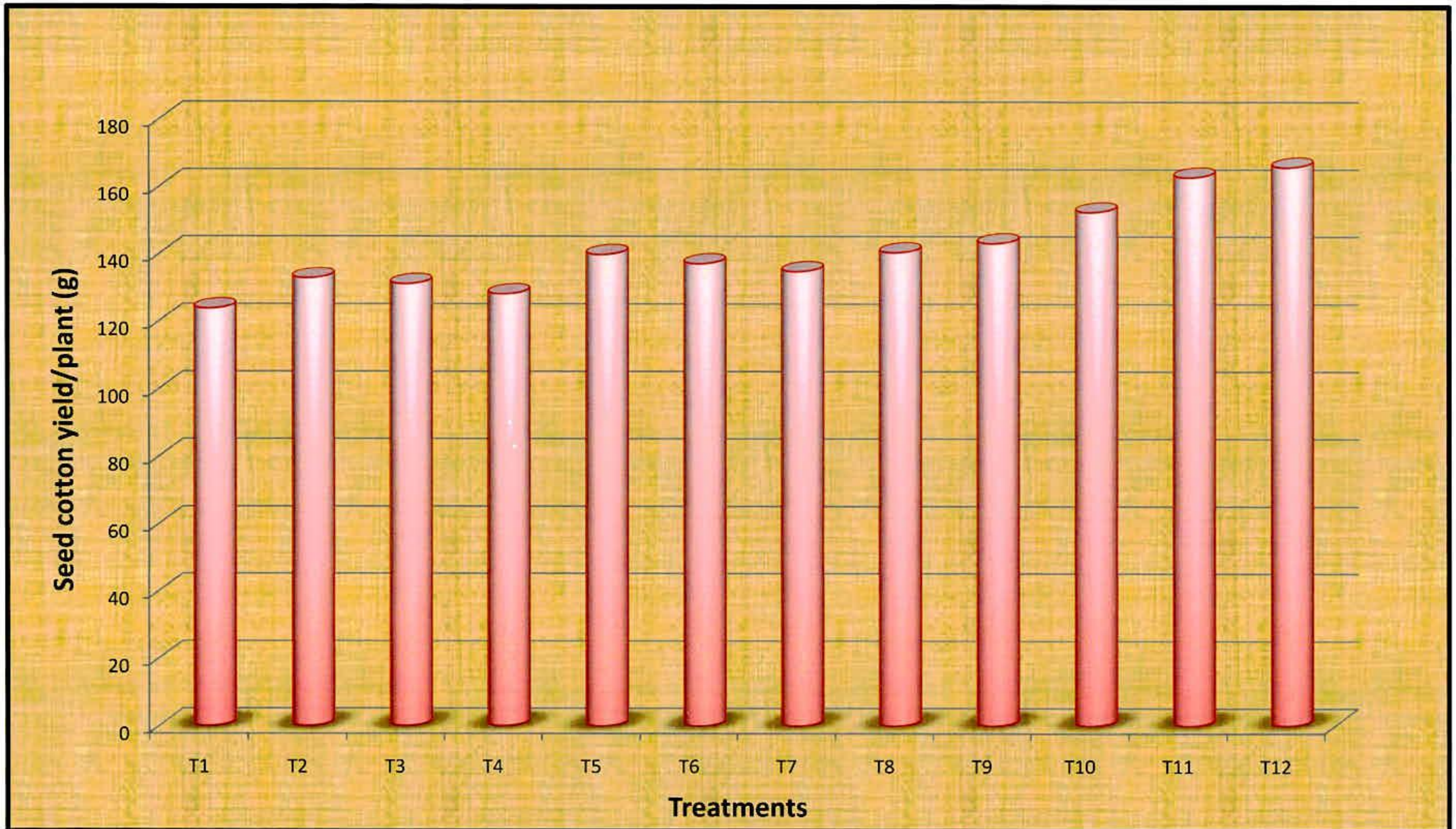


Fig. 4.7: Seed cotton yield per plant as influenced by different integrated nitrogen management treatments

4.2.7 Seed cotton yield (kg/ha)

Data pertaining to seed cotton yield as influenced by different integrated nitrogen management treatments are presented in Table 4.8 and graphically furnished in Fig 4.8.

An appraisal of data presented in Table 4.8 revealed that significantly higher seed cotton yield of 3587 kg/ha was produced with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) but remained at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) which recorded seed cotton yield of 3275 and 3486 kg/ha, respectively. An application of 100% RDN through inorganic fertilizer (T_1) registered significantly lower seed cotton yield (2594 kg/ha) but remained at par with rest of the treatments except T_{10}, T_{11} and T_{12}.

4.2.8 Stalk yield (kg/ha)

Data on stalk yield as influenced significantly by different treatments are presented in Table 4.8 and graphically depicted in Fig 4.8.

The results indicated that an application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB recorded higher stalk yield (6010 kg/ha) but it was found at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* +

Table 4.8: Seed cotton yield and stalk yield of cotton as influenced by different integrated nitrogen management treatments

Treatments	Seed cotton yield (kg/ha)	Stalk yield (kg/ha)
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	2594	4180
T_2: 125% RDN through inorganic fertilizer	2878	4529
T_3: 100% RDN + 25 kg $MgSO_4$/ha	2730	4257
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	2703	4349
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	2942	4651
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	2937	4782
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	2931	5035
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	2945	4811
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	2985	4939
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	3275	5496
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	3486	5781
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	3587	6010
S.Em. ±	166.5	263.1
C.D. (P = 0.05)	488.4	771.8
C.V. (%)	9.61	9.30

