"EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, FLOWERING, YIELD AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.) cv. Arka Komal."

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CERTIFICATE

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DECLARATION

I, **Ms. D. RAJANI** hereby declare that the thesis entitled **"EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, FLOWERING, YIELD AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.) cv. Arka Komal."** submitted to the Andhra Pradesh Horticultural University for the degree of **MASTER OF SCIENCE IN HORTICULTURE** in the major field of **HORTICULTURE** is the result of original research work done by me. I further declare that the thesis or part there of has not been published earlier in any manner.

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, FLOWERING, YIELD AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.) cv. Arka Komal."** submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE** of the **Andhra Pradesh Horticultural University, Venkataramanna gudem,** is a record of the bonafide research work carried out by **Ms. D. RAJANI** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of investigation have been duly acknowledged by the author of the thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	per cent
<	:	less than
$\geq$	:	more than or equal
@	:	at the rate of
°C	:	Degree centigrade
ANOVA	:	Analysis of variance
APHU	:	Andhra Pradesh Horticultural University
ANGRAU	:	Acharya N. G. Ranga Agricultural University
CCC	:	Cycocel
C.D.	:	Critical difference
cm	:	centimeter
cm^2	:	square centimeter
Contd.	:	Continue
cv.	:	cultivar
C.V.	:	Coefficient of variation
d.f.	:	degrees of freedom
DAS	:	Days after sowing
et al.	:	and others
Fig.	:	Figure
FS	:	Foliar spray
FYM	:	Farm yard manure
g	:	gram
GA_3	:	Gibberellic Acid
ha	:	hectare
hrs	:	hours
i.e.	:	that is
kg	:	kilogram
kg ha^{-1}	:	kilogram per hectare
m	:	meter
Max.	:	maximum
mg	:	milligrams
Min.	:	minimum
ml	:	milliliter
mm	:	millimeter
NAA	:	Naphthalene Acetic Acid
No.	:	Number
NS	:	Non-significant
ppm	:	parts per million

RBD	:	Randomized Block Design
RH	:	Relative Humidity
S. Em	:	Standard error of treatment means
t	:	tonne
t ha^{-1}	:	tonnes per hectare
viz.	:	namely
wt.	:	weight

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ABSTRACT

The present investigation entitled **"Effect of plant growth regulators on growth, flowering, yield and quality of french bean (*Phaseolus vulgaris* L.) cv. Arka Komal."** was carried out during Rabi (2009-2010) in student farm at College of Agriculture, Rajendranagar, Hyderabad. There are 10 treatments, each replicated thrice in RBD. The treatments consists of Gibberellic acid (150, 200 and 250 ppm), Naphthalene Acetic Acid (10, 15 and 20 ppm), Cycocel (250, 300 and 350 ppm) and Control (water spray).

The data collected at 60 days after sowing had revealed that the maximum plant height (55.66 cm), internodal length (10.56 cm) and number of branches per plant (15.08) were recorded with GA_3 250 ppm while maximum number of leaves per plant (34.40) were recorded in NAA 20 ppm.

Among the plant growth regulator treatments studied, foliar spray of Cycocel 350 ppm recorded minimum number of days to flower bud initiation (31.50 days), days to 50% flowering (36.46 days) and days to first pod appearance (35.95 days).

Maximum leaf area index (0.79) and dry matter production (17.50 g) was observed in GA_3 250 ppm. Maximum chlorophyll content (47.18 SPAD units) was recorded in CCC 350 ppm.

Foliar spray of GA_3 250 ppm recorded maximum number of pickings (3.50) and maximum number of pods per plant (12.53), maximum pod length (11.68 cm). GA_3 250 ppm recorded maximum pod length (11.68 cm). Maximum pod diameter (1.07 cm) was observed in Cycocel 350 ppm.

GA_3 250 ppm recorded maximum weight of 10 pods (52.33g), yield per plant (67.21 g), yield per plot (3.52 kg) and yield per ha (40.44 q), while control recorded 37.33 g of weight of 10 pods, 37.18 g of yield per plant, 2.05 kg of yield per plot and 28.17 q of yield per ha.

GA_3 250 ppm recorded minimum fiber content (3.18 g per 100 g of fresh pod) and maximum ascorbic acid content (12.40 mg/100g of fresh pod), Maximum protein content (3.02 g per 100 g of fresh pod) was observed in NAA 20 ppm.

Even though the gross returns was maximum in GA_3 250 ppm, net returns was maximum in NAA 20 ppm. This may be because of high cost of GA_3 which worked out low benefit cost ratio when compared to NAA, which is cheaper than GA_3.

Chapter-I

Introduction

CHAPTER I

INTRODUCTION

Among many economic genera of plants belonging to the Leguminaceae family the french bean (*Phaseolus vulgaris* L.) is valued as both vegetable and seed. It is also known as Kidney bean, Snap bean, Haricot bean and Navy bean. There are two types of french beans, namely bush beans and pole beans. Dwarf bush types are popular among the cultivars.

French bean is reported to be a native of South America and is of ancient origin. The crop is sown in two seasons from February-March and September-October in the tropical and subtropical climate. Normally it is cultivated in tropics and sub-tropics at an elevation of around 1000 m above Mean Sea Level. French beans are grown as winter crop in plains, while it can be grown throughout the year except winter in hills.

French bean is an important nutritive legume, having 91.4g of moisture, 1.7g protein, 0.1g fat, 4.5g carbohydrates, 3.0g fibre, vitamin A 22 I.U., 0.08 mg thiamine, 0.06g riboflavin, 14mg ascorbic acid /100g of edible portion.

Globally it is grown in an area of 0.68 million ha with total production of 4.7 million metric tonnes and productivity is 6.91 tonnes / ha. In India, it is grown in an area of 0.15 million ha with annual production of 0.42 million metric tonnes. It is largely grown in hilly areas of Himachal Pradesh, Jammu and Kashmir and North-Eastern states during summer and winter and autumn crop in part of Uttar Pradesh, Maharashtra, Karnataka and Andhra Pradesh. In Northern plains, it is cultivated on a limited scale as autumn or spring crop, because of susceptibility to low as well as high temperatures.

The role of plant growth regulators in enhancing the production of crop has been recognized and now the low cost technology has emerged as a boon for enhancing the agricultural production at an unprecedented rate. It has been observed that synthesis and translocation of photosynthates into sink is very poor at later stages of the crop, besides poor vegetative growth and flowering. Growth hormones play an important role as they are effective in small quantities and they regulate the various physiological processes and balance the source and sink thereby increasing the productivity.

Application of Plant growth regulators improved the plant growth, flowering and pod yield in many vegetable crops. GA_3 is very effective in increasing the plant height and number of leaves. The beneficial effect of gibberellins on vine growth was also recorded by several workers. NAA is used for prevention of pre harvest drop of fruits, increasing fruit set, increasing parthenocarpy and control of flowering. Similarly series of physiological alterations have been reported due to growth retardants such as Cycocel that are associated with an optimized yield formation in various crops (Oshio and Izumi, 1986). External application of plant growth regulators stimulate photosynthesis by increasing chlorophyll content, delaying senescence of leaves and regulating the metabolic activity or by enhance flower buds and check their abscission and thereby improve the yield (Adedipe *et al.,* 1971).

Inspite of high yield potential, the actual yield of french bean is low because of many physiological reasons, like reduced photosynthesis, bud abscission, bloom drop (Kay, 1979). As the information on effect of growth regulation on flowering and yield of french bean was meagre, hence the present investigation is aimed to improve the growth, flowering and fruiting by spraying various growth regulators at different concentrations at different times with the following objectives.

Objectives

1) To study the effect of plant growth regulators on growth and flowering.
2) To study the effect of plant growth regulators on yield and quality.
3) To study the effect of plant growth regulators on benefit cost ratio.

Chapter-II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Use of plant growth regulators (PGRs) revolutionized the growth of horticulture in both developed and developing countries. In fact plant growth regulators have become an integral part of agro-technical procedures of cultivated horticultural crops.

Foliar application of plant growth regulators is a convenient method to influence plant growth parameters, yield attributes and shelf life of vegetables. Voluminous work has accumulated over years on the effect of plant growth regulators on various vegetable crops, but pertaining to french bean, it is scanty. As such, the literature pertaining to crops other than french bean have also been included in this chapter. The present review deals with the effect of GA_3, NAA and Cycocel on morphological, floral and physiological characters, yield and yield attributes and Biochemical observations is reviewed under following headings.

2.1 Effect of Gibberellic acid (GA_3)

2.2 Effect of Naphthalene Acetic Acid (NAA)

2.3 Effect of Cycocel (CCC)

2.1 Effect of Gibberellic acid (GA_3)

2.1.1 Effect of Gibberellic acid on morphological parameters

Mishriky *et al*. (1990) reported that foliar spray of GA_3 at 50 ppm significantly improved the stem length and number of leaves per plant in peas.

Foliar application of GA_3 at 25 ppm resulted in significant increase in number of leaves (65.80), number of branches (19.72) and yield (0.732 kg) over control in fenugreek (Bagde *et al.,* 1993).

Arora *et al.* (1994) observed that foliar application of GA_3 at 25 ppm showed maximum length of main shoot and internodes in long melon cv. Utilissimus.

Bhople *et al.* (1998) reported that foliar spray of GA_3 at 100 ppm recorded maximum plant height (124.37 cm) in radish cv. Pusa Chetki. Foliar application of GA_3 at 200 ppm to faba bean cv. Giza-461 out yielded tallest plants (Hassanein *et al.,* 2000).

Medhi (2000) noticed that foliar spray of GA_3 at 10, 15 ppm to the french bean cv. HUR-137 resulted in increased number of leaves per plant over control. Foliar application of GA_3 at 40 ppm to soybean cv. CO 1, CO 2, JS 335 and PK 472 resulted in increased plant height (Govindan *et al*., 2000).

Vijay Kumar and Ray (2000) reported that foliar spray of GA_3 at 100 ppm produced maximum plant height (59.81 cm) and more number of leaves (25.43) in cauliflower cv. Pant Subhra.

Verma (2000) observed that GA_3 at 50 ppm (soaking + spraying) improved the plant growth and yield parameters of coriander. Balaraj *et al.* (2002) reported that foliar application of GA_3 at 100 ppm recorded maximum plant height and more number of branches followed by 50 ppm GA_3 in chilli.

Kore *et al*. (2003) observed that foliar application of GA_3 at 5 ppm produced significantly increased number of nodes, highest vine length, number of functional leaves and maximum yield in bottle gourd cv. Samrat.

Pandey *et al.* (2004) reported that foliar application of GA_3 at 50, 100, 150, 200, and 250 ppm to garden pea var. Azad P-3 resulted in increased plant height and more number of branches. Foliar spray of GA_3 at 200 ppm to French bean cv. Meghalaya local recorded maximum inter nodal length and plant height (Rai *et al*., 2004).

Purbey and Sen (2005) noticed that foliar spray of GA_3 at 100 ppm to fenugreek var. Rmt-1 recorded maximum plant height followed by GA_3 at 50 ppm.

Foliar application of GA_3 at 200 ppm was found to be significantly superior in increasing plant height (117.33 cm) in okra cv. Parbhani Kranthi (Kokare *et al*., 2006). Nawalagatti *et al.* (2008) noticed that foliar application of GA_3 at 20 ppm recorded maximum plant height, more number of branches in french bean cv. Arka Komal.

Sharma and Lashkari (2009) reported that foliar application of GA_3 at 50, 100 and 150 ppm to cluster bean cv. Pusa Navabahar resulted in maximum plant height and increased number of branches per plant over control.

2.1.2 Effect of Gibberellic acid on flowering and fruit set

Patil *et al*. (2005) observed that foliar application of GA_3 at 50 ppm to mung bean delayed flower initiation. Foliar application of GA_3 at 20 ppm to french bean var. Arka Komal resulted in significant reduction in number of days to 50% flowering (Nawalagatti *et al*., 2008).

2.1.3 Effect of Gibberellic acid on physiological parameters

Mishriky *et al*. (1990) reported that foliar application of GA_3 at 50 ppm significantly improved the dry weight of plant in peas. Foliar application of GA_3 at 10 and 15 ppm resulted in increased leaf area index and increased chlorophyll content over control in french bean cv. HUR-137 (Medhi 2000).

Purbey and Sen (2005) observed that foliar spray of GA_3 at 50 and 100 ppm to fenugreek cv. Rmt-1 resulted in increased dry matter accumulation over control.

Kokare *et al*. (2006) noticed that foliar application of GA_3 at 100 and 200 ppm significantly improved the number of leaves, leaf area index and plant dry matter in okra cv. Parbhani Kranthi.

Foliar application of GA_3 at 20 ppm to french bean cv. Arka Komal at 40 DAS and 60 DAS resulted in significantly maximum values for leaf area index and dry matter production (Nawalagatti *et al*., 2008).

2.1.4 Effect of Gibberellic acid on yield and yield attributes

Mishriky *et al*. (1990) noticed that foliar application of GA_3 at 50 ppm significantly improved the total yields in peas. Bagde *et al*. (1993) reported that foliar application of GA_3 at 25 ppm resulted in significant increase in yield (0.732 kg) in fenugreek.

Foliar application of GA_3 at 10 and 15 ppm resulted in increased number of pods per plant, pod length, pod yield than control in french ban cv. HUR-137 (Medhi, 2000).

Vijay Kumar and Ray (2000) reported that foliar spray of GA_3 at 100 ppm produced significantly higher yield (425.58q/ha) and 56.69% increase in yields over control in cauliflower cv. Pant Subhra.

Kore *et al*. (2003) noticed that foliar application of GA_3 at 5 ppm significantly improved the yield in bottle gourd cv. Samrat.

Foliar application of GA_3 at 50, 100, 150, 200, and 250 ppm to garden pea var. Azad P-3 resulted in increased values for pod length (8.80 cm), number of pods per plant and yield per plot where as GA_3 at 200 ppm recorded maximum pod girth (1.43 cm) and maximum 10 pod weight 67.64 g (Pandey *et al,*. 2004).

Rai *et al*. (2004) observed that foliar application of GA_3 at 200 ppm to french bean cv. Meghalaya local resulted in increased pod length.

Foliar application of GA_3 at 50 ppm increased the number of pods per plant by 44 per cent over control in mung bean (Patil *et al.*, 2005).

Purbey and Sen (2005) reported that foliar application of GA_3 at 50 and 100 ppm increased the number of pods per plant and pod length significantly than control in fenugreek cv. Rmt 1.

Kokare *et al*. (2006) observed that foliar application of GA_3 at 100 and 200 ppm increased the number of pods per plant, pod weight, pod yield per plant and pod yield per ha and at 200 ppm it recorded maximum fruit length (11.54 cm) in okra cv. Parbhani Kranthi.

Foliar application of GA_3 at 20 ppm recorded maximum number of pods per plant, pod length, pod weight and yield of green pods in french bean cv. Arka Komal (Nawalagatti *et al.*, 2008).

Sharma and Lashkari (2009) noticed that foliar spray of GA_3 at 50, 100 and 150 ppm to cluster bean cv. Pusa Navabahar resulted in increased weight of pods per plant.

2.1.5 Effect of Gibberellic acid on Biochemical observations:

Mishriky (1990) observed that foliar spray of GA_3 at 25 and 50 ppm resulted in decreased petiole fiber content in celery cv. Dulce. Mishriky *et al*. (1990) reported that foliar spray of GA_3 tended to increase the protein content of the green pods in peas.

Foliar application of GA_3 increased the ascorbic acid content of fruit in pepper (Belakbir *et al.,* 1998).

Pandey *et al.* (2004) noticed that foliar application of GA_3 at 200 ppm recorded maximum ascorbic acid content (3.40 mg/100g) in garden pea. Foliar spray of GA_3 at 50 and 100 ppm increased the protein content of seeds significantly than control in fenugreek cv. Rmt -1 (Purbey and Sen, 2005).

Kokare *et al*. (2006) reported that foliar application of GA_3 at 100 and 200 ppm resulted in significantly improved fruit girth and ascorbic acid content in okra cv. Parbhani Kranthi.

2.2 Effect of Naphthalene Acetic Acid (NAA)

2.2.1 Effect of Naphthalene Acetic Acid on morphological parameters

Chandrasekhar Reddy and Joshi (1990) observed that foliar spray of NAA at 100 ppm on brinjal resulted in more number of branches per plant. Foliar application of NAA at 10, 20 and 40 ppm to chillies resulted in significant increase in plant height over control (Katwale and Saraf, 1990).

Sharma *et al.* (1992) noticed that foliar spray of NAA at 100 ppm on brinjal plants recorded maximum plant height over control.