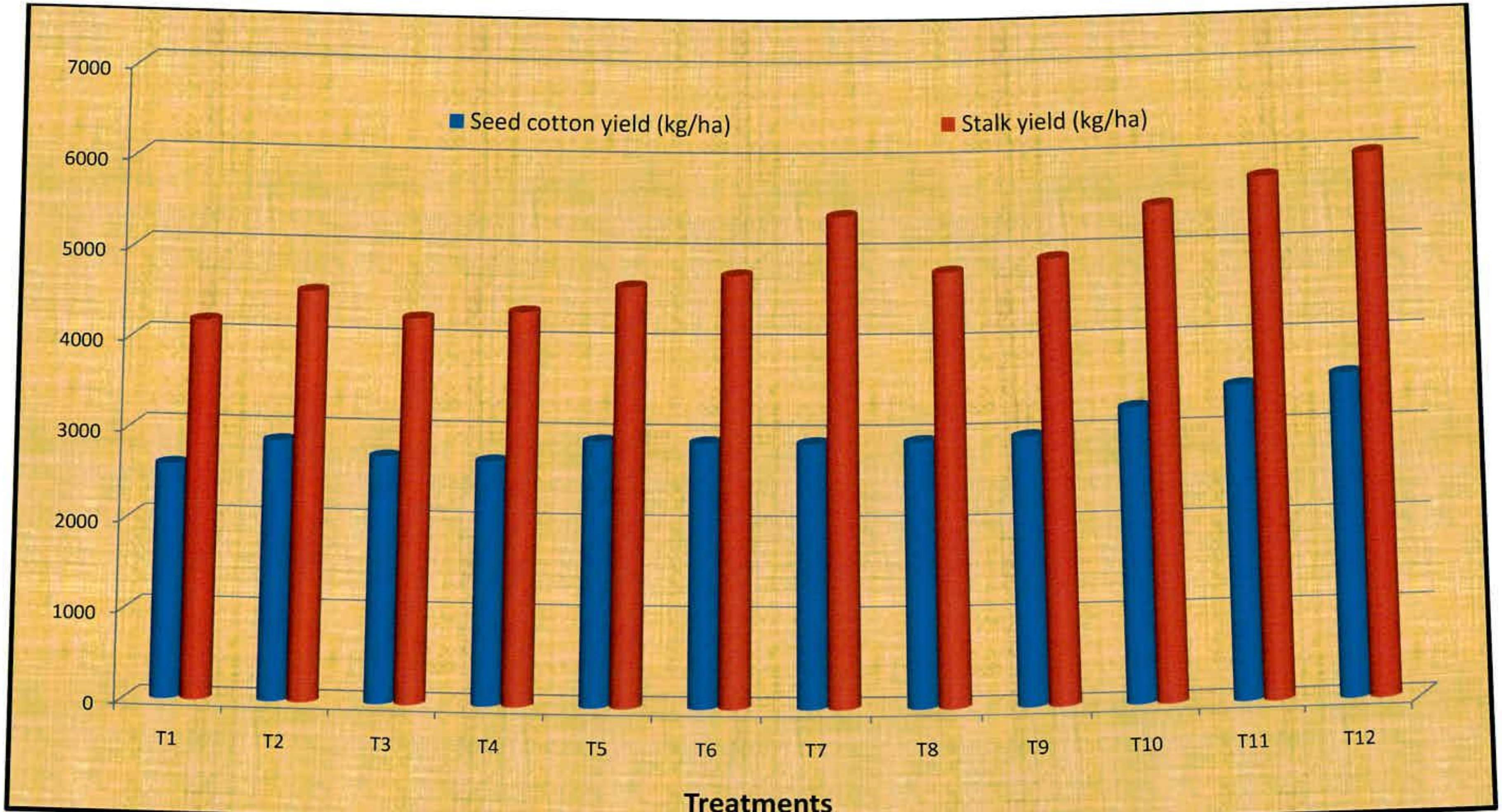


Fig. 4.8: Seed cotton yield and stalk yield Bt. cotton as influenced by different integrated nitrogen management treatments

PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) which recorded stalk yield of 5496 and 5781 kg/ha, respectively. An application of 100% RDN through inorganic fertilizer noted the lowest stalk yield (4180 kg/ha) being at par with treatments T_2, T_3, T_4, T_5, T_6, T_8 and T_9.

4.2.9 Harvest index

The data on harvest index as not influenced significantly by different integrated nitrogen management treatments are presented in Table 4.9.

Table 4.9: Harvest index of cotton as influenced by different integrated nitrogen management treatments

Treatments	Harvest index (%)
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	38.2
T_2: 125% RDN through inorganic fertilizer	38.8
T_3: 100% RDN + 25 kg $MgSO_4$/ha	39.0
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	38.3
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	38.8
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	38.0
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	36.8
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	38.0
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	37.6
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	37.3
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	37.6
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	37.4
S.Em. ±	0.74
C.D. (P = 0.05)	NS
C.V. (%)	5.01

4. 3 EFFECT ON QUALITY PARAMETERS

4.3.1 Oil content in cotton seed (%)

The data on oil content in cotton seed as influenced non significantly by different treatments are presented in Table 4.10.

4.3.2 Oil yield (kg/ha)

Data on oil yield as influenced by different nitrogen management treatments are tabulated in Table 4.10 and also graphically represented in Fig. 4.9.

The results showed that significantly higher oil yield of 652 kg/ha was produced with use of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) but found at par with treatments T_9 (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter*), T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha). The lowest oil yield (425 kg/ha) was noted with treatment T_1 (100% RDN through inorganic fertilizer) but found at par with treatmentsT_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9.

4.3.3 Lint index

The data on lint index presented in Table 4.11 as influenced non significantly by different treatments.

Table 4.10: Oil content in cotton seed and oil yield as different integrated nitrogen management treatments

Treatments	Oil content (%)	Oil yield (kg/ha)
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	16.3	425
T_2: 125% RDN through inorganic fertilizer	16.6	481
T_3: 100% RDN + 25 kg $MgSO_4$/ha	16.6	454
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	16.4	446
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	17.4	512
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	17.1	504
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	17.0	499
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	17.5	515
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	17.7	531
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	17.8	584
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	17.9	627
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	18.2	652
S.Em. ±	0.49	41.65
C.D. (P = 0.05)	NS	122.18
C.V. (%)	5.00	13.89

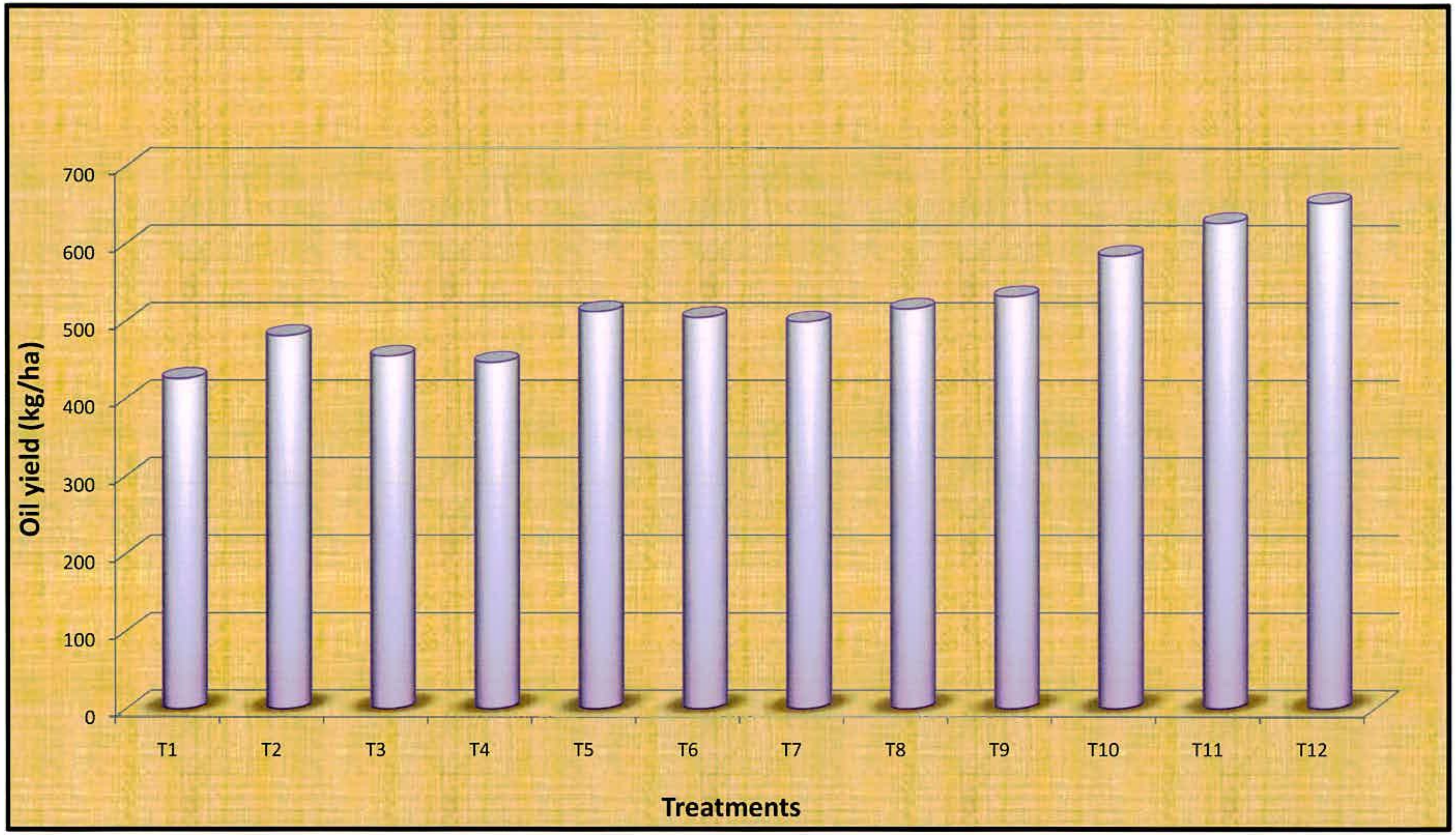


Fig. 4.9: Oil yield as influenced by different integrated nitrogen management treatments

4.3.4 Ginning percentage

The data summarized in Table 4.11 indicated that different integrated nitrogen management treatments did not exert their significant effect on ginning percentage.

4.3.5 Mean fibre length (mm)

The data on mean fibre length presented in Table 4.12 showed non significant effect of different treatments.

Table 4.11: Lint index and ginning percentage as influenced by different integrated nitrogen management treatments

Treatments	Lint index	Ginning percentage
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	4.96	38.7
T_2: 125% RDN through inorganic fertilizer	4.40	30.8
T_3: 100% RDN + 25 kg $MgSO_4$/ha	4.34	32.7
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	4.57	35.7
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	4.14	30.6
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	4.90	34.1
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	4.58	31.1
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	3.64	27.7
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	4.49	32.0
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	4.99	32.5
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	4.74	29.6
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	4.55	28.8
S.Em. ±	0.34	2.63
C.D. (P = 0.05)	NS	NS
C.V. (%)	13.03	14.27

Table 4.12: Mean fibre length of cotton as influenced by different integrated nitrogen management treatments

Treatments	Mean fibre length (mm)
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	29.4
T_2: 125% RDN through inorganic fertilizer	27.0
T_3: 100% RDN + 25 kg $MgSO_4$/ha	27.8
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	28.0
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	29.5
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	29.4
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	29.5
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	29.3
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	30.0
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	28.3
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	28.8
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	28.4
S.Em. ±	0.83
C.D. (P = 0.05)	NS
C.V. (%)	5.00

4.4 EFFECT ON NITROGEN CONTENT AND ITS UPTAKE BY Bt. COTTON

4.4.1 Nitrogen content (%)

A perusal of data summarized in Table 4.13 indicated different nitrogen management treatments did not exerted their significant effect on nitrogen content in leaf, stem and reproductive parts of cotton.

4.4.2 Nitrogen uptake by cotton (kg/ha)

Data on nitrogen uptake by cotton as influenced by different integrated nitrogen management treatments are tabulated in Table 4.13 and also graphically depicted in Fig. 4.10.

An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded significantly higher nitrogen uptake of 143.60 kg/ha being at par with treatments T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) and T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) which recorded N uptake of 130.1 and 139.4 kg/ha, respectively. The lowest nitrogen uptake of 91.36 kg/ha was noted with treatment T_1 (100% RDN through inorganic fertilizer) but found at par with treatments T_2 to T_9.

Table 4.13: Total nitrogen content and uptake by plant as influenced different integrated nitrogen management treatments

Treatments	Nitrogen content (%)	Nitrogen uptake (kg/ha)
T_1: 100% RDN (240 kg N/ha) through inorganic fertilizer	1.39	91.4
T_2: 125% RDN through inorganic fertilizer	1.42	105.2
T_3: 100% RDN + 25 kg $MgSO_4$/ha	1.41	99.4
T_4: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake)	1.40	96.5
T_5: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake)	1.41	106.3
T_6: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake)	1.45	111.5
T_7: 25% RDN (inorganic fertilizer) + 75% RDN (castor cake) + *Azotobacter*	1.44	114.4
T_8: 50% RDN (inorganic fertilizer) + 50% RDN (castor cake) + *Azotobacter*	1.47	112.9
T_9: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter*	1.47	115.6
T_{10}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	1.48	130.1
T_{11}: 75% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha	1.49	139.4
T_{12}: 100% RDN (inorganic fertilizer) + 25% RDN (castor cake) + *Azotobacter* + PSB	1.50	143.6
S.Em. ±	0.04	8.82
C.D. (P = 0.05)	NS	25.88
C.V. (%)	5.08	13.42

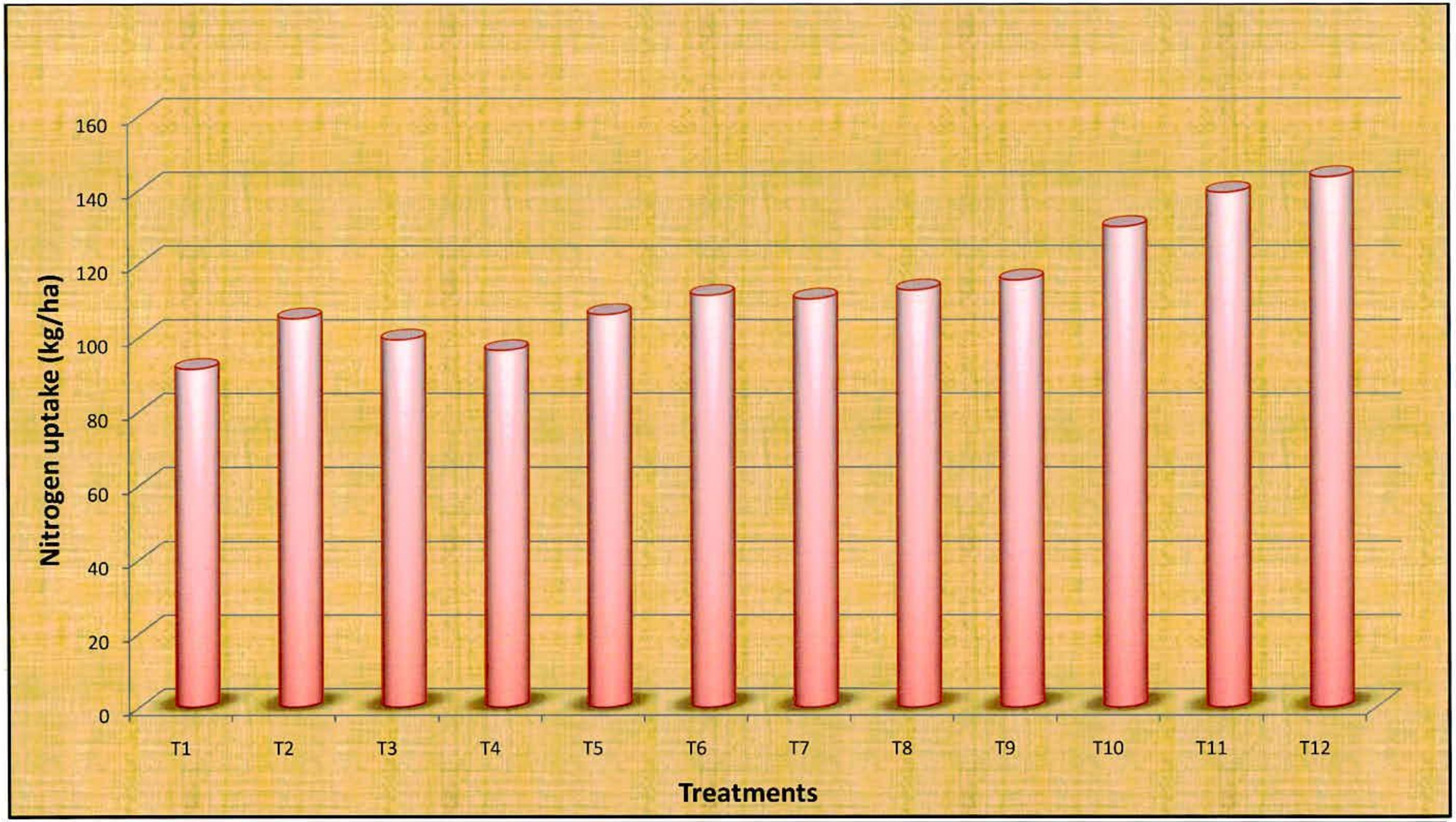


Fig. 4.10: Total nitrogen uptake (kg/ha) by plant as influenced by different integrated nitrogen management treatments

4. 5 EFFECT ON ECONOMICS

On the basis of prevailing market prices of seed cotton and different variable and non-variable inputs, the cost of production, gross realization, net income and benefit cost ratio (BCR) of various treatments were calculated and presented in Table 4.14. Net realization and BCR also illustrated graphically in Fig. 4.11

Maximum net income of ₹ 111707/ha and benefit : cost ratio (3.25) was recorded with treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) closely followed by treatment T_{11} which recorded net realization of ₹ 110218/ha and BCR of 3.22. Minimum net income (₹ 59672/ha) with benefit cost ratio (1.93) was recorded with treatment T_4 (25% RDN through inorganic fertilizer + 75% RDN through castor cake).