Bagde *et al.* (1993) reported that foliar application of NAA at 25, 50 and 75 ppm resulted in maximum plant height, increased number of leaves, number of branches and yield in fenugreek. Khare *et al.* (1993) observed that NAA at 250 ppm treated faba bean recorded maximum plant height (84.40 cm) over control (76.00 cm).

Foliar spray of NAA at 25 ppm on long melon produced more number of branches per plant and at 50 ppm it recorded maximum inter nodal length (Arora *et al.,* 1994).

NAA sprayed at 50, 100 and 150 ppm to *rabi* grown pumpkin improved the inter nodal length over control (Das and Das, 1996). Dharmender kumar *et al.* (1996) reported that NAA spraying at 50 ppm on cabbage recorded more number of inner leaves than control.

Lakshmamma and Subba Rao (1996) observed that black gram treated with NAA at 20 ppm gave significantly higher plant height (21.67 cm) than control (18.07 cm).

Spraying of NAA at 500 ppm to lablab bean increased the Internodal length and at 250 ppm it produced more number of primary and secondary branches (Uddin *et al.,* 1996).

Baruah and Das (1997) observed more number of branches per plant when NAA at 25 ppm sprayed to bottle gourd. Rahman and Karim (1997) observed an increase in the number of leaves and number of branches per plant with the application of 100 ppm NAA + 75 ppm TIBA and 50 ppm GA_3 over control in bottle gourd.

Syed *et al.* (1997) observed an increase in inter nodal length when NAA at 200 ppm sprayed in okra. Bhople *et al.* (1998) reported that foliar spray of NAA at 100 ppm recorded maximum number of branches (15.70) in radish cv. Pusa Chetki.

Dutta *et al.* (1998) noticed significant increase in inter nodal length of chrysanthemum with NAA at 100 ppm spray. Ghanta and Mitra (1998) reported that inter nodal length of papaya increased by NAA at 100 ppm treatment.

Foliar spray of NAA at 10, 15 and 20 ppm resulted in maximum plant height and increased number of branches per plant over control in fenugreek cv. Co.1 (Alagukannan and Vijayakumar, 1999).

Two sprays of Agromin (Chelated micronutrients) and planofix (NAA) in combination was the most beneficial treatment for improving the number of leaves in garlic (Singh *et al.*, 1999).

Das *et al*. (1999) observed a pronounced response to NAA application up to 100 ppm in respect to number of branches and number of leaves per plant in salvia.

Foliar spray of NAA at 15 ppm and Triacontanol (TRIA) at 15 ppm at 30 days after sowing to the french bean cv. HUR-137 gave significantly maximum number of leaves per plant (15.82) over control (Medhi, 2000)

Vijay Kumar and Ray (2000) observed that foliar application of NAA at 100 ppm resulted in significant increase in plant height and number of leaves over control in cauliflower cv. Pant Subhra. Number of branches per plant was increased with NAA spray over control in tomato (Singh *et al.* 2001).

Balaraj *et al*. (2002) reported that foliar application of NAA at 10 ppm and 20 ppm increased the plant height and number of branches over control in chilli.

Foliar spray of NAA at 40 ppm significantly increased the number of branches and number of leaves per plant in summer mung bean (Aurovinda Das and Rajendra Prasad 2003). Kore *et al.* (2003) reported that foliar application of NAA at 10 and 20 ppm increased vine length, number of functional leaves and number of nodes in bottle gourd cv. Samrat.

Mandal and Sanyal (2004) reported that foliar application of NAA at 50 ppm + CPPU at 20 ppm on french bean recorded maximum plant height.

Pandey *et al.* (2004) observed that foliar application of NAA at 500, 1000, 1500, 2000, and 2500 ppm to garden pea cv. Azad P-3 resulted in increased plant height and more number of branches over control.

Foliar spray of NAA at 50 and 100 ppm to french bean cv. Meghalaya local resulted in increased inter nodal length and plant height over control (Rai *et al.,* 2004).

Resmi and Gopalakrishnan (2004) observed that foliar spray of NAA at 15 ppm on yard long bean (*Vigna unguiculata var. sesquipedalis* L. Verdcourt) improved the vine length and recorded maximum number of branches per plant over the control.

Purbey and Sen (2005) reported that foliar spray of NAA at 10 and 20 ppm to fenugreek cv. Rmt-1 resulted in increased plant height over control.

Kokare *et al.* (2006) reported that foliar application of NAA at 100 and 200 ppm increased the plant height over control and at 200 ppm it recorded maximum number of leaves in okra cv. Parbhani Kranthi. Foliar application of NAA at 60 ppm to garlic resulted in maximum plant height (Singh *et al.,* 2008).

Sharma and Lashkari (2009) noticed that foliar application of NAA at 50, 100 and 150 ppm to cluster bean cv. Pusa Navabahar produced significant improvement in plant height, number of leaves per plant and number of branches per plant over control.

2.2.2 Effect of NAA on flowering and fruit set

Sharma *et al.* (1992) reported that foliar spray of NAA at 50 ppm to brinjal plant recorded minimum number of days for flowering. Singh (1995) found that foliar spray of NAA at 10 ppm to tomato induced early flowering and promoted fruit set.

Baruah and Das (1997) observed that foliar spray of NAA at 25 ppm to bottle gourd recorded minimum number of days to early flowering.

Aurovinda Das and Rajendra Prasad (2003) reported that foliar application of NAA at 20 ppm recorded minimum number of days to 50 percent flowering in green gram. Foliar application of NAA at 25 ppm to mung bean resulted in earlier initiation of flowering by 2 days over the control (Patil *et al.,* 2005).

2.2.3 Effect of NAA on physiological parameters

Dod *et al.* (1989) reported that NAA sprayed at 50 days after transplanting and again after an interval of 21 days with 50 ppm and 100 ppm concentration to chillies resulted in significant improvement in leaf area over control.

Foliar spray of NAA at 300 ppm to broad bean increased leaf area index and chlorophyll content of leaf over control significantly (El-Abd *et al*., 1989).

On chilli seedlings, Singh *et al*. (1990) noticed that foliar spray of NAA at 40 ppm at 40 and 60 days after transplanting resulted in greatest increase in leaf area index.

Kalita *et al*. (1995) reported that dry matter production of green gram was significantly increased with NAA at 40 ppm foliar spray over control. Panda and Sen (1995) observed the highest total dry matter production with NAA at 1500 ppm treatment on yam bean.

Foliar spray of NAA at 20 ppm to black gram increased the dry matter content and chlorophyll content over control (Lakshmamma and Subba Rao, 1996).

Revanappa and Nalawadi (1998) noticed that the dry weight of chilli plant was increased with NAA at 20 ppm foliar spray over control.

Foliar spray of NAA at 10, 15 and 20 ppm resulted in increased dry matter production per plant over control and at 20 ppm it recorded highest dry matter production (11.62 g) in fenugreek cv. CO.1 (Alagukannan and Vijayakumar, 1999).

Medhi (2000) reported that foliar application of NAA at 15 ppm resulted in maximum leaf chlorophyll content (2.34 mg/g fresh wt.) and leaf area index (2.33) in french bean cv. HUR-137.

With increasing concentration of NAA, fresh and dry weights of french bean were increased (Sanna *et al.* 2001).

Aurovinda Das and Rajendra Prasad (2003) reported that foliar application of NAA at 20 and 40 ppm to mungbean resulted in increased dry matter production. Purbey and Sen (2005) noticed that foliar spray of NAA at 20 ppm to fenugreek cv. Rmt-1 recorded maximum dry matter accumulation (22.05 g/plant).

Foliar application of NAA at 200 ppm produced maximum leaf area (28.10 dm^2) and plant dry matter (18.55 g) at 90 DAS in okra cv. Parbhani Kranthi (Kokare *et al.*,. 2006).

2.2.4 Effect of NAA on yield and yield attributes

Vasanthakumar and Sreekumar (1981) observed highest pod length (8.91 cm) of pea cv. Bonneville with NAA at 50 ppm as foliar spray over control (7.87 cm).

NAA at 100 ppm treated brinjal plants produced more number of fruits per plant and significant improvement in fruit weight (Chandrasekhar Reddy and Joshi, 1990). Rama Rao *et al.* (1990) reported that NAA at 20 ppm treated chilli produced more number of fruits.

Bisen *et al.* (1991) reported that plant growth regulators applied as a seed soak (24 h) resulted in increased growth and yield over foliar spray treatments at 3rd and 6th leaf stage. Maximum plant growth and highest green pod yield (158.2q/ha) were obtained with 50 ppm of NAA as a 24 h seed soak in garden pea cv. GC-322.

Shinde *et al.* (1991) noticed that seed soaking of cowpea with NAA at 20 ppm significantly increased the number of pods per plant, pod weight and pod yield over control.

The greatest fruit weight and fruit yield (809.83 g) per plant of *Capsicum annum* cv. IASH-P-2 WAS obtained with NAA at 75 ppm (Lyngdon and Sanyal, 1992).

NAA at 50 ppm recorded significant increase in number of fruits per plant and yield in brinjal whereas fruit length and fruit weight were maximum with NAA at 150 ppm (Sharma *et al.,* 1992).

Arora *et al.* (1994) reported that fruit length of long melon was increased with NAA at 50 ppm foliar spray where as at 100 ppm maximum fruit yield was observed. Kalita *et al.* (1995) reported that NAA at 100 ppm sprayed to green gram produced more number of pods per plant.

Uddin *et al.* (1996) observed that foliar spray of NAA at 250 ppm to lablab bean produced highest number of pods per plant.

The plant growth regulator NAA applied at the time of flowering to broad bean (*Vicia faba*) resulted in an increased number of pods per plant (Nowak *et al.,* 1997).

Baruah and Das (1997) reported that NAA at 25 ppm treated bottle gourd plants recorded more number of fruits and maximum yield over control. Revanappa and Nalawadi (1998) observed lengthiest fruit, more number of chilli pods and maximum yield with NAA at 20 ppm treatment.

Alagukannan and Vijayakumar (1999) noticed that foliar spray of NAA at 20 ppm produced maximum number of pods (20.22) highest pod length (10.34 cm), increased yield per plot and per ha over control in fenugreek cv. Co.1.

The field grown chilli treated with NAA at 50 ppm showed encouraging effects on increase of fruit weight (Barai and Sarkar, 1999).

Medhi (2000) reported that foliar spray of NAA at 15 ppm to the french bean cv. HUR-137 recorded maximum number of pods per plant (18.27), highest pod length (13.25 cm) and maximum pod yield (117.11 q/ha).

Vijay Kumar and Ray (2000) observed that foliar spray of NAA at 100 ppm resulted in significant increase in curd yield in cauliflower cv. Pant Subhra. Foliar application of NAA at 60 ppm to chilli produced more fruit yield per plant over control (Joshi and Singh, 2001).

Singh *et al.* (2001) reported that foliar spray of NAA at 20 ppm recorded maximum fruit weight per plant in tomato.

Foliar application of NAA at 20 and 40 ppm to mungbean resulted in increased pod length and maximum number of pods per plant (Aurovinda Das and Rajendra Prasad, 2003).

Kore *et al.* (2003) reported that foliar application of NAA at 10 and 20 ppm resulted in increased yield in bottle gourd cv. Samrat. Radhamani *et al.* (2003) reported that foliar spray of NAA at 40 ppm to greengram plant recorded maximum pod yield over control.

Chilli fruit length was significantly increased with NAA at 50 ppm foliar application over control (Thapa *et al.* 2003).

Maximum pod yield per plant in greengram was recorded with NAA at 40 ppm (Aurovinda Das and Rajendra Prasad, 2003).

Pandey *et al.* (2004) reported that foliar application of NAA at 500, 1000, 1500, 2000, 2500 ppm to garden pea cv. Azad P-3 resulted in increased pod girth and 10 pod weight whereas NAA at 1500 ppm recorded maximum number of pods per plant (14.67) and increased yield per plot (from 4.19 kg to 6.71 kg).

Rai *et al*. (2004) noticed that foliar spray of NAA at 50 and 100 ppm to french bean cv. Meghalaya local resulted in decreased pod length and increased yield per plant whereas NAA at 50 ppm recorded maximum pod diameter.

Foliar spray of NAA at 15, 30, 45 ppm on yard long bean (*Vigna unguiculata var. sesquipedalis* L. Verdcourt) resulted in significant increase in number of pods and mean fruit weight where as NAA at 15 ppm recorded increased fruit yield per plant from 344.68 g to 524.46 g. It increased productivity from 5.54 t/ha to 7.48 t/ha (Resmi and Gopalakrishnan, 2004).

Purbey and Sen (2005) reported that foliar application of NAA at 20 ppm to fenugreek cv. Rmt 1 recorded mean maximum number of pods per plant (32.65), and highest pod length (13.48 cm).

Patil *et al.* (2005) observed that foliar application of NAA at 25 ppm in mung bean recorded highest number of pods per plant.

Kokare *et al*. (2006) reported that foliar application of NAA at 200 ppm recorded maximum number of pods per plant (18.03), fruit girth (2.12 cm), pod weight (10.40 g), pod yield per plant (187.60g) and pod yield per ha (138.89 q) in okra cv. Parbhani Kranthi.

Nehra *et al.* (2006) noticed that foliar application of NAA at 20 ppm resulted in increased number of pods per plant in fenugreek.

. Foliar application of NAA at 50, 100 and 150 ppm to cluster bean cv. Pusa Navabahar recorded a significant increase in weight of tender pods per plant over control (Sharma and Lashkari, 2009).

2.2.5 Effect of NAA on Biochemical observations:

Alagukannan and Vijayakumar (1999) observed that foliar spray of NAA at 15 ppm expressed highest seed protein content (15.31%) over control (11.41%) in fenugreek cv. Co.1.

Pandey *et al*. (2004) reported that foliar application of NAA at 500, 1000, 1500, 2000, 2500 ppm resulted in increased ascorbic acid content over control in garden pea. Foliar application of NAA at 20 ppm to fenugreek cv. Rmt 1 recorded the mean maximum protein content (18.43%) in seed (Purbey and Sen, 2005).

Kokare *et al*. (2006) noticed that foliar application of NAA at 200 ppm resulted in maximum ascorbic acid content (17.35 mg/100g) in okra cv. Parbhani Kranthi.

2.3 Effect of Cycocel （CCC)

2.3.1 Effect of Cycocel on morphological parameters

Sadiq *et al.* (1990) reported that when cucumber cv. Marketer plants were sprayed with cycocel at 500 ppm at 4 leaf stage, the lowest stem length (118.8 cm) and maximum number of branches (5.5) were observed.

Arora and Dhankar (1992) noticed that cycocel application (100 ppm seed soaking + 100 ppm foliar spray at 20 and 40 DAS) resulted in maximum growth retarding effect and maximum number of leaves per plant in bhendi cv. HB-55.

Deka and Shadeque (1996) reported that when capsicum cv. California wonder seedlings were sprayed with cycocel (500 ppm, 1000 ppm and 1500 ppm) at 30 and 60 DAS or on both dates, highest number of branches (200.93) and highest number of leaves (635.73) were obtained in 1000 ppm concentration of cycocel at 30 DAS.

Rathod and Patel (1996) noticed highest plant height with water spray and lowest plant with foliar spray of cycocel at 750 ppm in okra cv. Parbhani Kranthi.

Foliar spray of cycocel at 750 ppm suppressed the plant height, improved the number of branches, leaves and ultimately yield of okra (Rathod and Patel, 1996)

Asghar *et al.* (1997) observed that plant height was greatly reduced when the plants were treated with cultar at 200 ppm as foliar spray in bhendi cv. T_{13}. Shepherd and Singh (1999) reported that foliar spray of cycocel at 3000 ppm to tomato cv. Angurlata recorded the minimum plant height.

Rodrigues *et al.* (1998) observed that growth retardants (Uniconazole, Paclobutrazole and Cycocel) were added at 2.0 mg/l to culture medium and recorded reduced inter nodal length in two cauliflower cultivars Santa Eliza No. 2 and Cicaba Precoce No1.

Aurovinda Das and Rajendra Prasad (2003) reported that foliar spray of CCC at 750 ppm to summer mung bean resulted in increased number of branches and number of leaves per plant over control.

Kore *et al.* (2003) studied the effect of GA_3 (5 and 10 ppm), NAA (10, 20 and 30 ppm), triacontanol (2 and 4 ppm) and paclobutrazol (50, 100 and 200 ppm) on bottle gourd cv. Samrat, and it was observed that irrespective of the concentration, GA_3 and NAA significantly increased the vine length, mean number of leaves per vine and reduced number of days for 50% flowering. The entire plant growth regulators exhibited significant effect on yield characters.

Anamika Dhaka (2004) recorded a reduction in shoot length in Bakla (Vicia faba L.) with increased concentrations of cycocel.