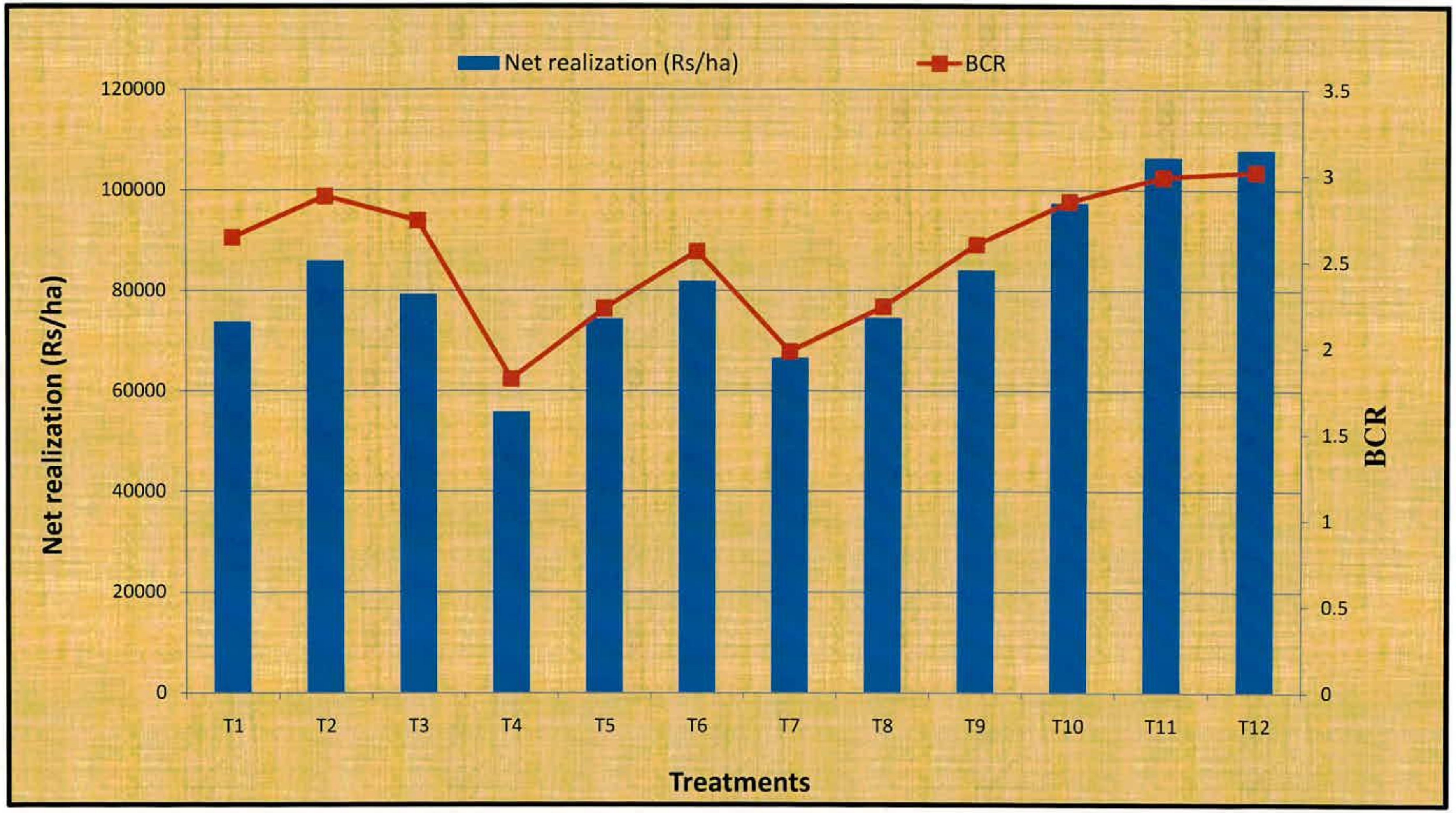


Fig. 4.11: Net realization (₹/ha) and benefit cost ratio as influenced by different integrated nitrogen management treatments

DISCUSSION

V. DISCUSSION

During the course of presenting the results of experiment, **"Integrated nitrogen management in Bt. cotton (*Gossypium hirsutum* L.)"** showed many significant variations in biometric observations of cotton among different treatments. In this chapter, an attempt has been made to establish "effect and cause relationship" in the light of available evidences and relevant literature. Possible explanations are given for the variations observed and supported by relevant findings. For the sake of convenience, the results presented in the preceding chapter are discussed under following major sub-heads :

5. 1 EFFECT OF WEATHER

5.2 EFFECT OF TREATMENTS ON GROWTH PARAMETERS

5.3 EFFECT OF TREATMENTS ON YIELD ATTRIBUTES AND YIELD

5.4 EFFECT OF TREATMENTS ON QUALITY PARAMETERS

5.5 EFFECT OF TREATMENTS ON NITROGEN CONTENT AND UPTAKE

5.6 EFFECT OF TREATMENTS ON ECONOMICS

5. 1 EFFECT OF WEATHER

The crop responses are mainly governed by soil, available soil moisture and condition of certain weather parameters during crop growth and development.

The meteorological data (Table 3.1) revealed that climatic conditions remained satisfactory during the crop growth period. It was observed that minimum temperature ranged between 6.8 to 27.5°C while maximum temperature between 24.5 to 39.6°C during the course of investigation. The average relative humidity and sunshine hours were optimum during the period of investigation. Thus, the crop season was normal for growth and development of *kharif* cotton. There was no adverse effect on subsequent growth and development of the crop on account of timely and need based control measures of pests and diseases. Moreover, all the cultural operations required for the crop were met adequately at the right time. Hence, whatever variations observed for different characters under the study were mainly attributed to the different treatments imposed in the experiment.

5.2 EFFECT OF TREATMENTS ON GROWTH PARAMETERS

The experimental results presented in Table 4.1 revealed that plant population of cotton at 30 DAS and at harvest was not significantly affected due to different integrated nitrogen management treatments. It indicates that uniform plant population was maintained during the crop growth period in all the treatments. It also indicated that there was no any adverse effect of any treatments on germination of crop seeds. Hence, whatever variation observed in growth and yield attributes and yield of Bt. cotton were only attributed due to various treatments.

An appraisal of data presented in Table 4.2 revealed that the notable taller plant height of 33.3, 78.6, 140.1 and 162.3 cm at 30, 60, 90 and 120 DAS, respectively was observed under treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB). Further, the magnitude of increase in plant height at 30, 60, 90 and 120 DAS under treatment T_{12} was to the tune of 62.4, 30.8, 27.7 and 33.4 percent, respectively over treatment T_1 (100% RDN through inorganic fertilizer). Treatment T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) ranked second position in recording the plant height at 30, 60, 90 and 120 DAS. This might be due to adequate supply of N through inorganic fertilizers along with castor cake as well as seed inoculation with biofertilizers which enhanced cell division and cell enlargement which converted more solar energy into chemical energy might be resulted in faster growth in term of taller plants leading to increased dry matter production through larger photosynthesizing surface. These results are in close vicinity with the findings of Pandey *et. al*. (1989) observed that establishment of *Azotobacter chroococum* in rhizosphere resulted in significant increase in growth of cotton crop; Bodake and Rana (2008) reported that application of 75% RDF + 25% RDN through castor cake gave maximum plant height at harvest in spring sunflower; Sunitha *et al.,* (2010), Modhvadia *et al.*, (2012) noted that maximum plant height observed with application of 240 kg N ha^{-1} and Alitabar *et al.*, (2013) reported that application of 225 kg N ha^{-1} gave maximum plant height.