Foliar spray of growth retardant Paclobutrazol at 100, 150, 200 and 250 ppm to French bean cv. Meghalaya local resulted in reduced plant height over control and at 150 ppm it resulted in reduced inter nodal length (Rai *et al.*, 2004).

Resmi and Gopalakrishnan (2004) reported that foliar spray of CCC at 300, 400 and 500 ppm on yard long bean (*Vigna unguiculata var. sesquipedalis* L. Verdcourt) resulted in increased number of branches.

Bora and Sarma (2006) noticed that foliar application of cycocel to pea cvs. Aparna and Azad-P-1 reduced shoot growth. Foliar application of CCC at 400 ppm recorded minimum plant height and significantly improved the number of leaves in okra cv. Parbhani Kranthi (Kokare *et al*., 2006).

Rajendra Prasad and Srihari (2008) reported that foliar spray of CCC at 300 ppm to 20 and 40 days age seedlings of okra recorded minimum inter nodal length, reduced plant height, improved number of branches and leaves over control.

Singh *et al.* (2008) noticed that foliar application of cycocel at 600 ppm to garlic at 50 and 80 days after sowing showed a reduction in plant height.

Foliar application of CCC at 1000, 1500 and 2000 ppm to cluster bean cv. Pusa Navabahar resulted in significant decrease in plant height and increase in number of branches and leaves per plant (Sharma and Lashkari, 2009).

2.3.2 Effect of Cycocel on flowering and fruit set

Foliar spray of cycocel at 50 ppm induced earliest flowering in bhendi, whereas NAA at 25 ppm SDT + 25 ppm foliar spray delayed flowering (Arora *et al.*, 1990).

Arora and Dhankar (1992) reported that cycocel at 100 ppm SDT + CCC at 100 ppm as foliar spray will induce early flowering and picking over control in bhendi cv. HB-55.

Ibrahim *et al.* (1996) observed that cycocel at 2000 ppm reduced the number of days to flowering (44.38) in tomato cv. Roma. Aurovinda Das and Rajendra Prasad (2003) reported that application of CCC at 750 and 1500 ppm to summer mungbean cvs. PS-16 and Pusa Baisakhi reduced the days to 50 percent flowering by 3-4 days.

Resmi and Gopalakrishnan (2004) noticed that foliar spray of CCC at 300 ppm on yard long bean (*Vigna unguiculata var. sesquipedalis* L. Verdcourt) induced early flowering and fruit harvest (46 days).

Foliar application of CCC at 400 ppm produced earliest 50% flowering in okra cv. Parbhani Kranthi (Kokare *et al.*, 2006).

2.3.3 Effect of Cycocel on physiological parameters

Narse Gowda and Mundappa Gowda (1980) observed that cycocel at 1000 ppm resulted in maximum chlorophyll content (1.736 mg/100g) followed by cycocel at 1500 ppm (1.405 mg/100g) and untreated plants (1.34 mg/100g). A single application of cycocel at 40 DAS recorded maximum chlorophyll content (1.654 mg/100g) followed by two sprays at 20 and 40 days after sowing (1.331 mg/100g) in okra.

Prakash and Ramachandran (2000) reported that when brinjal cv. CO-2 treated with anti transpirants (5Mm cycocel, 2% lime wash, 1% KCl) and stress conditions, stress conditions decreased the chlorophyll content whereas cycocel increased the chlorophyll content than other anti transpirants.

Application of CCC at 750 and 1500 ppm to mungbean resulted in increased dry matter production (Aurovinda Das and Rajendra Prasad, 2003).

Kokare *et al.* (2006) noticed that foliar application of CCC at 200 and 400 ppm resulted in significantly increased leaf area index, plant dry matter and at 400 ppm it recorded maximum leaf chlorophyll content in okra cv. Parbhani Kranthi.

2.3.4 Effect of cycocel on yield and yield attributes

In brinjal, cycocel significantly thickened the fruits as compared to Maleic Hydrazide, GA_3 and control (Das and Prusty, 1969).

Verma *et al.* (1969) observed that Maleic Hydrazide at 200 ppm in cucumber increased the total weight of fruit when sprayed at 1-2 leaf stage and again at 3-4 leaf stage. Foliar spray of Maleic Hydrazide at 50 ppm increased the fruit weight in bottle gourd (Choudhury and Babel, 1970).

Mehrotra *et al*. (1970) reported that the fruit length (9.87 cm) was significantly reduced by cycocel at 1500 ppm, which was due to reduction in cell division and elongation in okra.

Sen and Naik (1973) obtained heaviest fruits with single application of chloromequat + N in tomato. Shukla and Tiwari (1973) recorded significant increase in fruit length, seed number and fruit size in okra with CCC spray treatment.

Marisiddiah and Mundappa Gowda (1977) reported that cycocel at 1000 ppm significantly increased the fruit diameter and fruit weight followed by control and minimum with cycocel at 1500 ppm in tomato.

Gopala Krishnan and Choudhury (1978) observed that maleic hydrazide at 400 ppm significantly increased the mean weight of fruits per vine in watermelon.

Foliar spray of CCC at 75 ppm increased the number of fruits which is due to increase in number of branches per plant in okra cv. HB-55. And it improved the fruit length in okra cv. HB-55 (Arora *et al*., 1990).

Sadiq *et al.* (1990) observed that when cucumber cv. Marketer was treated with cycocel at 500 ppm at 4^{th} leaf stage observed that a maximum fruit yield of 93,722.2 kg/ha.

Mangal *et al*. (1991) reported that when carrot cv. Hissar selection was sprayed with CCC at 250 ppm at 30 and 45 days after sowing yielded 252.2 q/ha whereas control yielded 120.3 q/ha.

Foliar spray of cycocel resulted in the production of significantly higher number of fruits compared to that of seed treatment whereas seed soaking and foliar spray of cycocel at 1200 ppm gave highest yield of 18.15 t/ha in okra (Patel and Singh, 1991).

Arora and Dhankar (1992) noticed that fruit diameter was maximum with CCC at 100 ppm (seed soaking + foliar spray) in okra cv. HB-55.

Gowda *et al*. (1992) reported that when bhendi plants were treated with cycocel at 1000 ppm significantly increased the fruit diameter (1.99 cm), fruit weight (18.09 g) and fruit yield per plant (94.3 g) followed by control and minimum values were recorded with 1500 ppm.

Selvaraj *et al*. (1995) observed that when garlic crop is sprayed with cycocel at 1000 ppm, the highest bulb yield of 18t/ha and 17.36 t/ha in the main and autumn crops respectively, compared with 8.6 t/ha and 7.54 t/ha in controls were obtained.

Foliar spray of cycocel at 1000 ppm at 30 days after sowing significantly increased number of fruits (35.33), fruit set (83.04%) and yield of 1700 g per plant were obtained in capsicum cv. California Wonder (Deka and Shadeque, 1996).

Ibrahim *et al.* (1996) reported that cycocel application increased the number of fruits per plant (from 11.62 to 13.93) and total yield (from 18.07 to 22.79 t/ha).

Gera and Dhaka (1997) observed the effect of irrigation (PEC), cycocel and its combination. Cycocel at 500 ppm along with 1.6 PEC produced the maximum yield (33.466 q/ha) and significantly affected all the growth attributes except dry weight of leaves, chlorophyll content of leaves, diameter of roots and root to shoot ratio in radish.

Asane *et al*. (1998) reported that cycocel at 500 and 1000 ppm reduced the plant height and increased the pod yield over control in peas.

Aurovinda Das and Rajendra Prasad (2003) reported that application of CCC at 750 ppm to mungbean resulted in increased pod length and number of pods per plant (from 15.7 to 19.3).

Foliar spray of Paclobutrazole at 100 ppm recorded maximum pod length and at 150 ppm it recorded maximum number of pods (56.78) and yield per plant (389.05 g) in french bean cv. Meghalaya local (Rai *et al.,* 2004).

Resmi and Gopalakrishnan (2004) observed that foliar spray of CCC at 300 ppm on yard long bean (*Vigna unguiculata var. sesquipedalis* L. Verdcourt) recorded maximum values for number of pods per plant (573.92), mean fruit weight (17.95 g), fruit yield per plant and productivity (t/ha).

Kokare *et al*. (2006) reported that foliar application of CCC at 200 and 400 ppm significantly increased the number of pods per plant, length of fruit, girth of fruit, weight of pod, pod yield per plant and pod yield per ha in okra cv. Parbhani Kranthi.

Rajendra Prasad and Srihari (2008) noticed that foliar spray of CCC at 300 ppm on 20 and 40 days age seedlings of okra recorded maximum yield per plant.

Foliar application of CCC at 1000 ppm to cluster bean cv. Pusa Navabahar resulted in maximum tender pod weight per plant (Sharma and Lashkari, 2009).

2.3.5 Effect of cycocel on Biochemical observations:

Jayachandran and Sethumadhavan (1988) reported that foliar spray of CCC in ginger resulted in an undesirable increase in crude fiber with increase in CCC concentrations.

Phookan *et al.* (1991) observed that foliar spray of CCC at 1500 ppm resulted in highest ascorbic acid content (35 mg/100g) in tomato.

Deka and Shadeque (1996) noticed that foliar application of Cycocel at 500 ppm resulted in high ascorbic acid content (102.85 mg/100g) at 30 DAT in sweet pepper.

Martins *et al.* (1998) reported that growth retardants decreased xylem thickness and induced fiber formation in tomato.

Foliar application of CCC at 200 and 400 ppm resulted in significantly increased ascorbic acid content in okra cv. Parbhani Kranthi (Kokare *et al.*, 2006).

Sharma and Lashkari (2009) observed that foliar application of CCC at 1000 ppm recorded maximum crude protein of pods in clusterbean cv. Pusa Navbahar.

Chapter- III

Materials & Methods

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled **"EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, FLOWERING, YIELD AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.) cv. Arka Komal."** was carried out during Rabi (2009-2010) in student farm at College of Agriculture, Rajendranagar, Hyderabad.

3.1 DETAILS OF THE EXPERIMENTAL SITE

3.1.1 GEOGRAPHICAL LOCATION OF THE EXPERIMENTAL SITE

The experimental site was located at student farm, Rajendranagar, Hyderabad. The location falls under arid sub tropical climatic zone with an average rainfall of 800 mm at an altitude of 542.3 m above mean sea level on 17.90^0 N latitude and 78.23^0 E longitudes. It experiences hot dry summers and mild winters. The meteorological data during the period of investigation with monthly averages as recorded at Agricultural Research Institute, Rajendranagar are presented in Appendix I.

3.2 DETAILS OF THE EXPERIMENT

For this study, experiment was conducted during 2009-2010. The experiment was carried out to study the "Effect of plant growth regulators on growth, flowering, yield and quality of french bean (*Phaseolus vulgaris* L.) cv. Arka Komal." The experiment was conducted with the seeds of French bean cultivar Arka Komal. There are 10 treatments, each replicated thrice in RBD.

3.2.1 Experimental details:

Location	: Students farm, Rajendra nagar
Crop	: French bean (*Phaseolus vulgaris* L.)
Variety	: Arka Komal
Season	: Rabi (2009-10)
Number of treatments	: 10
Method of application	: Spraying at 20 and 40 days after sowing.
Number of replications	: 3
Design	: RBD (Randomized Block Design)
Spacing	: 50 cm × 30 cm
Plot size	: 3 m × 3 m
Interval of data recording	: 15 days

3.2.2 Treatment Details

T_1: Gibberellic acid (150 ppm)

T_2: Gibberellic acid (200 ppm)

T_3: Gibberellic acid (250 ppm)

T_4: Naphthalene Acetic Acid (10 ppm)

T_5: Naphthalene Acetic Acid (15 ppm)

T_6: Naphthalene Acetic Acid (20 ppm)

T_7: Cycocel (250 ppm)

T_8: Cycocel (300 ppm)

T_9: Cycocel (350 ppm)

T_{10}: Control (water spray)

3.2.3 DESCRIPTION OF FRENCH BEAN CULTIVAR ARKA KOMAL

It is an improved cultivar from Australian collection IIHR 60. It is an early variety, bushy growth habit, bears profusely. Pods are straight, tender, fleshy, dark green, stringless. Keeping and cooking qualities are very good and with stands transport better. Yields 5-7.5 t of pods per acre in 65 - 70 days.

3.2.4 PLANT GROWTH REGULATORS USED IN EXPERIMENTATION

Traditional plant growth regulators viz., Gibberellic acid (GA_3), Naphthalene Acetic Acid (NAA) and Cycocel (CCC) were used in the experiment.

List of plant growth regulators used in the experiments

S.No	Chemical (trade name)	Abbreviation	Molecular Formula	Molecular Weight	Soluble in
1	Gibberellic acid	GA_3	$C_{19}H_{22}O_6$	346.37	Alcohol (polar solvents)
2	α-Naphthalene Acetic acid	NAA	$C_{12}H_{10}O_2$	186.21	Alcohol (polar solvents)
3	Cycocel	CCC	$C_5H_{13}C_{12}N$	158.06	Water

3.3 CULTURAL PRACTICES

3.3.1 Land preparation

The land was brought to fine tilth by ploughing and harrowing. The experimental area was divided in to plots of 3m x 3m size. Number of rows in each plot are 6. Irrigation channels of 0.5 m size were provided separately for each plot. Well decomposed farmyard manure at 25 t ha^{-1} is incorporated into all the plots uniformly as basal application and well mixed with the soil. Standard recommended cultural practices were followed during the entire crop period.

3.3.2 Lay out

The layout of the experiment is indicated in the figure 1.

3.3.3 Manures and Fertilizers

The recommended dosage of N, P and K 20:50:50 kg/ha was applied in the form of Urea, Single Super Phosphate and Muriate of Potash respectively. Nitrogen was applied in 2 splits, the first dose as basal application and other split dose at 30 days after planting. The entire dose of phosphorus and potash were applied at the time of sowing as basal dose.

3.3.4 Sowing

Certified seeds of Arka Komal were sown with a spacing of 50 cm x 30 cm at a depth of 5 cm. Two seeds were sown per hill. A light irrigation was given immediately after sowing. Sowing of Arka Komal seeds was taken up on 29th October 2009. Total number of plants in each plot are 60.

3.3.5 Thinning

Thinning was done at 7 days after sowing retaining one healthy seedling per hill.

3.3.5 Weeding and irrigation

The experimental site was kept free from weeds by periodical hand weeding. Irrigation was given at an interval of 5-6 days depending on the soil moisture condition.

3.3.6 Plant protection

As a precautionary measure to control the bean aphid (*Aphis craccivora*) and bean pod borer (*Heliothis armigera*), monocrotophos at 0.2% was sprayed twice, first spraying was given at 25 days after sowing and second spraying was given at 50 days after sowing. To control fungal diseases copper oxy chloride at 3g per liter water was sprayed at two weeks and five weeks after sowing.

3.3.7 Biometrical data

Uniformly growing five plants were randomly selected and tagged from the net plot area in each treatment and replication for the purpose of recording the biometrical observations.

3.4 PREPARATION OF PLANT GROWTH REGULATOR SOLUTIONS

Stock solution of GA_3, NAA and Cycocel were prepared by dissolving required quantity of the substance in 95% alcohol and later diluted with water to the required concentration.

3.4.1 Method of application

The plant growth regulators were applied as whole plant sprays (2 times) with the help of Ganesh sprayer on french bean plants at 20 and 40 days after sowing (DAS).

3.5 MORPHOLOGICAL OBSERVATIONS:

3.5.1 Plant height (cm)

Five plants were selected at random in each plot and tagged for recording plant height. Plant height was measured from the base of the plant at ground level to the tip of the plant at 15, 30, 45 and 60 days after sowing with the help of a scale. The average was computed and expressed in centimeters.

3.5.2 Number of leaves per plant

The total number of leaves per plant including those on main stem as well as on branches were counted on tagged plants at 15 days intervals (15, 30, 45 and 60 DAS respectively). The average was computed and expressed in number of leaves per plant.

3.5.3 Number of branches per plant

The branches from five randomly selected plants from each plot were counted at 15, 30, 45 and 60 DAS. The average was computed and expressed as number of branches per plant.

3.5.4 Intermodal length (cm)

Intermodal length for tagged plants in each plot was measured at 15, 30, 45 and 60 DAS with the help of a scale. The average was computed and expressed in centimeters.

3.5.5 Days to flower bud initiation (days)

Number of days taken from sowing of seeds to the appearance of first floret was recorded and expressed in days.

3.5.6 Days to 50% flowering (days)

Number of days taken for 50% of the plants to come to flowering was recorded and expressed in days.

3.5.7 Days to first pod appearance (days)

Number of days taken from sowing of seeds to the appearance of first pod was recorded and expressed in days.