A perusal of data presented in Table 4.3 indicated that higher number of monopodial branches per plant of 3.4 and 4.6 at 60 and 90 DAS, respectively were observed under treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB). Further, the magnitude of increase in number of monopodial branches per plant at 60 and 90 DAS under treatment T_{12} was to the tune of 37.6 and 35.3 percent, respectively over treatment T_1 (100% RDN through inorganic fertilizer). Similarly, the data presented in Table 4.4 indicated that higher number of sympodial branches per plant of 8.7, 17.4 and 26.8 at 60, 90 and 120 DAS, respectively was observed under treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB). Further, the magnitude of increase in number of sympodial branches per plant at 60, 90 and 120 DAS under treatment T_{12} was to the tune of 36.4, 38.9 and 36.7 percent, respectively over treatment T_1 (100% RDN through inorganic fertilizer). Treatment T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) ranked second position in recording the number of monopodial branches per plant at 60 and 90 DAS and sympodial branches per plant at 60, 90 and 120 DAS.

More number of monopodial and sympodial branches per plant in this treatment is due to availability of major growth promoting nutrient N from inorganic fertilizer; P and micronutrients from castor cake, *Azotobacter* fix atmospheric nitrogen, PSB convert insoluble phosphorus into soluble from which helps in better availability of N, P and micronutrients resulted in higher accumulation and translocation might have improved vegetative growth ultimately increased monopodial and sympodial branches. These results are in conformity with those reported by Pandey *et. al*. (1989) observed that establishment of *Azotobacter chroococum* in rhizosphere resulted in significant increase in growth of cotton crop; Modhvadia *et al.*, (2012) reported that application of 240 kg N/ha produced significantly higher no. of monopodial and sympodial branches/plant) in cotton crop and Alitabar *et al.*,(2013) results reported that application of 150 kg N ha^{-1} gave maximum sympodial branches per plant.

5.3 EFFECT OF TREATMENTS ON YIELD ATTRIBUTES AND YIELD

Data pertaining to number of bolls per plant at 120, 150, 180 DAS and at last picking (Table 4.5), weight of seeds per boll and 100 seeds weight (Table 4.6) and weight of seed cotton per boll and seed cotton yield per plant (Table 4.7) were significantly influenced due to different integrated nitrogen management treatments.

An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) exerted its notable impact on increment of number of bolls per plant (22.3, 45.6, 55.3 and 59.7, respectively) at 120, 150, 180 DAS and at last picking followed by the treatments T_{10} and T_{11} (Table 4.5). The percent increase in number of bolls per plant were 55.9, 36.9, 30.7 and 30.4% at 120, 150, 180 DAS and at last picking over treatment T_1. Similarly remarkably higher weight of seeds per boll (3.9 g) were recorded under application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) followed by the treatments T_{11}, T_{10}, T_9, T_8 and T_5 (Table 4.6). The percent increase in weight of seeds per boll was 34.84 percent over treatment T_1.

Increased value of these yield attributes might be due to the fact that addition of castor cake and inoculation of *Azotobacter* and PSB along with inorganic fertilizers increased availability of nutrients which might have accelerated crop growth there by enhanced photosynthetic activity, which might have enhanced number of flowers and their fertilization resulting in higher number of bolls per plant and weight of seeds per boll. This might be also due to higher dry matter accumulation and effective partitioning of the assimilates to the sink, as a result of availability of nitrogen coinciding with physiological needs of the crop. These findings corroborated by Pandey *et. al.*, (1989) observed that establishment of *Azotobacter chroococcum* in rhizosphere resulted in significant increase yield attributing parameters in cotton crop; Sawan *et al.*, (2006) showed that number of bolls/plant, significantly increased with application of nitrogen @143 kg/ha; Hallikeri *et al.*, (2010) observed that application of 160 kg N/ha produced significantly higher no. of bolls/plant in cotton crop; Bibi *et al.*, (2011) reported that application of 150 kg N/ha significantly increased bolls per plant and Modhvadia *et al.*, (2012) showed that application of 240 kg N/ha produced significantly higher no. of bolls/plant.

100 seeds weight (Table 4.6) was significantly influenced due to different treatments of integrated nitrogen management. Among different treatments, an application of 100% RDN through inorganic fertilizer + 25 % N through castor cake + *Azotobacter* + PSB (T_{12}) stood first with maximum value of 100 seed weight of 11.3 g followed by T_{11} and T_{10} treatments. Percent increase in 100 seed weight under treatment T_{12} was to the tune of 43.4% over treatment T_1.

Further, higher assimilating surface at reproductive development stage resulted in better grain formation because of adequate production of metabolites and their translocation towards sink/grain as evident from nutrient concentration and their uptake might have resulted in increased weight of individual seed (bold seed). The results supported by the findings of Sawan *et al*., (2006) showed that seed index significantly increased with application of nitrogen @143 kg/ha and Bodake and Rana (2008) reported that application of 50% RDN through inorganic fertilizer and 50% RDN through castor cake gave significantly higher 1000 seeds weight of sunflower.

On the other hand, different treatments of INM did not exert their significant influence on number of seeds per boll (Table 4.6).

An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}), exerted its notable impact on weight of seed cotton per boll (5.80 g) followed by treatments T_{10} and T_{11}. The percent increase in weight of seed cotton per boll was 40.3 percent over treatment T_1. Similarly remarkably higher seed cotton yield per plant (165.7 g) was recorded under application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) followed by the treatments T_{10} and T_{11} (Table 4.6). The percent increased in seed cotton yield per plant was 33.9 percent over treatment T_1.

Increase in seed cotton yield per plant with application of 100% RDN through fertilizer in conjuction with 25% RDN through castor cake along with

Azotobacter + PSB evidently resulted from higher number of bolls per plant, weight of seeds per boll, 100 seeds weight and weight of seed cotton per boll. The results supported by the finding of Sawan *et al*., (2006); Hallikeri *et al*., (2010); Bibi *et al*., (2011) and Modhvadia *et al.* (2012) reported that application of nitrogen produced significantly higher boll weight in cotton crop.

The remarkable differences in seed cotton yield and stalk yield (Table 4.8) of Bt. cotton were noted due to different integrated nitrogen management treatments. An application of 100% RDN through inorganic fertilizer + 25 % N through castor cake + *Azotobacter* + PSB (T_{12}) registered maximum seed cotton yield (3587 kg/ha) and stalk yield (6010 kg/ha) followed by treatments T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) and T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB). Treatments T_{12}, T_{11} and T_{10} recorded 38.2, 34.4 and 26.2 percent higher seed cotton yield; 43.8, 38.3 and 31.4 percent higher stalk yield over treatments T_1, respectively. Higher yield in these treatments might be due to cumulative effect of elevated growth stature as well as yield structure. Increase in seed cotton yield and stalk yield were mainly because of increase in plant height (Table 4.2), number of monopodial (Table 4.3) and sympodial (Table 4.4) branches per plant, number of bolls per plant (Table 4.5), weight of seed per boll (Table 4.6), higher value of 100 seeds weight (Table 4.6), weight of seed cotton per boll (Table 4.7) and weight of seed cotton per plant (Table 4.7) resulted from combined effect of organic manure (castor cake), biofertilizers (*Azotobacter* and

Plat III : 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12})

Plat III : 100% RDN (240 kg N/ha) through inorganic fertilizer (T_1)

PSB) and chemical fertilizer that provided balanced nutrition and favourable soil environment for better plant growth resulted in maximum seed cotton and stalk yield/ha. Moreover, organic manure and biofertilizers might have helped in increase of uptake of nutrients due to release of nutrients at its optimum for a longer period, increase the supply of easily assimilated major and micro nutrients to plant besides mobilizing unavailable plant nutrients into available form by biofertilizer and at the same time improved soil physical condition that in turn gave higher yields. These findings indicated that the combined application of organic sources (castor cake and biofertilizers) and chemical fertilizer is superior to sole inorganic fertilizer application. The results are supported by Hallikeri *et al.,*(2010), Sunitha *et al.,*(2010) and Modhavadia *et al.,*(2012) reported that application of nitrogen (160 to 240 kg N/ha) produced significantly higher seed cotton yield; Anon., (2003), Das *et al.*, (2006) and Ismail *et al.*, (2011) noted that seed inoculation with biofertilizer (*Azotobacter* and PSB) resulted in considerable improvement in seed cotton yield; Anon. (2012) reported that application of castor cake (500 kg/ha) + seed treatment with *Azotobacter* + PSB (25 g/kg seed) gave significantly the highest seed cotton yield and Anon. (2006) results showed that application of 75% RDN from castor cake and 25% RDN from FYM gave significantly higher seed cotton yield and stalk yield

Harvest index (Table 4.9) was not significantly influenced due to different treatments of integrated nitrogen management.

5.4 EFFECT OF TREATMENTS ON QUALITY PARAMETERS

Different treatments of INM did not exert their significant influence on oil content (Table 4.10).

Oil yield (Table 4.10) was significantly influenced due to different treatments of integrated nitrogen management. Among different treatments, an application of 100% RDN through inorganic fertilizer + 25 % N through castor cake + *Azotobacter* + PSB (T_{12}) recorded significantly higher oil yield (652 kg/ha) followed by T_{11} and T_{10} treatments. Percent increase in oil yield under treatment T_{12} was to the tune of 53.3% over treatment T_1. Increase in oil yield with application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB evidently resulted from higher seed cotton yield. Sawan *et al.,* (2006) noted that oil yield per hectare (total production) significantly increased, which is attributed to the significant increase in cotton seed yield.

Different treatments of INM did not exert their significant influence on lint index (Table 4.11). These results are similar to those reported by Das *et al.,* (2006) and Mahavishnan *et al.* (2008).

Ginning percentage (Table 4.11) was not significantly influenced due to different treatments of integrated nitrogen management. These results are similar to those reported by Das *et al.* (2006) reported that different sources of nitrogen did not exert any significant effect on ginning percentage of cotton with the application of 60 kg N/ha through fertilizer.

Different treatments of INM did not exert their significant influence on mean fibre length (Table 4.12). These results are similar to those reported by Das *et al.* (2006) reported that different sources of nitrogen did not exert any significant effect on fibre length of cotton with the application of 60 kg N/ha through fertilizer and Mahavishnan *et al.* (2008) found that fibre length were remained unaffected due to various N management practices in cotton..

5.5 EFFECT OF TREATMENTS ON NITROGEN CONTENT AND UPTAKE

Nitrogen content (Table 4.13) was not significantly influenced due to different integrated nitrogen management treatments. This might be due to dilution effect. On the contrary Wanjura and Sundaraman (1976) reported that N concentration in vegetative parts was increase with increased N levels.

Total nitrogen uptake (Table 4.13) by plant was also significantly influenced due to different integrated nitrogen management treatments. An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) considerably increased total nitrogen uptake (143.60 kg/ha) than all other treatments followed by treatments T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha) and T_{10} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB). The increase in nitrogen uptake was 57.1, 52.5 and 42.3 percent higher under treatment T_{12}, T_{11} and T_{10}, respectively against the treatment T_1. This might be due to better nourishment resulted from combined application of inorganic fertilizer, castor cake and biofertilizers on growth and yield attributes ultimately resulted in higher seed cotton and stalk yield and consequently more nitrogen utilization by the crop. Similar conclusion was drawn by Das *et al.* (2006) whose results indicated considerable increase in NPK uptake by cotton with the application of 30 kg N/ha through *Azotobacter* inoculation, Das and Reddy (2009) and Bodake and Rana (2008) reported that application of 100% RDF through fertilizer gave maximum total nitrogen uptake.

5.3 EFFECT OF TREATMENTS ON ECONOMICS

Data on economics as influenced by different integrated management treatments are presented in Table 4.14. The highest net realization of ₹ 1,11,707/ha with BCR value of 3.25 was recorded with application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) closely followed by T_{11} (75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha). The treatment T_{12} gave higher net profit of ₹ 52,035/ha over treatment T_4 (25% RDN through inorganic fertilizer + 75% RDN through castor cake) which was to the tune of 87.2 percent. This indicated that integrated use of castor cake and biofertilizers along with chemical fertilizer found more beneficial with respect to net return. This could be attributed due to higher seed and stalk yield received in these treatments. Similar trend was also observed by Anon. (2006) showed that an application of 25% RDN through organic sources and 75% RDN through inorganic sources recorded the highest net realization and BCR in cotton crop; Bodake and Rana (2008) reported that an application of 50% RDF + 50% RDN through castor cake gave maximum net return in spring sunflower and Das and Reddy (2009) reported that application of higher level of nitrogen gave maximum profit.

SUMMARY AND CONCLUSION

VI. SUMMARY AND CONCLUSION

A field experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District Banaskantha (North Gujarat) to study, **"Integrated Nitrogen Management in Bt. cotton (*Gossypium hirsutum* L.)"** during *kharif* season of 2013-14 on loamy sand soil. The experiment was laid out in randomized block design with three replications. Total twelve treatments were evaluated in the present study *viz,* T_1: 100% RDN through inorganic fertilizer (240 kg N/ha), T_2: 125% RDN through inorganic fertilizer, T_3: 100% RDN through inorganic fertilizer + 25 kg $MgSO_4$/ha, T_4: 25% RDN through inorganic fertilizer + 75% RDN through castor cake, T_5: 50% RDN through inorganic fertilizer + 50% RDN through castor cake, T_6: 75% RDN through inorganic fertilizer + 25% RDN through castor cake, T_7: 25% RDN through inorganic fertilizer + 75% RDN through castor cake + *Azotobacter,* T_8: 50% RDN through inorganic fertilizer+ 50% RDN through castor cake + *Azotobacter,* T_9: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter,* T_{10}: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB, T_{11}: 75% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB + 25 kg $MgSO_4$/ha and T_{12}: 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB.

The results presented and discussed in preceding chapters are summarized as under:

[1] Plant population recorded at 30 DAS and at harvest was not significantly affected due to different integrated nitrogen management treatments.

[2] An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded significantly higher plant height at 30, 60, 90 and 120 DAS while the lowest plant height 20.5, 60.1, 109.7 and 121.7 cm at 30, 60, 90 and 120 DAS, respectively was recorded under T_1(100% RDN through inorganic fertilizer).

[3] Significantly higher number of monopodial branches per plant was noted under T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) at 60 and 90 DAS which was at par with T_9, T_{10} and T_{11} at 60 DAS and T_{10} and T_{11} at 90 DAS.

[4] Remarkably higher sympodial branches per plant was recorded with T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) at 60, 90 and 120 DAS.

[5] An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB registered significantly higher number of bolls per plant at 120,150,180 DAS and at final picking, however, it was statistically at par with T_{10} and T_{11} at 120,150,180 DAS and at final picking.

[6] Significantly higher weight of seeds per boll was produced under T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) over rest of the treatments except T_8, T_9, T_{10} and T_{11} treatments.

[7] Significantly maximum 100 seeds weight was registered under treatment T_{12} which remained at par with treatments T_{10} and T_{11}.

[8] Any treatment had no significant influence on number of seeds per boll.

[9] Treatment T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB) recorded significantly higher weight of seed cotton per boll but remained at par with treatments T_5, T_6, T_7, T_8, T_9, T_{10} and T_{11}.

[10] Seed cotton yield per plant was found significantly maximum under application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB and being at par with treatments T_{10} and T_{11}.