3.6 PHYSIOLOGICAL OBSERVATIONS:

3.6.1 Leaf area index (LAI)

The leaf area of five randomly selected plants in each experimental plot was measured with Planimeter at 15, 30, 45 and 60 days after sowing. The Planimeter readings were substituted to the following formula for calculating leaf area index.

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

3.6.2 Dry matter production (g)

Five plant samples were collected from each plot at random at different stages of plant growth and dried in an electric oven at 60^{o}C to a constant weight. These values were used for estimation of dry matter (g).

3.6.3 Chlorophyll content (SPAD units)

Chlorophyll content of tagged plants in each plot was measured with SPAD chlorophyll meter and expressed in SPAD units.

The chlorophyll meter (or SPAD units) is a simple, portable diagnostic tool that measures the greenness or relative chlorophyll content of leaves. Meter readings are given in Minolta Company-defined SPAD (soil plant analysis development) values that indicate relative chlorophyll contents.

The meter measures how much of the light of a certain wavelength (best absorbed by the chlorophyll molecules) is absorbed by the sample.

The instrument measures transmission of red light at 650 nm, at which chlorophyll absorbs light, and transmission of infrared light at 940 nm, at which no absorption occurs.

3.7 YIELD AND YIELD ATTRIBUTES:

3.7.1 Number of pickings:

Number of pickings for every treatment was calculated.

3.7.2 Number of pods per plant

The number of pods per plant was obtained by adding the number of pods of all pickings from the tagged plants in each plot and averaged to arrive at the number of pods per plant.

3.7.3 Pod length (cm)

The length of pods measured from each treatment was recorded immediately after picking from the tagged plants in each plot and averages were worked out.

3.7.4 Pod diameter (cm)

The diameter of pods was measured with vernier calipers immediately after picking from the tagged plants in each plot and averages were worked out and expressed in centimeters.

3.7.5 Weight of 10 pods (g)

Weight of 10 pods was obtained by adding the pods of all pickings from the tagged plants in each plot and taken 10 pods weight from those and expressed in grams.

3.7.6 Yield per plant (g)

The total yield (by weight) obtained from the tagged plants in each plot and averages were worked out and expressed in grams.

3.7.7 Yield per plot (kg)

The total yield (by weight) per plot obtained from each plot and expressed in kilo grams.

3.7.8 Yield per ha (q)

The total yield (by weight) per hectare obtained from each plot and expressed in quintals.

3.8 BIO CHEMICAL OBSERVATIONS

3.8.1 Fiber content (%)

Fiber content of the pod was estimated as per the procedure given by Ranganna (1986).

3.8.2 Protein content (%)

The Protein content of the pod was calculated by multiplying per cent nitrogen content in pod with the factor 6.25. Per cent nitrogen content was calculated by Micro – Kjeldahl method as per the procedure given by Ranganna (1986).

$$\text{Nitrogen \%} = \frac{\text{Sample titre- Blank titre} \times \text{Normality of HCL} \times 14 \times \text{Volume made up of the digest} \times 100}{\text{Aliquot of the digest taken} \times \text{Weight of the sample taken} \times 1000}$$

Protein % = Nitrogen % × 6.25

3.8.3 Ascorbic acid content (mg/100 g)

Ascorbic acid content of French bean pods was estimated by 2, 6-Dichlorophenol- Indophenol Visual Titration Method as per the procedure given by Ranganna (1986).

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

$$\text{mg of ascorbic acid per 100 g} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquat of extract taken for estimation} \times \text{Wt or volume of sample taken for estimation}}$$

3.9 BENEFIT COST RATIO

The benefit cost ratio of the french bean crop, was computed by taking into account, the actual cost incurred for cultivation which included the cost of all inputs. The net income was calculated on the basis of selling price of french bean pods prevailing during the period, after deducting the actual cost of cultivation.

3.10 STATISTICAL ANALYSIS

The data was analyzed using computer software programmed by the method of variance outlined by Panse and Sukhatme (1985). Statistical significance was tested by F value at 5 per cent level of significance. Critical difference at 0.05 level was worked out for the effects which were significant. The results have been depicted graphically where ever necessary.

Chapter-IV

Results

CHAPTER IV

RESULTS

The data obtained during the course of the present investigation was statistically analyzed and the results obtained are presented in this chapter.

In this chapter, the results on morphological, physiological, yield and yield attributes and biochemical parameters of french bean as influenced by foliar spray of GA_3, NAA and Cycocel in different concentrations are presented.

4.1 Plant height (cm)

The data recorded on plant height as influenced by the plant growth regulator treatments are presented in table 2 and fig. 2.

At 15 DAS, there was no significant difference observed for plant height as the treatments were imposed at 20 days after sowing.

Out of the growth regulators used, GA_3 and NAA showed increased plant height with increase in concentrations, while reduced plant height was observed in Cycocel as the concentration increased on 30,45 and 60 days after sowing.

At 30 days after sowing significant differences were observed among the treatments for plant height. Plant height recorded at 30 days after sowing ranged between 35.83 cm to 20.90 cm. The maximum plant height was recorded in GA_3 250 ppm 35.83 cm which was on par with GA_3 200 ppm (32.36 cm). The minimum plant height (20.90 cm) was recorded in Cycocel 350 ppm which was on par with NAA 10 ppm (21.89 cm) and CCC 300 ppm (24.04 cm). The plant height in rest of the treatments ranged between 24.34 cm (NAA 15 ppm) to 31.86 cm (GA_3 150 ppm).

The plant height at 45 days after sowing ranged between 47.33 cm to 24.66 cm. The maximum plant height (47.33 cm) was observed in GA_3 250 ppm which was on par with GA_3 200 ppm (44.33 cm). The minimum plant height (24.66 cm) was recorded in Cycocel at 350 ppm which was on par with CCC 300 ppm (25.00 cm), CCC 250 ppm (27.22 cm) and NAA 10 ppm (27.77 cm). Plant height in rest of the treatments ranged between 29.33 cm (NAA 15 ppm) to 37.00 cm (GA_3 150 ppm).

The plant height at 60 days after sowing ranged between 55.66 cm to 26.66 cm. The maximum plant height (55.66 cm) was observed in GA_3 250 ppm which was on par with GA_3 200 ppm (53.16 cm).The minimum plant height (26.66 cm) was recorded in Cycocel at 350 ppm which was on par with NAA 10 ppm (28.50 cm), CCC 300 ppm (30.00 cm) and CCC 250 ppm (31.00 cm). Plant height in rest of the treatments ranged between 31.75 cm (control) to 40.66 cm (GA_3 150 ppm).

4.2 Number of leaves / plant

The data recorded on number of leaves per plant as influenced by the plant growth regulator treatments are presented in table 3 and fig. 3.

At 15 DAS, there was no significant difference observed for number of leaves per plant as the treatments were imposed at 20 days after sowing.

In general with increase in concentration of the growth regulators, the leaf number increased at 45 and 60 days after sowing. But in the initial stages of the crop growth the results were in consistent.

The data at 30 days after sowing revealed that significant differences were observed among the treatments for number of leaves per plant. The treatment GA_3 250 ppm recorded maximum number of leaves per plant 19.80 which was on par with GA_3

200 ppm (18.70), GA_3 150 ppm (18.50) and NAA 20 ppm (18.00). Minimum number of leaves per plant (12.90) were observed in control treatment which was on par with NAA 10 ppm (14.00). Number of leaves per plant in rest of the treatments ranged between 14.70 (NAA 15 ppm) to 16.90 (CCC 250 ppm).

The data on number of leaves per plant at 45 days after sowing revealed that the number of leaves per plant at 45 DAS ranged between 46.50 to 27.00. The maximum number of leaves per plant (46.50) were recorded in GA_3 250 ppm which was on par with GA_3 200 ppm (42.00) and which differed significantly over the other treatments. Treatments NAA 10 ppm and CCC 250 ppm recorded minimum number of leaves per plant (27.00) which was on par with NAA 15 ppm (29.33) and control (30.00). Number of leaves per plant in rest of the treatments ranged between 38.00 (GA_3 150 ppm) to 32.00 (CCC 300 ppm).

The data collected at 60 days after sowing had revealed that the maximum number of leaves per plant 34.40 were recorded in NAA 20 ppm which was on par with GA_3 250 ppm (34.00), GA_3 200 ppm (33.00) and CCC 350 ppm (31.50). Minimum number of leaves per plant (24.90) were observed in NAA 10 ppm which was on par with CCC 250 ppm (25.30), control (26.40), NAA 15 ppm (27.70) and GA_3 150 ppm (28.00).

4.2 Number of branches / plant

The data recorded on number of branches plant as influenced by the plant growth regulator treatments are presented in table 4 and fig. 4.

At 15 DAS, there was no significant difference observed for number of branches per plant as the treatments were imposed at 20 days after sowing.

In general with increase in concentration of the growth regulators, the number of branches per plant increased at 45 and 60 days after sowing. But in the initial steps of the crop growth the results were in consistent.

At 30 days after sowing significant differences were observed among the treatments for number of branches. Number of branches per plant recorded at 30 days after sowing ranged between 8.70 to 6.40. The maximum number of branches per plant (8.70) were recorded in GA_3 250 ppm. The minimum number of branches per plant (6.40) were recorded in Cycocel at 350 ppm which was on par with control (6.70), NAA 10 ppm (6.80), NAA 15 ppm (6.90). Number of branches in rest of the treatments ranged between 7.60 (CCC 250 ppm) to 7.00 (GA_3 150 ppm).

Number of branches per plant at 45 days after sowing ranged between 12.62 to 9.12. The maximum number of branches per plant (12.62) were recorded in GA_3 250 ppm which was on par with NAA 20 ppm (12.32), CCC 350 ppm (11.50), GA_3 200 ppm (11.37) and GA_3 150 ppm (11.29). The minimum number of branches per plant (9.12) were recorded in NAA 10 ppm which was on par with control (9.25), CCC 250 ppm (9.25). Number of branches per plant in rest of the treatments were 10.50 (NAA 15 ppm) and 11.00 (CCC 300 ppm).

Number of branches per plant at 60 days after sowing ranged between 15.08 to 9.50. The maximum number of branches per plant (15.08) were recorded in GA_3 250 ppm (15.08) which was on par with GA_3 200 ppm (14.00). The minimum number of branches per plant (9.50) were recorded in Cycocel at 250 ppm which was on par with control (9.99), NAA 10 ppm (10.00) and NAA 15 ppm (10.54). Number of branches per plant in rest of the treatments ranged between 13.00 (GA_3 at 150 ppm) to 11.75 (CCC 300 ppm).

4.3 Internodal length (cm)

The data recorded on internodal length as influenced by the plant growth regulator treatments are presented in table 5 and fig. 5.

At 15 DAS, there was no significant difference observed for internodal length as the treatments were imposed at 20 days after sowing.

Out of the growth regulators used, GA_3 and NAA showed increased internodal length with increase in concentrations, while reduced internodal length was observed in Cycocel as the concentration increased from 250 ppm to 350 ppm and observations taken on 30,45 and 60 days after sowing.

At 30 days after sowing significant differences were observed among the treatments for internodal length. Internodal length recorded at 30 days after sowing ranged between 5.05 cm to 3.18 cm. The maximum internodal length 5.05 cm was observed in GA_3 250 ppm. The minimum internodal length 3.18 cm was recorded in CCC 350 ppm which was on par with CCC 300 ppm (3.40 cm). The internodal length in rest of the treatments ranged between 4.89 cm (NAA 20 ppm) to 3.53 cm (CCC 250 ppm).

The internodal length at 45 days after sowing ranged between 6.63 cm to 3.24 cm. The maximum internodal length 6.63 cm was observed in GA_3 250 ppm. Application of CCC 250 ppm recorded significantly lower intermodal length (3.24 cm) than other treatments. The internodal length in rest of the treatments ranged between 6.13 cm (GA_3 200 ppm) to 3.87 cm (CCC 300 ppm).

The data on internodal length at 60 days after sowing ranged between 10.56 cm to 4.74 cm. Among the treatments the maximum internodal length 10.56 cm was observed in GA_3 250 ppm which was on par with GA_3 200 ppm (10.13 cm). The minimum internodal length 4.74 cm was recorded in CCC 350 ppm which was on par with CCC 300 ppm (5.30 cm), CCC 250 ppm (5.55 cm). The intermodal length in rest of the treatments ranged between 6.14 cm (NAA 10 ppm) to 8.48 cm (GA_3 150 ppm).

4.4 Days to flower bud initiation

The data recorded on number of days to flower bud initiation as influenced by the plant growth regulator treatments are presented in table 6 and fig. 6. Significant differences were observed among the treatments for days to flower bud initiation.

Out of the growth regulators used, GA_3 and NAA showed increased number of days to flower bud initiation with increase in concentrations, while less number of days to flower bud initiation was observed in Cycocel as the concentration increased.

Data collected on number of days to flower bud initiation ranged between 31.50 days to 37.50 days. Among the treatments studied foliar spray of Cycocel 350 ppm was recorded minimum number of days (31.50 days) to flower bud initiation which was on par with CCC 300 ppm (32.50 days). The maximum number of days taken to flower bud initiation (37.50 days) was recorded by GA_3 250 ppm which was on par with GA_3 200 ppm (36.50 days). Number of days taken to flower bud initiation in rest of the treatments ranged between 34.00 days (CCC 250 ppm) to 36.00 days (NAA 10 ppm).

4.5 Days to 50% flowering

The data recorded on number of days to 50% flowering as influenced by the plant growth regulator treatments are presented in table 6 and fig. 7. Significant differences were observed among the treatments for days to 50% flowering.

Out of the growth regulators used, GA_3 and NAA showed increased number of days to 50% flowering with increase in concentrations, while less number of days to 50% flowering was observed in Cycocel as the concentration increased.

Data collected on number of days taken to 50% flowering ranged between 36.46 to 40.37 days. Among the treatments studied foliar spray of Cycocel 350 ppm was recorded minimum number of days (36.46 days) for 50% flowering which differed significantly over the other treatments. The maximum number of days to 50% flowering (40.37 days) was recorded by GA_3 250 ppm which was on par with GA_3 200 ppm (40.32 days). Number of days to 50% flowering in rest of the treatments ranged between 37.28 days (CCC 300 ppm) to 39.80 days (GA_3 150 ppm).

4.7 Days to first pod appearance

The data recorded on number of days taken to first pod appearance as influenced by the plant growth regulator treatments are presented in table 6 and fig. 8. Significant differences were observed among the treatments for days to first pod appearance.

Out of the growth regulators used, GA_3 and NAA showed increased number of days taken to first pod appearance with increase in concentrations, while less number of days to first pod appearance was observed in Cycocel as the concentration increased.

Data collected on number of days taken to first pod appearance ranged between 35.95 to 45.20 days. Among the treatments studied foliar spray of Cycocel 350 ppm had recorded minimum number of days (35.95 days) to first pod appearance which differed significantly over the other treatments. The maximum number of days taken to first pod appearance (45.20 days) was recorded by GA_3 250 ppm. Number of days taken to first pod appearance in rest of the treatments ranged between 38.15 days (CCC 300 ppm) to 43.65 days (GA_3 200 ppm).

4.8 Leaf area index

The data recorded on leaf area index as influenced by the plant growth regulator treatments are presented in table 7 and fig. 9.

At 15 DAS, there was no significant difference observed for leaf area index as the treatments were imposed at 20 days after sowing.

In general with increase in concentration of the growth regulators, the leaf area index increased at 30, 45 and 60 days after sowing.

The data at 30 days after sowing revealed that significant differences were observed among the treatments for leaf area index. Among the treatments GA_3 250 ppm recorded maximum leaf area index (0.510). Minimum leaf area index (0.297) was observed in control treatment was significantly lower than the other treatments. Leaf area index in rest of the treatments ranged between 0.491 (NAA 20 ppm) to 0.321 (CCC 250 ppm).

The data at on leaf area index at 45 days after sowing revealed that the leaf area index at 45 DAS ranged between 0.880 to 0.508. The maximum leaf area index (0.880) was recorded in GA_3 250 ppm which differed significantly over the other treatments. Minimum leaf area index (0.508) was observed in control treatment. Leaf area index in rest of the treatments ranged between 0.764 (GA_3 200 ppm) to 0.590 (CCC 250 ppm).

The data at on leaf area index at 60 days after sowing revealed that the leaf area index at 60 DAS ranged between 0.790 to 0.410. The maximum leaf area index (0.790) was recorded in GA_3 250 ppm which differed significantly over the other treatments. Minimum leaf area index (0.410) was observed in control. Leaf area index in rest of the treatments ranged between 0.738 (GA_3 200 ppm) to 0.500 (CCC 300 ppm).