[11] An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) produced significantly higher seed cotton yield and stalk yield but it was found at par with treatments T_{10} and T_{11}.

[12] Harvest index was not significantly affected due to different integrated nitrogen management treatments.

[13] The seed oil content did not affect significantly due to different integrated nitrogen management treatments.

[14] Significantly higher oil yield was noted under T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB), which was found at par with T_9, T_{10} and T_{11}.

[15] Different integrated nitrogen management treatments were failed to exert their significant influence on lint index, ginning percentage and mean fibre.

[16] An application of 100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB (T_{12}) recorded significantly higher nitrogen uptake (143.6 kg/ha) over rest of the treatments except T_{10} and T_{11}.

[17] Maximum net realization (₹ 1,11,707/ha) and BCR (3.25) were registered with T_{12} (100% RDN through inorganic fertilizer + 25% RDN through castor cake + *Azotobacter* + PSB).

CONCLUSION :

On the basis of the results of one year experiment, it can be concluded that *kharif* Bt. Cotton may be fertilized with 75% recommended dose of N (180 kg/ha) through inorganic fertilizer + 25% RDN (60 kg/ha) through castor cake along with seed inoculation with *Azotobacter* and PSB for securing higher seed cotton yield and net realization grown on loamy sand soil of North Gujarat.

REFERENCES

REFERENCES

AICCIP 1999a. *Annual Report 1998*-99. All India Coordinated Cotton Improvement Project., Project Coordinator, CICR, Regional station, Coimbatore, pp. 34.

AICCIP 1999b. *Annual Report 1998*-99. All India Coordinated Cotton Improvement Project., Project Coordinator, CICR, Regional station, Coimbatore, pp. 36.

AICCIP 2003a. *Annual Report 2002*-03. All India Coordinated Cotton Improvement Project., Project Coordinator, CICR, Regional station, Coimbatore, pp. 16.

AICCIP 2003b. *Annual Report 2002*-03. All India Coordinated Cotton Improvement Project., Project Coordinator, CICR, Regional station, Coimbatore, pp. 17.

AICCIP 2004. *Annual Report 2003*-04. All India Coordinated Cotton Improvement Project., Project Coordinator, CICR, Regional station, Coimbatore, pp. 15.

AICCIP 2005. *Annual Report 2004*-05. All India Coordinated Cotton Improvement Project., Project Coordinator, CICR, Regional station, Coimbatore, pp. 25.

AICCIP 2012. *Annual Report 2011-12*. All India Coordinated Cotton Improvement Project., Project Coordinator, CICR, Regional station, Coimbatore, pp. 21.

Alitabar, R.A., Salimbeck, R., Alishah, O., Ali, S .A. and Arkhor 2013. The effects of nitrogen and row spacing on growth and yield of cotton varieties. *International Journal of Agriculture: Research and Review.* **3** (1) : 120-125

Anonymous 2006. Effect of organic manure and inorganic fertilizers and their interaction on cotton - late sown wheat cropping sequence, *Annual Report 2005-06*, Dept. of Agronomy, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, pp. 33-41.

Bibi, Z., Khan, N.U., Mussarat, M., Khan, M.J., Ahmad, R., Khan I.U. and Shaheen, S. 2011. Response of *Gossypium hirsutum* genotypes to various nitrogen levels. *Pakistan Journal of Botany*, **43** (5) : 2403-2409.

Bodake, P.S. and Rana, D.S. 2008. Evaluation of jatropha and castor cake as a source of nutrient and soil amendment in spring sunflower (*Helianthus annuus*) - maize (*Zea mays*) sequence. *Indian Journal of Agronomy,* **54** (3) : 284-290.

Butter, G. S., Sekhon, K. S. and Singh, S. 2010. Effect of different spacings and nitrogen levels on growth and yield attributes of American cotton (*Gossypium hirsutum* L.) Bt. hybrids under irrigated conditions. *Journal of Cotton Research and Devlopment*, **24** (1) : 73

CCI 2014. Area, production and yield of cotton in India (2013-14). Cotton Advisory Board, New Mumbai – 400 614 (Maharashtra).

Clawson, E. L., Cothren, J. T., and Blouin, D. C. 2006. Nitrogen fertilization and yield of cotton in ultra-narrow and conventional row spacings. *Agronomy Journal,* **98** : 72-79.

Das, A., Prasad, M., Gautam, R.C. and Shivay, Y.S. 2006. Productivity of cotton as influenced by organic and inorganic sources of nitrogen. *Indian Journal of Agricultural sciences* **76** (6) : 354-357.

Das, D.M. and Reddy, M.G. 2009. Influence of level and frequency of nitrogen application on nutrient uptake, yield and economics of Bt. cotton Hybrids, *Journal of ANGRAU,* **37** (1&2) : 50-52.

Emara, M.A. and El-Gammaal, A.A. 2012. Effect of plant distribution and nitrogen fertilizer levels on new promising hybrid cotton (Giza 89 X Giza 86) *Journal of Agricultural Research*, **38** (1) : 54-71.

Hallikeri, S. S., Halemani, H. L., Patil, V. C., Palled, Y. B., Patil, B. C. and Katageri, I.S. 2010. Effect of nitrogen levels, split application of nitrogen and detopping on seed cotton yield and fibre quality in Bt-cotton. *Karnataka Journal of Agriculture Science*, **23** (3) : 418-422.

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.

Ismail, S., Karle, A.S. and Patil, V.D. 2011. Effect of transgenic Bt. cotton on yield and non-target soil microorganisms. Marathwada Agricultural University, Parbhani, MS, India.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kummar, R. M. 1981. Response of irrigated hybrid cotton to levels and trail of nitrogen application. M. Sc. (Agri.) Thesis, University of Agriculture Sciences, Bangalore (Karnataka).

Kundu, B. S. and Gaur, A. C., 1980. Establishment of nitrogen fixing and phosphate solubilizing bacteria in rhizosphere and their effect on yield and nutrient uptake of wheat crop. *Pl. Soil*, **57** : 223-230.

Mahavishnan, K., Prasad, M. and Rekha, K. 2008. Production potential and quality parameters of cotton (*Gossypium hirsutum* L.) as influenced by integrated nutrient management option in cotton-sunflower cropping system. *Indian Journal of Agriculture Research*, **42**(2): 147-149.

Modhvadia, J.M., Solanki, R.M. and Khanpara, M.D. 2012. Growth and yield of Bt. cotton (*Gossypium hirsutum* L.) as affected by nitrogen, phosphorus and potassium under irrigation condition. *GAU Research Journal*, **37** (2) : 97-99.

Olsen, S.R., Cole, V.C., Wetanable, F.C. and Dean, L.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA. Circ. No 939.

Pandey, A., Shende, S.T. and Apte, R.G. 1989. Effect of *Azotobacter chroococum* seed inoculation on its establishment in rhizosphere on growth, yield and yield attributing parameters of cotton (*Gossypium hirsutum*), *Zentralblatt for Microbiology* **144** (8) : 146-149.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical methods for agricultural workers. ICAR Publication, New Delhi.

Patel, R.M. 2007. Effect of preceding *kharif* crops on growth and yield of rabi castor (*Ricinus communis* L.) as influenced by varying level of spacing and nitrogen under North Gujarat agro-climatic condition Ph.D. (Agri) thesis submitted to SDAU, Sardarkrushinagar.

Piper, C.S. (1966). Soil and plant analysis. Academic Press, New York.

Prakash, A.H., Bandyopadhyay, K.K., Gopalakrishanan, N. and Kumar, A.A. 2010. Interaction of thermal time and nitrogen levels on growth and productivity of cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Science*, **80** (8) : 704-709.

Sagarka, B.K., Malavia, D.D., Solanki, R.M., Kachot, N.A. and Dabhi, B.M. 2002. Response of *rabi* hybrid cotton to irrigation methods and nitrogen levels. *Indian Journal of Agricultural Research*, **36** (3) : 200-203.