4.9 Dry matter production (g)

The data recorded on dry matter production as influenced by the plant growth regulator treatments are presented in table 8 and fig. 10.

At 15 DAS, there was no significant difference observed for dry matter production as the treatments were imposed at 20 days after sowing.

Out of the growth regulators used, GA_3 and NAA showed increased dry matter production with increase in concentrations, while reduced dry matter production was observed in Cycocel as the concentration increased on 30,45 and 60 days after sowing.

At 30 days after sowing significant differences were observed among the treatments for dry matter production. Dry matter production recorded at 30 days after sowing ranged between 7.06 g to 4.80 g. The significantly higher dry matter production was recorded in GA_3 250 ppm 7.06 g. The minimum dry matter production (4.80 g) was recorded in Cycocel at 350 ppm. The dry matter production in rest of the treatments ranged between 6.25 g (NAA 20 ppm) to 4.94 g (control).

The dry matter production at 45 days after sowing ranged between 17.15 g to 9.12 g. Application of GA_3 250 ppm recorded significantly higher dry matter production (17.15 g) than other treatments. The minimum dry matter production (9.12 g) was recorded in NAA 10 ppm which was on par with CCC 350 ppm (9.22 g), CCC 300 ppm (9.86 g) and CCC 250 ppm (10.33 g) and GA_3 150 ppm (10.99 g). Dry matter production in rest of the treatments ranged between 14.68 g (NAA 20 ppm) to 10.93 g (control).

The dry matter production differed significantly at 60 days after sowing and ranged between 15.50 g to 8.67 g. The maximum dry matter production (15.50 g) was observed in GA_3 250 ppm. The minimum dry matter production (8.67 g) was recorded in Cycocel 350 ppm which was on par with NAA 10 ppm (9.03 g), CCC 300 ppm (9.50 g), control (9.76 g), CCC 250 ppm (9.96 g) and GA_3 150 ppm (10.36 g). Dry matter production in rest of the treatments ranged between 13.52 g (NAA 20 ppm) to 13.52 g (NAA 15 ppm).

4.10 Chlorophyll content (SPAD units)

The data recorded on chlorophyll content as influenced by the plant growth regulator treatments are presented in table 9 and fig. 11.

At 15 DAS, there was no significant difference observed for chlorophyll content (SPAD units) as the treatments were imposed at 20 days after sowing.

Among the growth regulators tried, GA_3 and Cycocel showed increase in chlorophyll content with increase in concentrations on 30,45 and 60 days after sowing. Statistically significant differences were observed among the treatments for chlorophyll content.

Data recorded at 30 days after sowing ranged between 26.66 SPAD units to 20.03 SPAD units. Among the treatments NAA 10 ppm has shown maximum chlorophyll content (26.66 SPAD units) which differed significantly over the other treatments. The minimum chlorophyll content (20.03 SPAD units) was recorded in control. Chlorophyll content in rest of the treatments ranged between 24.54 SPAD units (NAA 15 ppm) to 21.96 SPAD units (CCC 250 ppm).

Significant differences were observed among the treatments for chlorophyll content of leaves at 45 days after sowing. The maximum chlorophyll content (47.18 SPAD units) was recorded in CCC 350 ppm which was on par with NAA 10 ppm (45.66 SPAD units), NAA 15 ppm (44.64 SPAD units) and CCC 300 ppm (43.70 SPAD units) The minimum chlorophyll content (26.62 SPAD units) was recorded in GA_3 250 ppm.

At 60 DAS, there was no significant difference observed among the treatments for chlorophyll content (SPAD units). However GA_3 100 ppm recorded the highest chlorophyll content (26.66 SPAD units).

4.11 Number of pickings

The data recorded on number of pickings as influenced by the plant growth regulator treatments are presented in table 10 and fig. 12. Significant differences were observed among the treatments for number of pickings.

The number of pickings ranged between 3.50 to 2.00. Among the treatments studied foliar spray of GA_3 250 ppm had recorded maximum number of pickings (3.50) which was on par with NAA 15 ppm (3.00), NAA 20 ppm (3.00), GA_3 200 ppm (2.90) and NAA 10 ppm (2.90). While control had recorded minimum number of pickings (2.00) which was on par with CCC 250 ppm (2.23), GA_3 150 ppm (2.33) and CCC 300 ppm (2.50).

4.12 Number of pods per plant

The data recorded on number of pods per plant as influenced by the plant growth regulator treatments are presented in table 10 and fig 13. Significant differences were observed among the treatments for number of pods per plant.

Data collected on number of pods per plant ranged between 12.53 to 10.02. The maximum number of pods per plant (12.53) was recorded by GA_3 250 ppm which was on par with GA_3 200 ppm (12.31). Among the treatments studied control had recorded minimum number of pods per plant (10.02).

4.12 Pod length (cm)

The data recorded on pod length as influenced by the plant growth regulator treatments are presented in table 11 and fig. 14 indicated that out of the growth regulators used, GA_3 and NAA showed increased pod length with increase in concentrations, while reduced pod length was observed in Cycocel as the concentration increased. Significant differences were observed among the treatments for pod length.

Data collected on pod length ranged between 11.68 cm to 9.41 cm. Among the treatments studied GA_3 250 ppm was recorded maximum pod length (11.68 cm) which was on par with GA_3 200 ppm (11.43 cm). Cycocel 350 ppm was recorded minimum pod length (9.41 cm) which was on par with CCC 300 ppm (9.60 cm). While the rest of the treatments were in the order of GA_3 150 ppm (11.20 cm) followed by NAA 20 ppm (10.85 cm), NAA 15 ppm (10.53 cm), control (10.37 cm) CCC 250 ppm (10.30 cm) and NAA 10 ppm (10.26 cm).

4.13 Pod diameter (cm)

Data presented in the table 11 and fig. 15 has shown that increase in pod diameter was increased with increase in concentration of plant growth regulators. Significant differences were observed among the treatments for pod diameter.

Data recorded on pod diameter ranged between 1.07 cm to 0.96 cm. Among the treatments the maximum pod diameter (1.07 cm) was observed in Cycocel 350 ppm which was on par with GA_3 250 ppm (1.06 cm), NAA 20 ppm (1.04 cm), CCC 300 ppm (1.04 cm). The minimum pod diameter (0.96 cm) was observed in NAA 10 ppm.

4.14 Weight of 10 pods (g)

Data presented in the table 11 and fig. 16 showed that weight of 10 pods was increased with increase in concentration of plant growth regulators. Significant differences were observed among the treatments for weight of 10 pods.

Data collected on weight of 10 pods ranged between 52.33 g to 35.26 g. The maximum weight of 10 pods (52.33 g) was recorded by GA_3 250 ppm which was on par with GA_3 200 ppm (49.56 g), GA_3 150 ppm (48.83 g). Minimum weight of 10 pods (35.26 g) was recorded by CCC 250 ppm which was on par with CCC 300 ppm (36.23 g).

4.16 Yield / plant (g)

The data recorded on yield per plant as influenced by the plant growth regulator treatments are presented in table 12. Significant differences were observed among the treatments for yield per plant. Yield per plant was increased with increase in concentration of the growth regulators.

Data collected on yield per plant ranged between 67.21 g to 37.18 g. The maximum yield per plant (67.21 g) was recorded by GA_3 250 ppm which differed significantly over the other treatments. Minimum yield per plant (37.18 g) was recorded by control treatment which was on par with CCC 250 ppm (37.50 g). Yield per plant in rest of the treatments ranged between 61.41 g (GA_3 200 ppm) to 41.96 g (CCC 300 ppm).

4.17 Yield / plot (kg)

The data recorded on yield per plot as influenced by the plant growth regulator treatments are presented in table 12. Significant differences were observed among the treatments for yield per plot. Yield per plot was increased with increase in concentration of the growth regulators.

Data collected on yield per plot ranged between 3.52 kg to 2.05 kg. The maximum yield per plot (3.52 kg) was recorded by GA_3 250 ppm which differed significantly over the other treatments. Minimum yield per plot (2.05 kg) was recorded by control treatment which was on par with CCC 250 ppm (2.20 kg). Yield per plot in rest of the treatments ranged between 3.25 kg (GA_3 200 ppm) to 2.30 kg (CCC 300 ppm).

4.18 Yield / ha (q)

The data recorded on yield per ha. influenced by the plant growth regulator treatments are presented in table 12 and fig. 17. Significant differences were observed among the treatments for yield per ha. Yield per ha was increased with increase in concentration of the growth regulators.

Data collected on yield per ha ranged between 40.44 q to 28.10 q. The maximum yield per ha (40.44 q) was recorded by GA_3 250 ppm which differed significantly over the other treatments. Minimum yield per ha (28.10 q) was recorded by control treatments which was on par with CCC 250 ppm (28.18 q), CCC 300 ppm (30.10 q), NAA 10 ppm (31.96 q), NAA 15 ppm (32.18 q), CCC 350 ppm (33.29 q) and GA_3 150 ppm (33.44 q).

4.19 Fiber content (g)

The data recorded on fiber content as influenced by the plant growth regulator treatments are presented in table 13 and fig. 18. Significant differences were observed among the treatments for fiber content.

Data collected on fiber content ranged between 3.18 g to 3.74 g. Among the treatments the minimum fiber content (3.18 g) was recorded in GA_3 250 ppm which was on par with GA_3 200 ppm (3.22 g). The maximum fiber content (3.74 g) was recorded in Cycocel 350 ppm which differed significantly over the other treatments. Fiber content in rest of the treatments ranged between 3.23 g (GA_3 150 ppm) to 3.58 g (CCC 300 ppm).

4.20 Protein content (%)

The data recorded on protein content as influenced by the plant growth regulator treatments are presented in table 13 and fig. 19. Significant differences were observed among the treatments for protein content.

Data collected on protein content ranged between 3.02 g to 2.01 g. Among the treatments the maximum protein content (3.02 g) was observed in NAA 20 ppm which was on par with GA_3 250 ppm (2.97 g), GA_3 200 ppm (2.91 g) and NAA 15 ppm (2.89 g). The minimum protein content (2.01 g) was observed in control which was on par with GA_3 150 ppm (2.11 g). Protein content in rest of the treatments ranged between 2.84 g (CCC 250 ppm) to 2.32 g (CCC 300 ppm).

4.21 Ascorbic acid content (mg/100g of fresh pod)

The data recorded on ascorbic acid content as influenced by the plant growth regulator treatments are presented in table 13 and fig. 20. Significant differences were observed among the treatments for ascorbic acid content.

Data collected on ascorbic acid content ranged between 12.40 (mg/100g of fresh pod) to 10.00 (mg/100g of fresh pod). Among the treatments studied foliar spray of GA_3 250 ppm recorded maximum ascorbic acid content (12.40 mg/100g of fresh pod) which differed significantly over the other treatments. Minimum ascorbic acid content (10.00 mg/100g of fresh pod) was recorded in Cycocel 250 ppm and CCC 300 ppm (10.00 mg/100g of fresh pod). Ascorbic acid content in rest of the treatments ranged between 11.60 mg/100g of fresh pod (GA_3 200 ppm) to 10.80 mg/100g of fresh pod (NAA 10 ppm).

4.22 Benefit cost ratio

The data recorded on benefit cost ratio as influenced by the plant growth regulator treatments are presented in table 14.Control incurred the least cost of cultivation (Rs. 35,064.50 per hectare). Maximum cost of cultivation (Rs. 1,02,452.72 per hectare) was incurred by GA_3 250 ppm.

Foliar spray of GA_3 250 ppm recorded the maximum gross returns (Rs. 1,21,320 per hectare). Minimum gross returns (Rs. 84,330 per hectare) was recorded by control.

Foliar spray of NAA 20 ppm recorded the maximum net returns (Rs. 68,007 per hectare). Minimum net returns (Rs. 14,675 per hectare) was recorded by GA_3 200 ppm. While control recorded Rs. 49,263 per hectare of net returns.

Foliar spray of NAA 20 ppm recorded the maximum benefit cost ratio (1.92). Minimum benefit cost ratio (0.16) was recorded by GA_3 200 ppm. While control recorded 1.40 benefit cost ratio.

Table 4: Effect of foliar sprays of different plant growth regulators on number of branches per plant at 15, 30, 45 and 60 days after sowing in french bean cv. Arka Komal

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
GA_3 at 150 ppm	1.70	7.00	11.29	13.00
GA_3 at 200 ppm	1.60	7.60	11.37	14.00
GA_3 at 250 ppm	1.70	8.70	12.62	15.08
NAA at 10 ppm	1.83	6.80	9.12	10.00
NAA at 15 ppm	1.20	6.90	10.50	10.54
NAA at 20 ppm	1.40	7.50	12.32	12.68
CCC at 250 ppm	1.70	7.60	9.25	9.50
CCC at 300 ppm	1.70	7.20	11.00	11.62
CCC at 350 ppm	1.53	6.40	11.50	11.75
Control (water spray)	1.40	6.70	9.25	9.99
SE(m)	0.15	0.19	0.44	0.68
CD (P=0.05)	N.S.	0.57	1.33	2.03

Table 12: Effect of foliar sprays of different plant growth regulators on yield/plant (g), yield/plot (Kg) and yield/ha (q) in french bean cv. Arka Komal

Treatments	Yield/plant (g)	Yield/plot (Kg)	Yield/ha (q)
GA_3 at 150 ppm	59.77	3.13	33.44
GA_3 at 200 ppm	61.41	3.25	34.54
GA_3 at 250 ppm	67.21	3.52	40.44
NAA at 10 ppm	45.90	2.52	31.96
NAA at 15 ppm	54.74	2.94	32.18
NAA at 20 ppm	57.46	3.06	34.44
CCC at 250 ppm	37.50	2.20	28.18
CCC at 300 ppm	41.96	2.30	30.10
CCC at 350 ppm	49.10	2.76	33.29
Control (water spray)	37.18	2.05	28.10
SE(m)	0.50	0.07	1.79
CD (P=0.05)	1.52	0.22	5.37

Table 6: Effect of foliar sprays of different plant growth regulators on days to flower bud initiation, days to 50 % flowering and days to first pod appearance in french bean cv. Arka Komal

Treatments	Days to flower bud initiation (days)	Days to 50% flowering (days)	Days to first pod appearance (days)
GA_3 at 150 ppm	35.00	39.80	42.60
GA_3 at 200 ppm	36.50	40.32	43.65
GA_3 at 250 ppm	37.50	40.37	45.20
NAA at 10 ppm	36.00	39.50	42.25
NAA at 15 ppm	34.50	39.30	41.30
NAA at 20 ppm	34.50	38.46	41.00
CCC at 250 ppm	34.00	38.44	38.35
CCC at 300 ppm	32.50	37.28	38.15
CCC at 350 ppm	31.50	36.46	35.95
Control (water spray)	35.50	39.30	42.10
SE(m)	0.46	0.13	0.16
CD (P=0.05)	1.37	0.41	0.50

Table 10: Effect of foliar sprays of different plant growth regulators on number of pickings and number of pods/plant in french bean cv. Arka Komal

Treatments	Number of pickings	Number of pods/plant
GA_3 at 150 ppm	2.33	12.31
GA_3 at 200 ppm	2.90	12.23
GA_3 at 250 ppm	3.50	12.53
NAA at 10 ppm	2.90	10.72
NAA at 15 ppm	3.00	11.91
NAA at 20 ppm	3.00	12.01
CCC at 250 ppm	2.23	10.51
CCC at 300 ppm	2.50	11.46
CCC at 350 ppm	2.70	11.91
Control (water spray)	2.00	10.02
SE(m)	0.21	0.08
CD (P=0.05)	0.62	0.26

Table 11: Effect of foliar sprays of different plant growth regulators on pod length (cm), pod diameter (cm) and weight of 10 pods (g) in french bean cv. Arka Komal

Treatments	Pod length (cm)	Pod diameter (cm)	Weight of 10 pods (g)
GA_3 at 150 ppm	11.20	0.98	48.83
GA_3 at 200 ppm	11.43	1.02	49.56
GA_3 at 250 ppm	11.68	1.06	52.33
NAA at 10 ppm	10.26	0.96	43.06
NAA at 15 ppm	10.53	0.98	46.20
NAA at 20 ppm	10.85	1.04	47.16
CCC at 250 ppm	10.30	0.98	35.26
CCC at 300 ppm	9.60	1.04	36.23
CCC at 350 ppm	9.41	1.07	42.00
Control (water spray)	10.37	1.02	37.33
SE(m)	0.14	0.015	1.65
CD (P=0.05)	0.43	0.046	4.95

Table 9: Effect of foliar sprays of different plant growth regulators on chlorophyll content (SPAD units) at 15, 30, 45 and 60 days after sowing in french bean cv. Arka Komal

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
GA_3 at 150 ppm	19.66	23.71	37.29	26.66
GA_3 at 200 ppm	20.33	23.54	33.14	25.59
GA_3 at 250 ppm	19.00	22.62	26.62	25.49
NAA at 10 ppm	20.00	26.66	45.66	26.25
NAA at 15 ppm	20.33	24.54	44.64	26.00
NAA at 20 ppm	19.66	24.38	35.32	26.00
CCC at 250 ppm	19.33	21.96	42.80	26.10
CCC at 300 ppm	19.66	22.27	43.70	26.11
CCC at 350 ppm	20.00	24.19	47.18	26.20
Control (water spray)	20.66	20.03	36.22	26.08
SE(m)	0.34	0.47	1.38	0.22
CD (P=0.05)	N.S.	1.42	4.14	N.S.