Sawan, Z.M., Mahmoud, H. and Guibali, A.H. 2006. Response of yield, yield components and fiber properties of Egyptian cotton (*Gossypium barbadense* L.) to nitrogen fertilization and foliar applied potassium and mepiquat chloride. The *Journal of Cotton Science* **10**: 224-234.

Sikka, S.M. and Joshi, A.B. 1960. Cotton in India. A Monograph. Vol. I. ICCC, Bombay, pp. : 145-146.

Sundaram, V., Krishna Iyar, K.R. and Sreenivasan, S. 2002. Hand book of methods of tests for cotton fibers, yarns and fabrics, Part-I : *Ginning tests, Fibre tests Moisture tests and Structural studies*. Published by Central Institute for Research on Cotton Technology, ICAR, Mumbai-19.

Sunitha, V., Chandrasekhar, K. and Veeraraghavaiah, R. 2010. Performance of Bt.cotton hybrids at different nitrogen levels. *Journal Cotton Research and Devlopment*, **24** (1) : 52-55.

Tiwari, P.N., Gambhir, P.N. and Rajan, T.S. 1974. Rapid and non destructive determination of oil in oilseeds by pulse, N.M.R. Technique. *Journal of American Oil Cheistry Society,* **51** : 104-109.

Wanjura, D.F. and Sundaraman, H.D. 1976. Vegetative and fruiting development and nitrogen concentration of dwarf determinate cotton cultivar. *Agronomy Journal* **30** : 744-748.

APPENDICES

APPENDIX – I

Analysis of variance for plant population and plant height

Source of variation	d.f.	Mean sum of square					
		Plant population		Plant height (cm)			
		30 DAS	At Harvest	30 DAS	60 DAS	90 DAS	120 DAS
Replication	2	9.528	16.778	7.114	42.134	161.411	170.271
Treatments	11	8.838	4.657	52.466*	100.657*	283.192*	458.357*
Error	22	8.225	7.263	5.118	30.448	97.8127	127.564

*Significant at 5 per cent level of probability.

APPENDIX – II

Analysis of variance for number of monopodial and sympodial branches per plant

Source of variation	d.f.	Mean sum of square				
		Number of monopodial branches per plant		Number of sympodial branches per plant		
		60 DAS	90 DAS	60 DAS	90 DAS	120 DAS
Replication	2	0.243	0.268	0.498	2.068	8.423
Treatments	11	0.263*	0.403*	1.607*	6.542*	13.072*
Error	22	0.077	0.119	0.367	2.011	4.492

*Significant at 5 per cent level of probability.

APPENDIX – III

Analysis of variance for number of bolls per plant

Source of variation	d.f.	Mean sum of square			
		Number of bolls per plant			
		90 DAS	120 DAS	180 DAS	Last picking
Replication	2	1.750	6.778	1.444	10.528
Treatments	11	14.614*	44.747*	54.081*	50.391*
Error	22	4.205	11.535	17.444	20.740

*Significant at 5 per cent level of probability.

APPENDIX – IV

Analysis of variance for weight of seeds per boll, number of seeds per boll, 100 seeds weight, weight of seed cotton per boll and seed cotton yield per plant

Source of variation	d.f.	Mean sum of square				
		Weight of seeds per boll (g)	Number of seeds per boll	100 seeds weight (g)	Weight of seed cotton per boll (g)	Seed cotton yield per plant (g)
Replication	2	0.014	1.843	0.025	0.081	275.028
Treatments	11	0.324*	6.928	3.787*	0.677*	520.202*
Error	22	0.120	7.299	0.683	0.273	129.058

*Significant at 5 per cent level of probability.

APPENDIX – V

Analysis of variance for seed cotton yield, stalk yield and harvest index

Source of variation	d.f.	Mean sum of square		
		Seed cotton yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)
Replication	2	276501.8	389607.9	1.528
Treatments	11	276123.5*	1047374.5*	1.369
Error	22	83195.1	207721.7	1.643

*Significant at 5 per cent level of probability.

APPENDIX – VI

Analysis of variance for quality patameters

Source of variation	d.f.	Mean sum of square				
		Oil content (%)	Oil yield (kg/ha)	Ginning percentage	Lint index	Mean fibre length (mm)
Replication	2	1.289	15044.8	15.971	0.385	0.070
Treatments	11	1.180	14751.9*	27.928	0.430	2.366
Error	22	0.743	5206.1	20.892	0.348	2.076

*Significant at 5 per cent level of probability.

APPENDIX – VIII

Analysis of variance for total nitrogen content and total nitrogen uptake

Source of variation	d.f.	Mean sum of square	
		Total nitrogen content (%)	Total nitrogen uptake (kg/ha)
Replication	2	0.006	572.328
Treatments	11	0.004	806.826
Error	22	0.005	233.569

*Significant at 5 per cent level of probability.

APPENDIX – VIII

Total cost of cultivation of cotton and other details of cost incurred

Sr. No.	Particulars	PB	Labour	Frequancy	Cost (₹ha⁻¹)
[A]	**PRE SOWING OPERATIONS :**				
1.	Tractor cultivation	-	-	2	1800
2.	Harrowing and planking by tractor	-	-	1	900
3	Preparation of beds, bunds and irrigation channels	1	3	1	600
4	Castor cake application	-	2	1	300
[B]	**SOWING OPERATION:**				
1.	Bt. cotton seed cost @ ₹2111 /kg (2.5 kg/ha)	-	-	-	5277
2.	Sowing by dibbling and fertilizer application (basal)	-	10	1	1500
[C]	**POST SOWING OPERATION :**				
1.	Gap filling	-	2	1	300
2.	Split fertilizer application	-	3	3	450
3.	Irrigation	-	8	8	10800
4.	2 Hand weeding	-	15	2	2250
5.	Interculturing	2	2	2	1140
6.	Plant protection measures Pendimethalin 30 EC Cholropyriphos 20 EC Imidachlopride Carbendazim and Mancozeb	- - - -	1 1 1 1	1 1 1 1	4236
7.	Five picking	-	40	5	6000
8.	Stalk removal	-	5	1	750
				Total Cost:-	**36303**

APPENDIX – IX

Economics of different treatments

Treatments	Seed cotton yield (kg/ha)	Stalk yield (kg/ha)	Gross realization (₹/ha)	Common cost of cultivation (₹/ha)	Treatment cost (₹/ha)	Total cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR
T_1	2594	4180	118835	36303	4917	41220	77615	2.88
T_2	2878	4529	131759	36303	5677	41980	89779	3.14
T_3	2730	4257	124979	36303	5552	41855	83124	2.99
T_4	2703	4349	123810	36303	27835	64138	59672	1.93
T_5	2942	4651	134730	36303	20198	56501	78229	2.38
T_6	2937	4782	134571	36303	12554	48857	85714	2.75
T_7	2931	5035	134413	36303	27873	64176	70237	2.09
T_8	2945	4811	134915	36303	20236	56539	78377	2.39
T_9	2985	4939	136780	36303	12592	48895	87885	2.80
T_{10}	3275	5496	150138	36303	12629	48932	101206	3.07
T_{11}	3486	5781	159775	36303	13254	49557	110218	3.22
T_{12}	3587	6010	161400	36303	13390	49693	111707	3.25

Seed Cotton: ₹ 45 /kg
Stalk : ₹ 0.5/kg

Urea: ₹ 5.84/kg
SSP : ₹ 7.50/kg

Castor cake: ₹ 6.30/kg
$MgSO_4$: ₹ 25/kg

Azotobacter : ₹ 15/200 g
PSB : ₹ 15/200 g

CERTIFICATE

This is to certify that, I have no objection for supplying to any scientist only one copy or any part of this thesis at a time through reprographic process, if necessary for rendering reference service in a library or documentation center.

M. G. Patel

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Place: SARDARKRUSHINAGAR
Date: 27 October, 2014