Table 13: Effect of foliar sprays of different plant growth regulators on fiber content (g), protein content (%) and ascorbic acid content (mg/100g) in french bean cv. Arka Komal

Treatments	Fiber content (g)	Protein content (%)	Ascorbic acid content (mg/100 g)
GA_3 at 150 ppm	3.23	2.11	11.20
GA_3 at 200 ppm	3.22	2.91	11.60
GA_3 at 250 ppm	3.18	2.97	12.40
NAA at 10 ppm	3.31	2.55	10.80
NAA at 15 ppm	3.28	2.89	11.20
NAA at 20 ppm	3.26	3.02	11.20
CCC at 250 ppm	3.57	2.84	10.00
CCC at 300 ppm	3.58	2.32	10.00
CCC at 350 ppm	3.74	2.78	10.80
Control (water spray)	3.56	2.01	10.80
SE(m)	0.01	0.05	0.24
CD (P=0.05)	0.04	0.16	0.73

Table 8: Effect of foliar sprays of different plant growth regulators on dry matter production (g) at 15, 30, 45 and 60 days after sowing in french bean cv. Arka Komal

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
GA_3 at 150 ppm	1.740	5.76	10.99	10.36
GA_3 at 200 ppm	1.717	6.24	13.21	12.96
GA_3 at 250 ppm	1.723	7.06	17.15	15.50
NAA at 10 ppm	1.713	5.50	9.12	9.03
NAA at 15 ppm	1.710	5.80	11.23	10.88
NAA at 20 ppm	1.733	6.25	14.68	13.52
CCC at 250 ppm	1.773	4.99	10.33	9.96
CCC at 300 ppm	1.723	4.95	9.86	9.50
CCC at 350 ppm	1.743	4.80	9.22	8.67
Control (water spray)	1.737	4.94	10.93	9.76
SE(m)	0.012	0.15	0.69	0.59
CD (P=0.05)	N.S.	0.45	2.09	1.76

Table 14: Effect of foliar sprays of different plant growth regulators on economics of production in french bean cv. Arka Komal

Treatments	Cost of cultivation (Rs/ ha)	Gross returns (Rs/ ha)	Net returns (Rs/ ha)	Benefit cost ratio
GA_3 at 150 ppm	75497.43	100320	24823	0.33
GA_3 at 200 ppm	88975.07	103650	14675	0.16
GA_3 at 250 ppm	102452.72	121320	18867	0.18
NAA at 10 ppm	35188.93	95880	60691	1.72
NAA at 15 ppm	35251.15	96540	61289	1.74
NAA at 20 ppm	35313.36	103320	68007	1.92
CCC at 250 ppm	46119.75	84540	38420	0.83
CCC at 300 ppm	48331.03	90330	41999	0.87
CCC at 350 ppm	50542.123	99870	49328	0.97
Control (water spray)	35064.50	84330	49265	1.40

Table 8: Effect of foliar sprays of different plant growth regulators on leaf area index at 15, 30, 45 and 60 days after sowing in french bean cv. Arka Komal

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
GA_3 at 150 ppm	0.270	0.462	0.720	0.701
GA_3 at 200 ppm	0.287	0.487	0.764	0.738
GA_3 at 250 ppm	0.290	0.510	0.880	0.790
NAA at 10 ppm	0.263	0.413	0.612	0.604
NAA at 15 ppm	0.263	0.451	0.648	0.616
NAA at 20 ppm	0.280	0.491	0.709	0.690
CCC at 250 ppm	0.270	0.321	0.590	0.520
CCC at 300 ppm	0.267	0.348	0.614	0.500
CCC at 350 ppm	0.280	0.354	0.646	0.564
Control (water spray)	0.287	0.297	0.508	0.410
SE(m)	0.007	0.001	0.005	0.003
CD (P=0.05)	N.S.	0.003	0.015	0.010

Table 4: Effect of foliar sprays of different plant growth regulators on number of leaves per plant at 15, 30, 45 and 60 days after sowing in french bean cv. Arka Komal

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
GA_3 at 150 ppm	4.66	18.50	38.00	28.00
GA_3 at 200 ppm	5.00	18.70	42.00	33.00
GA_3 at 250 ppm	5.00	19.80	46.50	34.00
NAA at 10 ppm	5.33	14.00	27.00	24.90
NAA at 15 ppm	4.33	14.70	29.33	27.70
NAA at 20 ppm	4.66	18.00	36.00	34.40
CCC at 250 ppm	5.00	16.90	27.00	25.30
CCC at 300 ppm	5.00	15.90	32.00	29.90
CCC at 350 ppm	4.66	15.50	34.00	31.50
Control (water spray)	4.33	12.90	30.00	26.40
SE(m)	0.265	0.90	1.58	1.08
CD (P=0.05)	N.S.	2.71	4.74	3.25

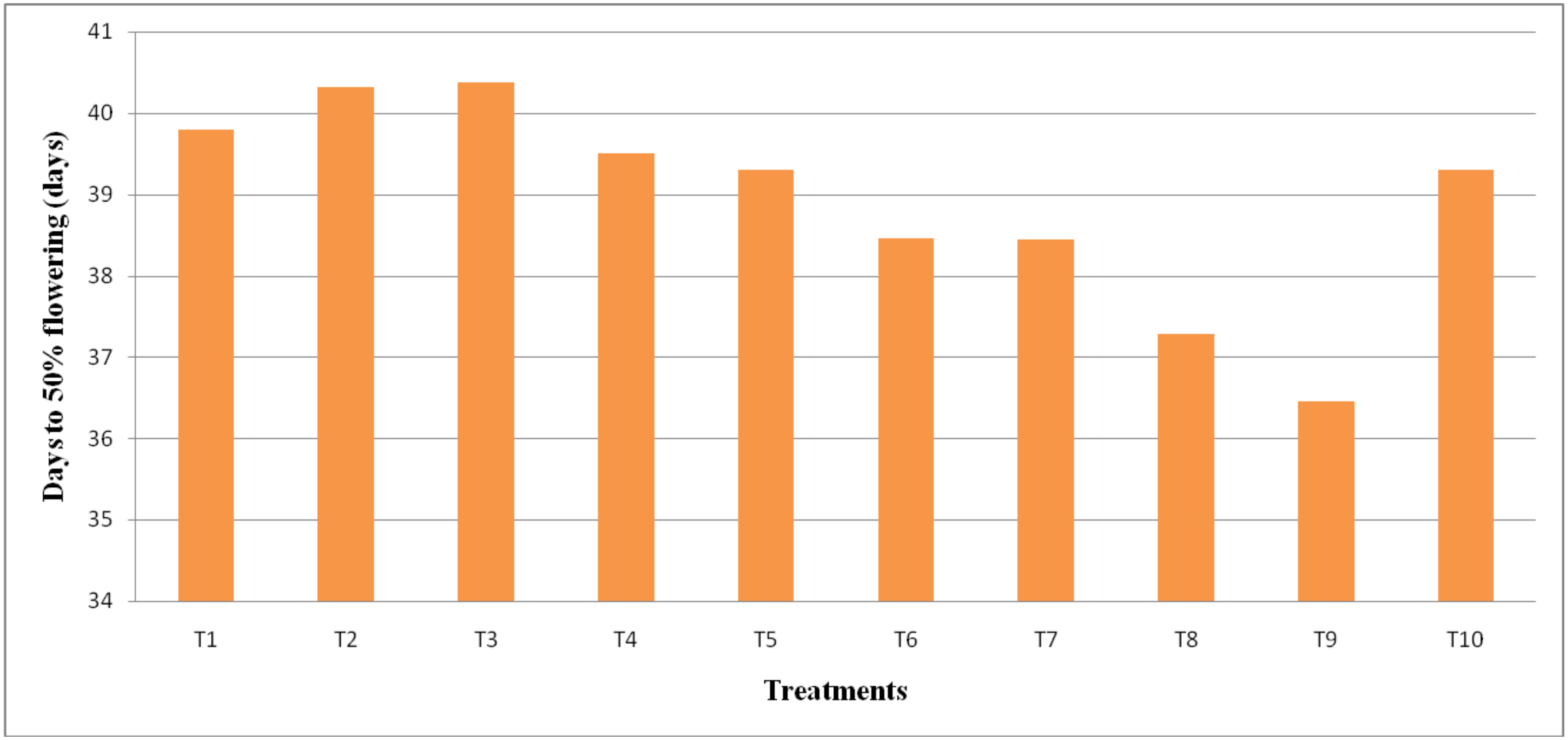

Fig. 7: Effect of foliar spray of different plant growth regulators on days to 50% flowering in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

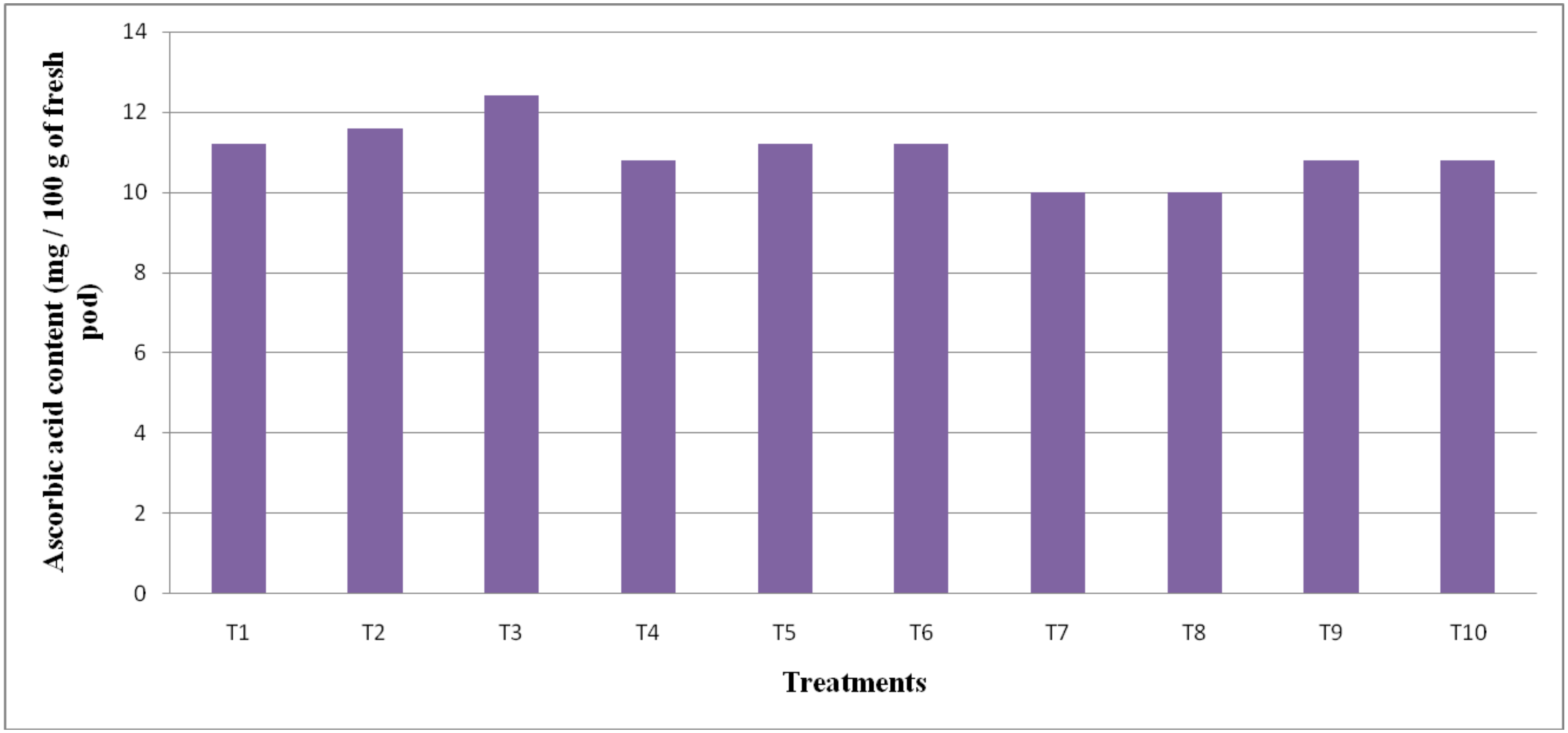

Fig. 20: Effect of foliar spray of different plant growth regulators on ascorbic acid content in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**
T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

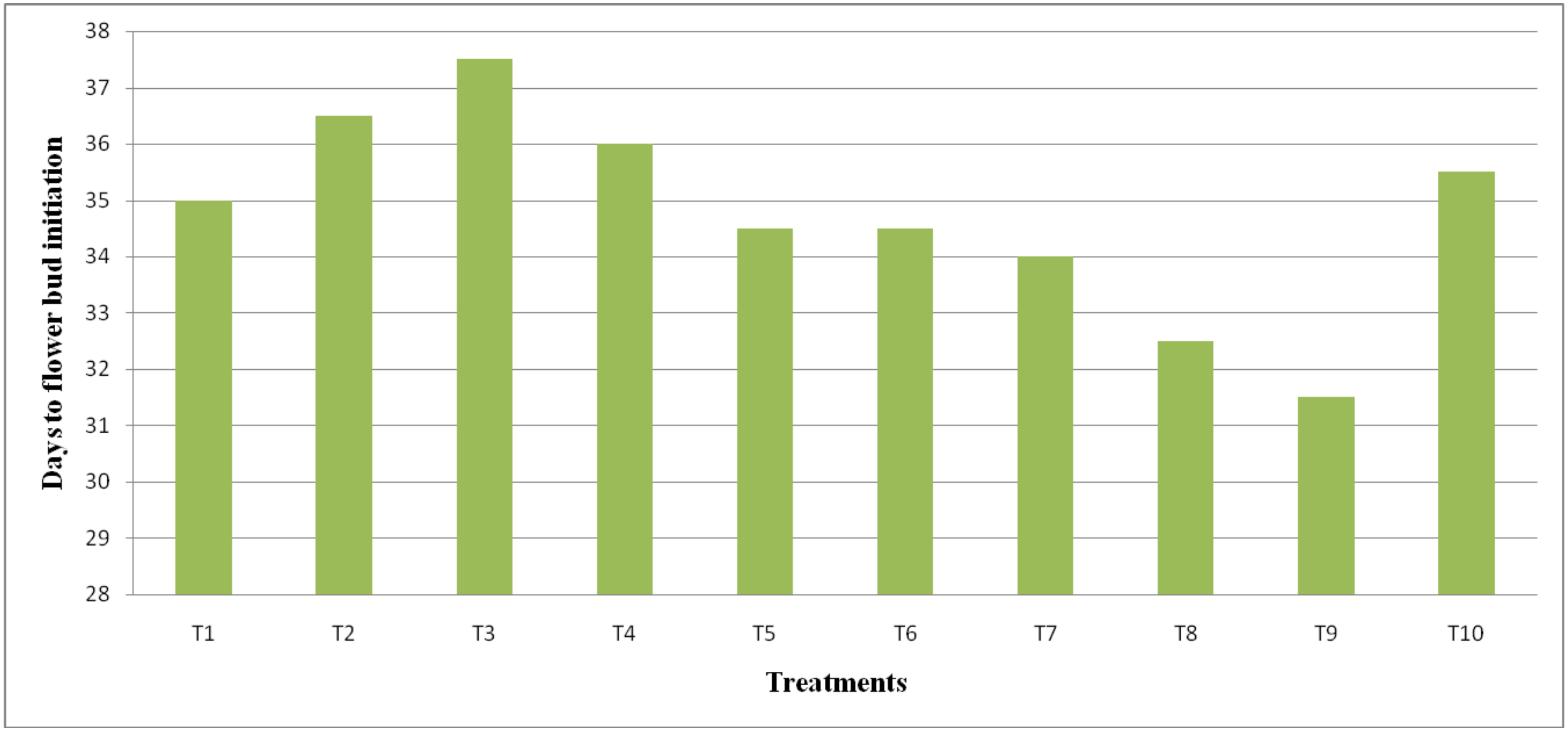

Fig. 6: Effect of foliar spray of different plant growth regulators on days to flower bud initiation in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

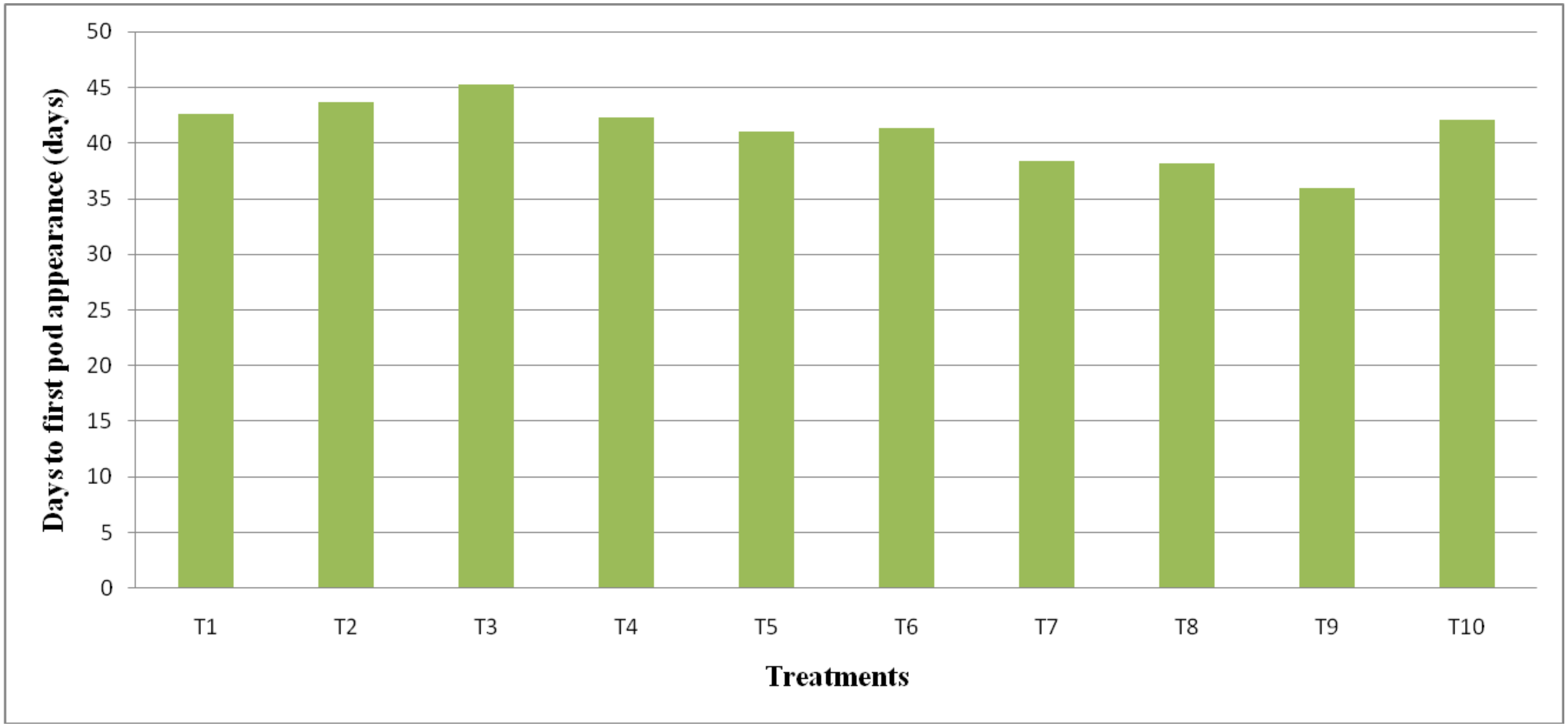

Fig. 8: Effect of foliar spray of different plant growth regulators on days to first pod appearance in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

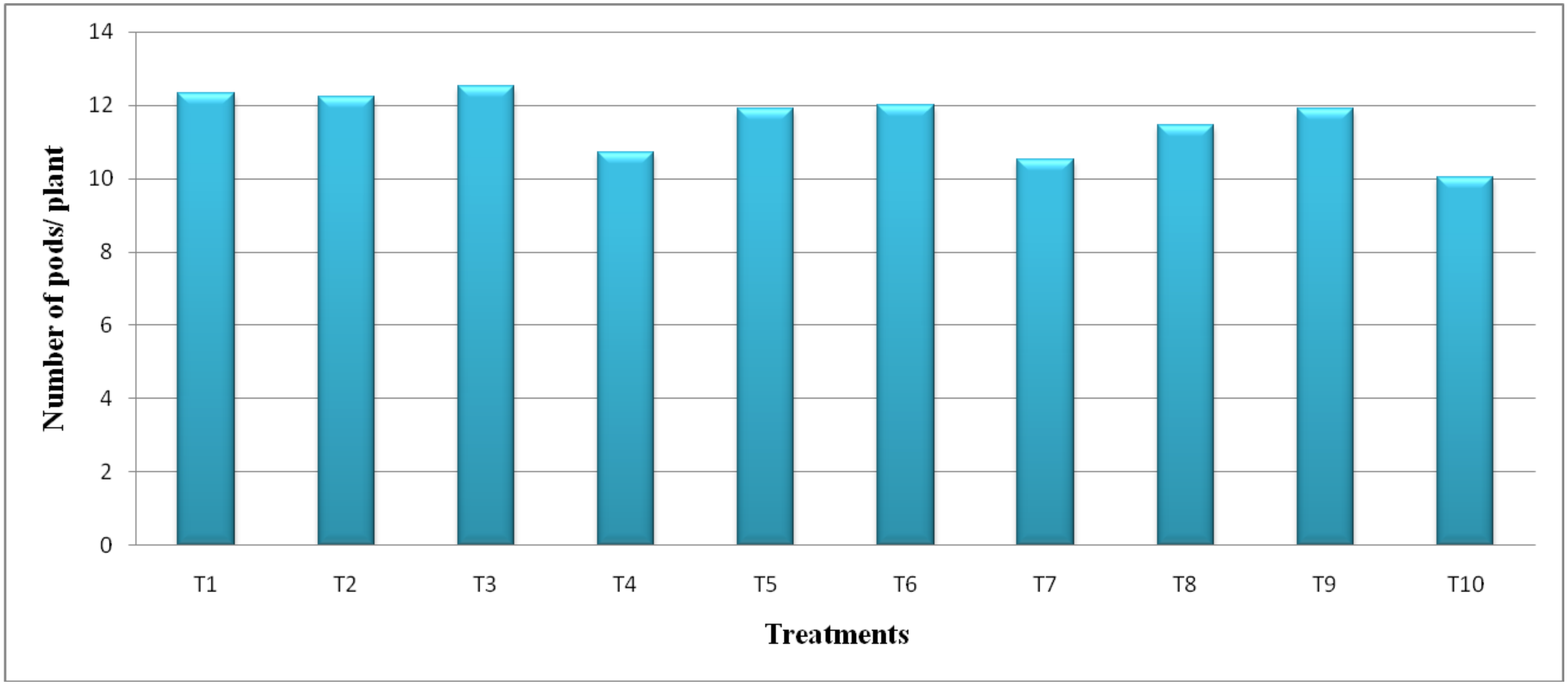

Fig. 13: Effect of foliar spray of different plant growth regulators on number of pods/plant in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

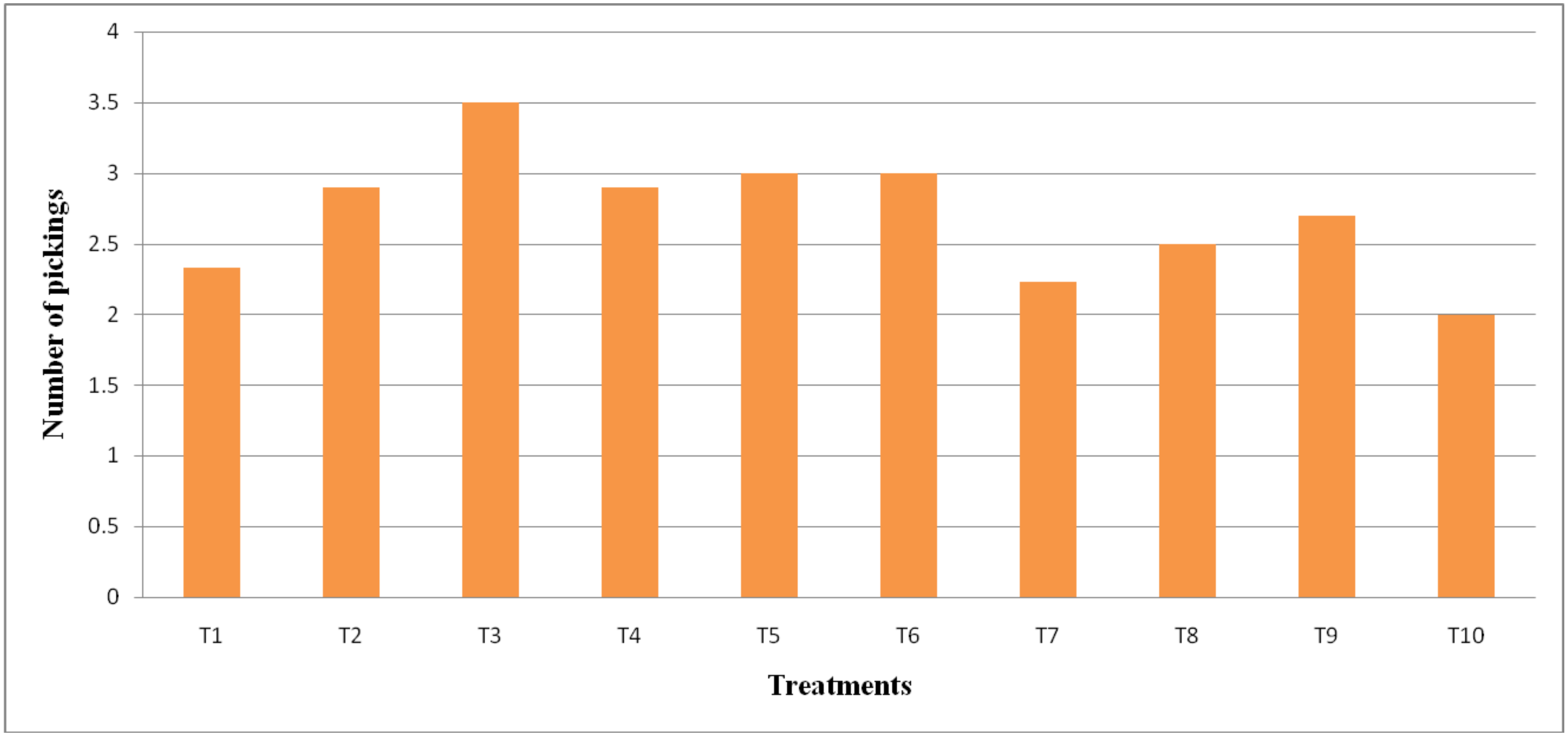

Fig. 12: Effect of foliar spray of different plant growth regulators on number of pickings in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

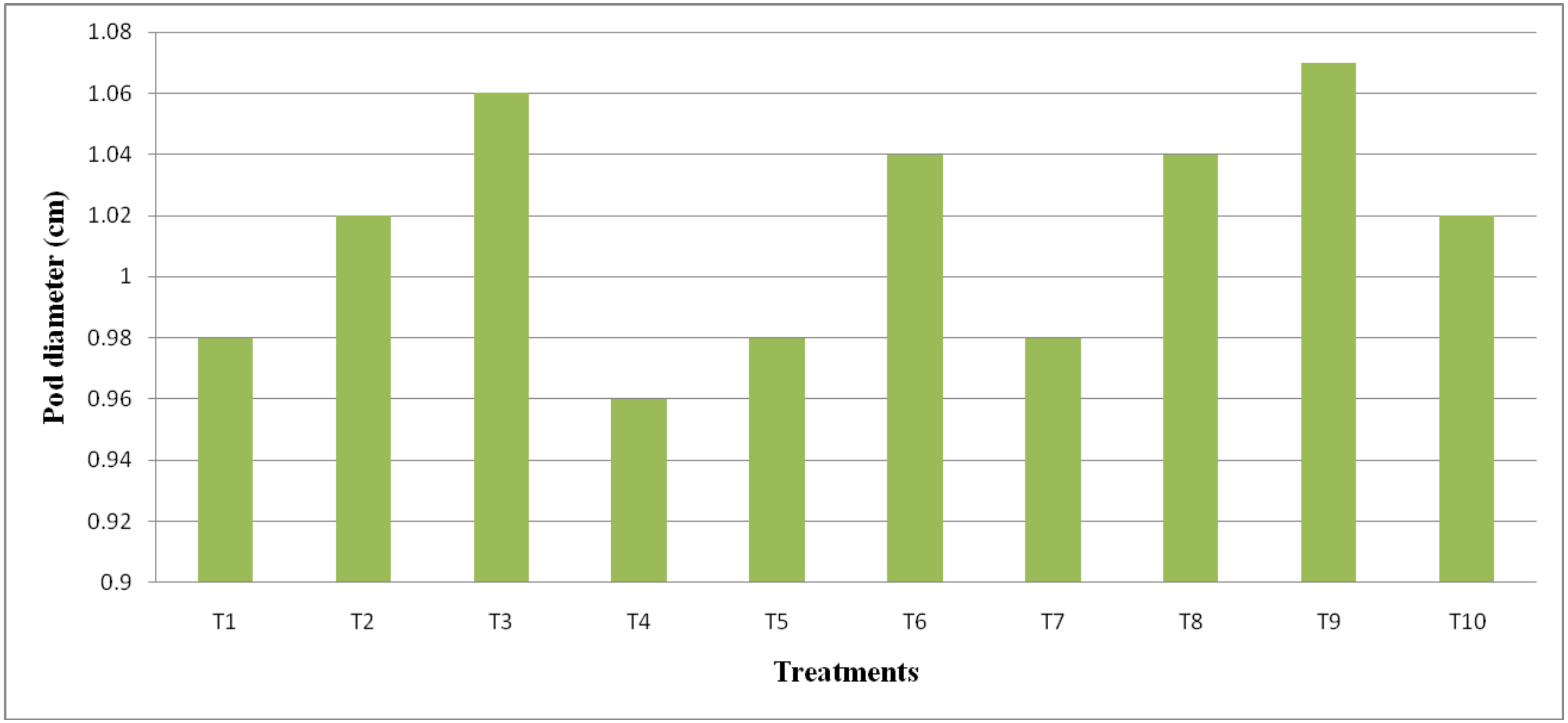

Fig. 15: Effect of foliar spray of different plant growth regulators on pod diameter in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

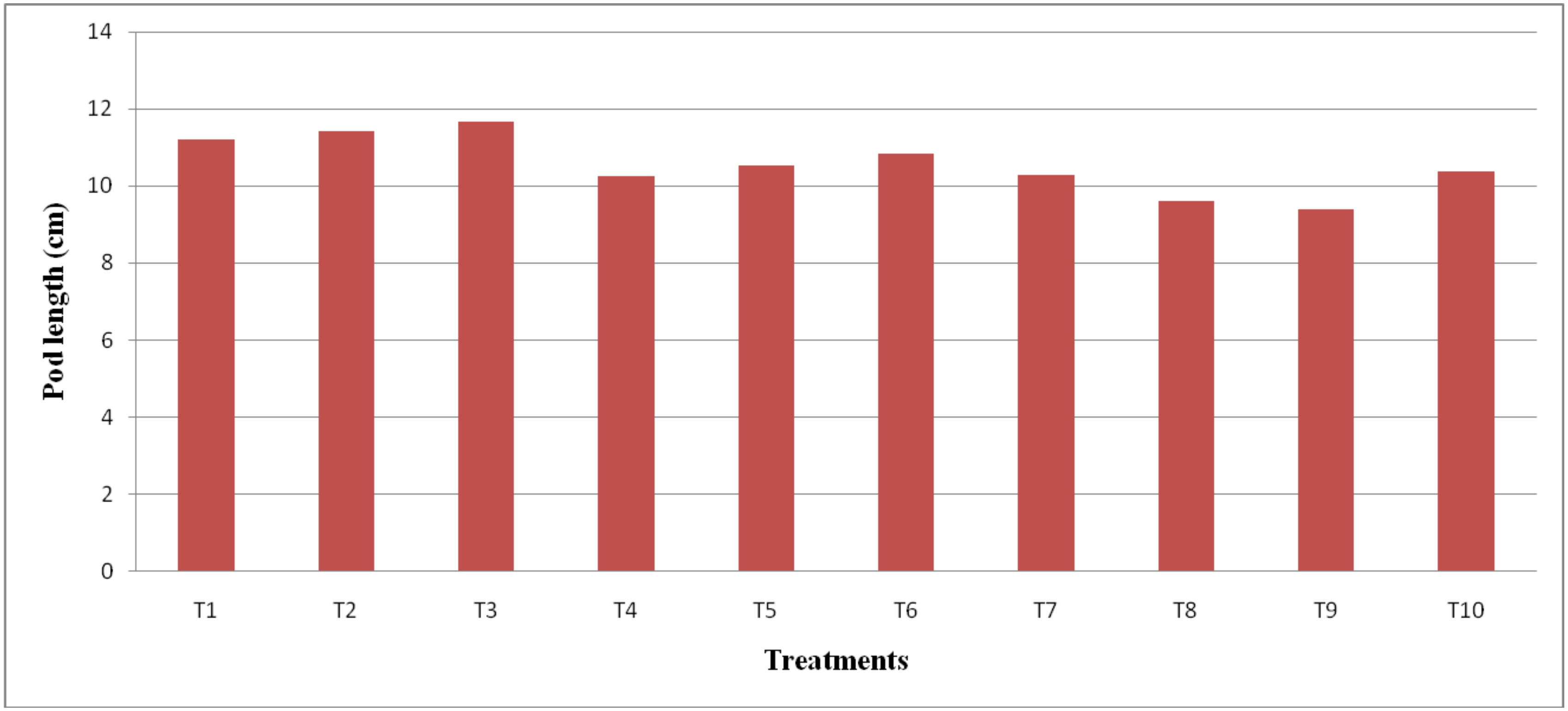

Fig. 14: Effect of foliar spray of different plant growth regulators on pod length in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

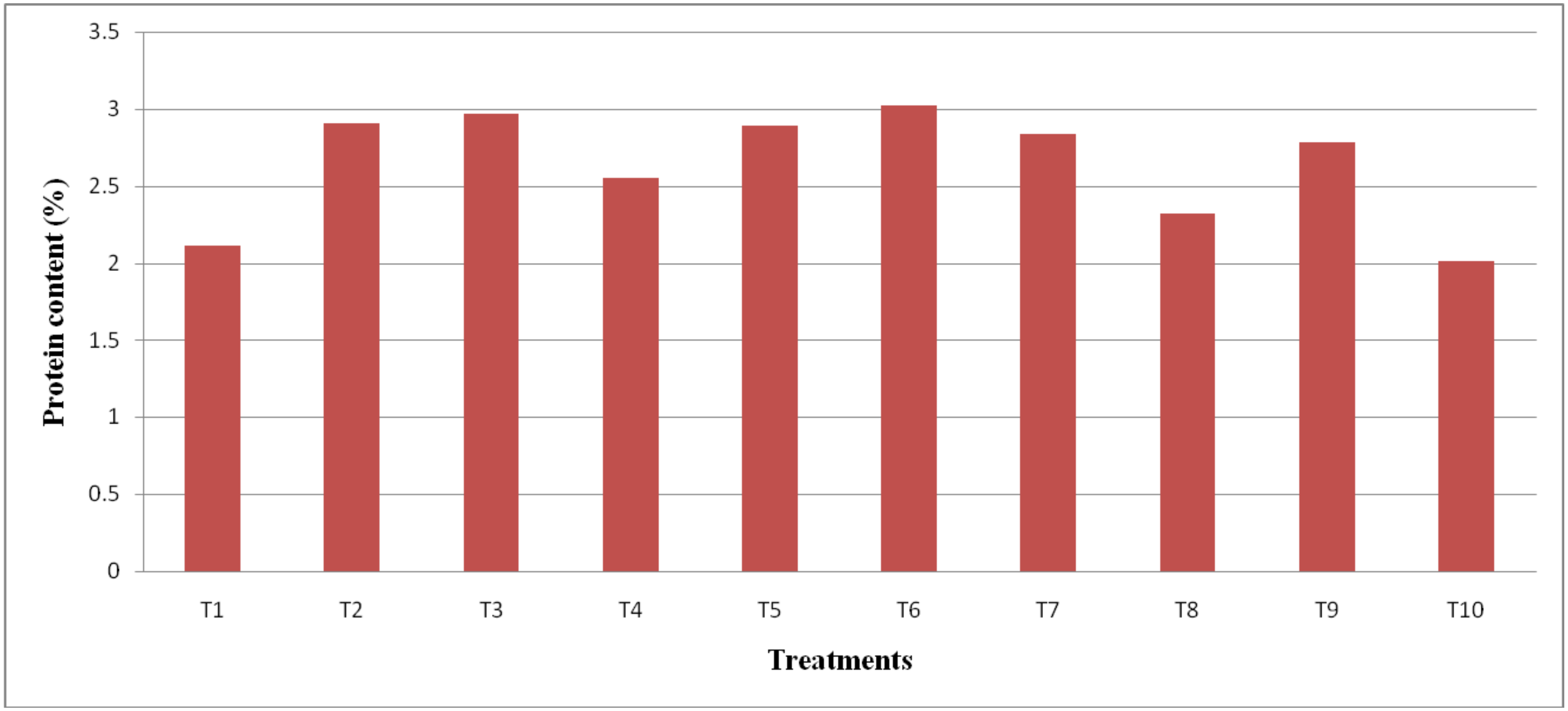

Fig. 19: Effect of foliar spray of different plant growth regulators on protein content in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

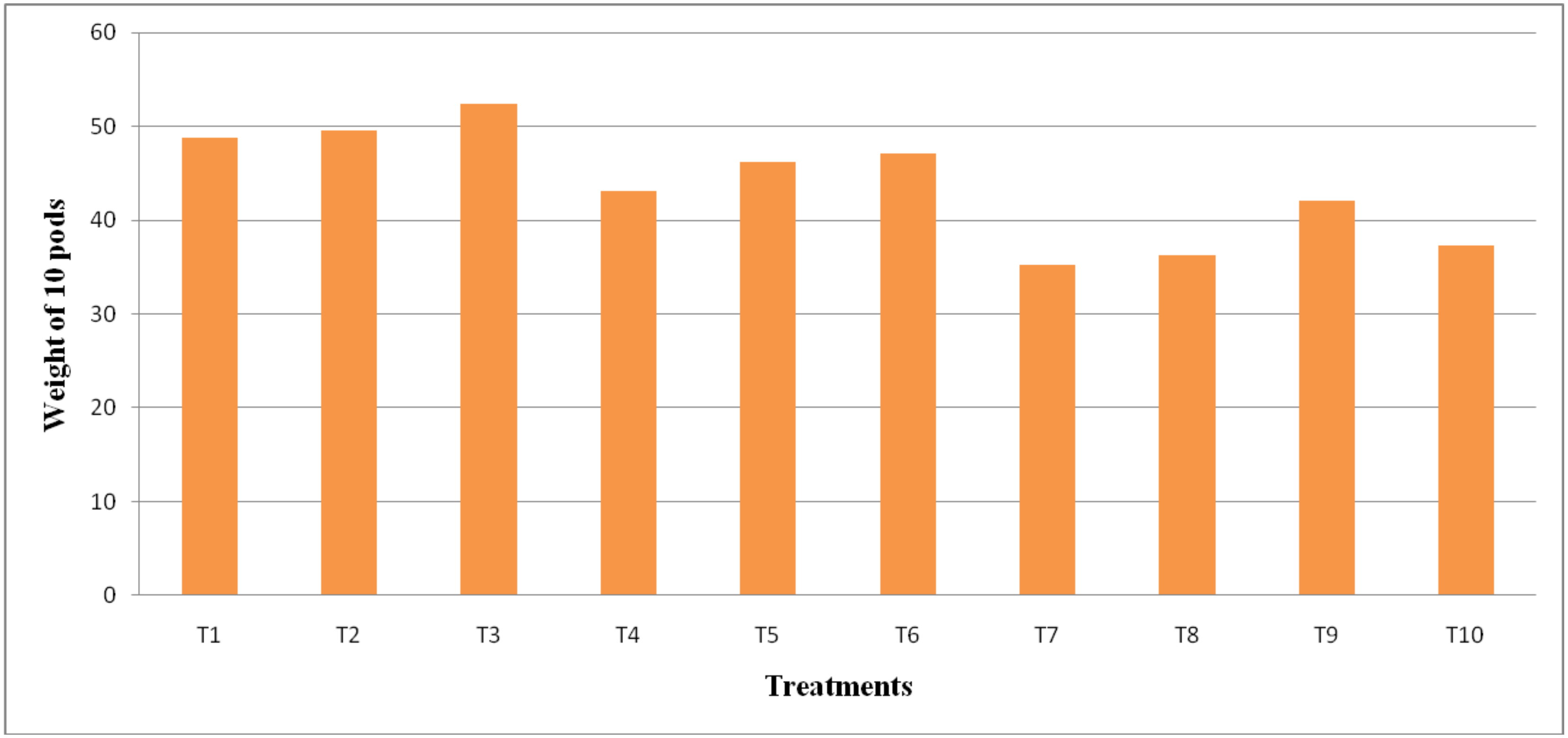

Fig. 16: Effect of foliar spray of different plant growth regulators on weight of 10 pods in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

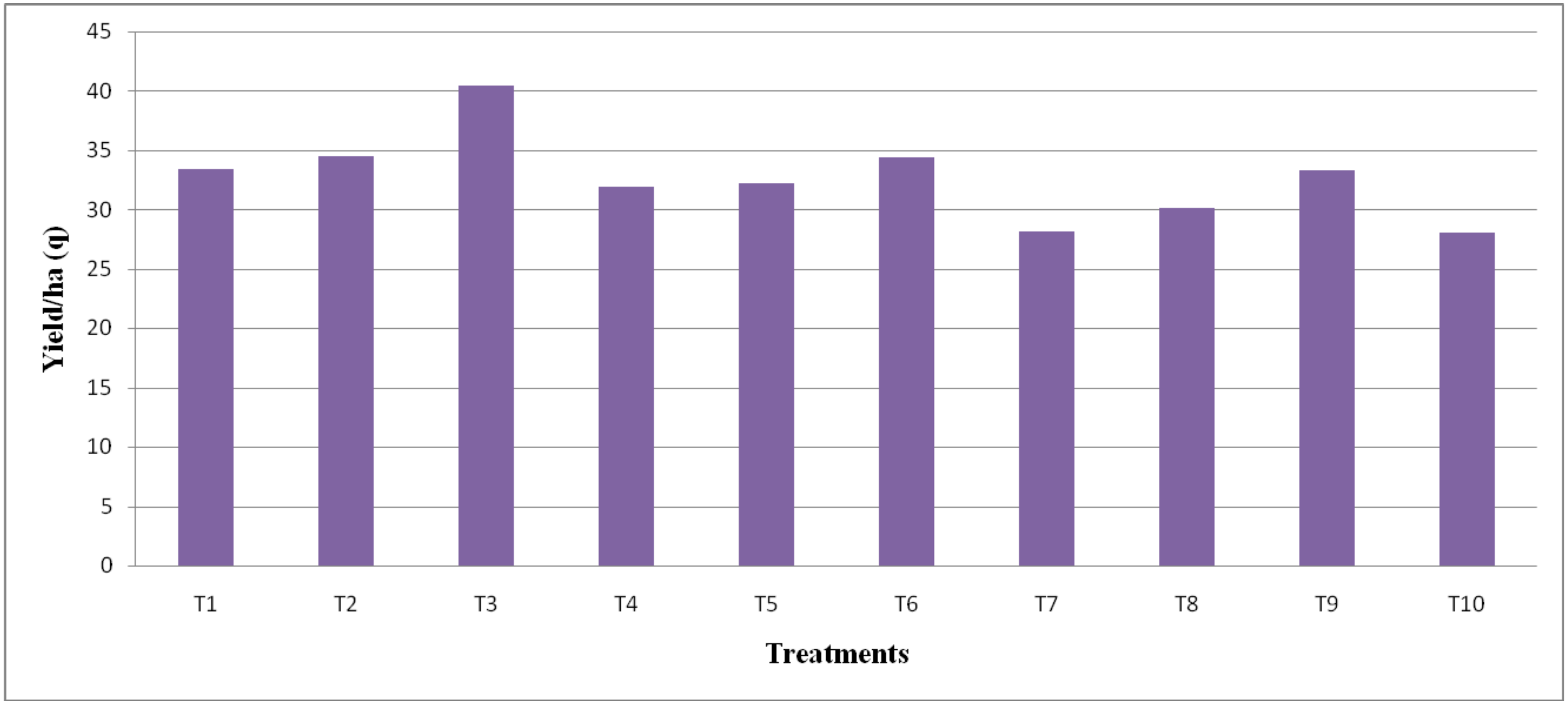

Fig. 17: Effect of foliar spray of different plant growth regulators on yield/ha in french bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

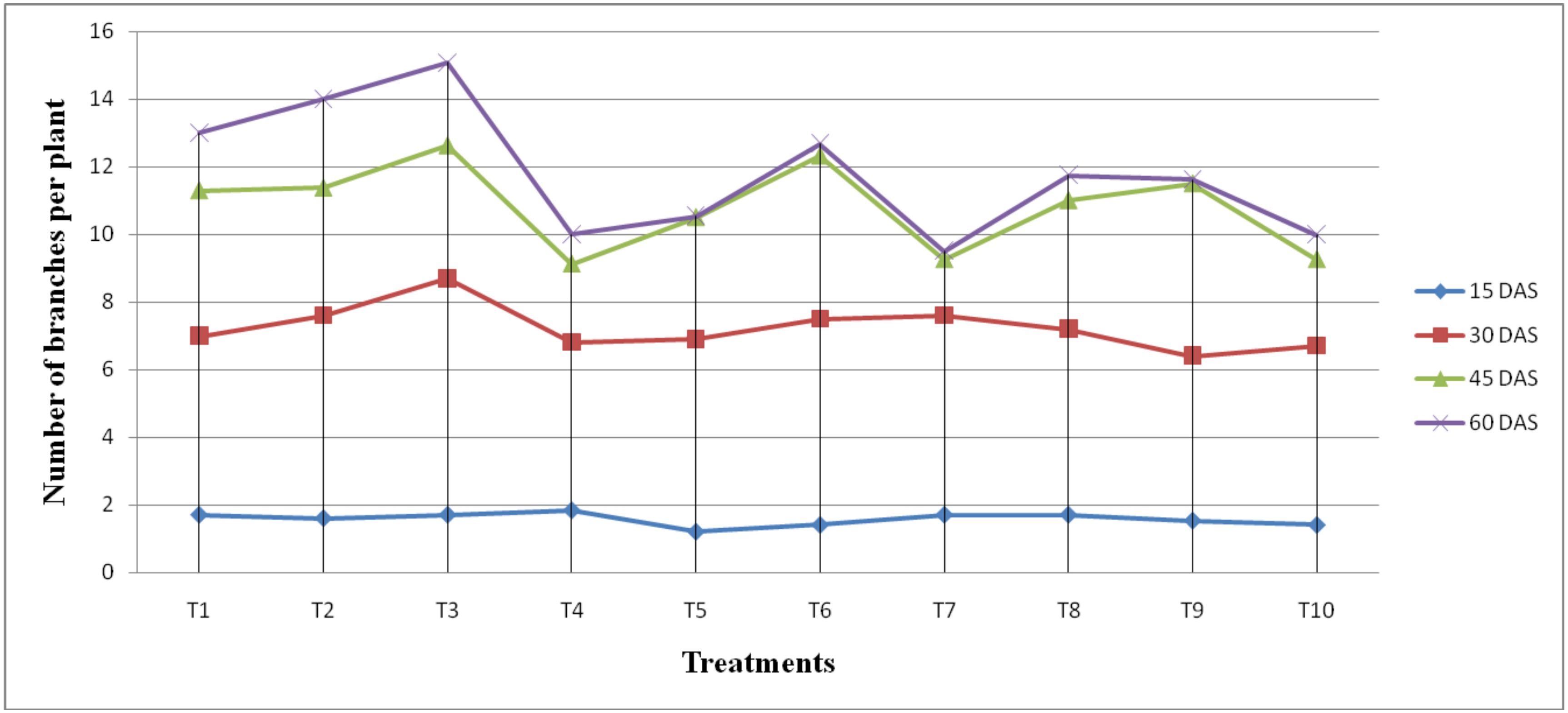

Fig. 4: Effect of foliar spray of different plant growth regulators on number of branches per plant at 15, 30, 45 and 60 days after sowing in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

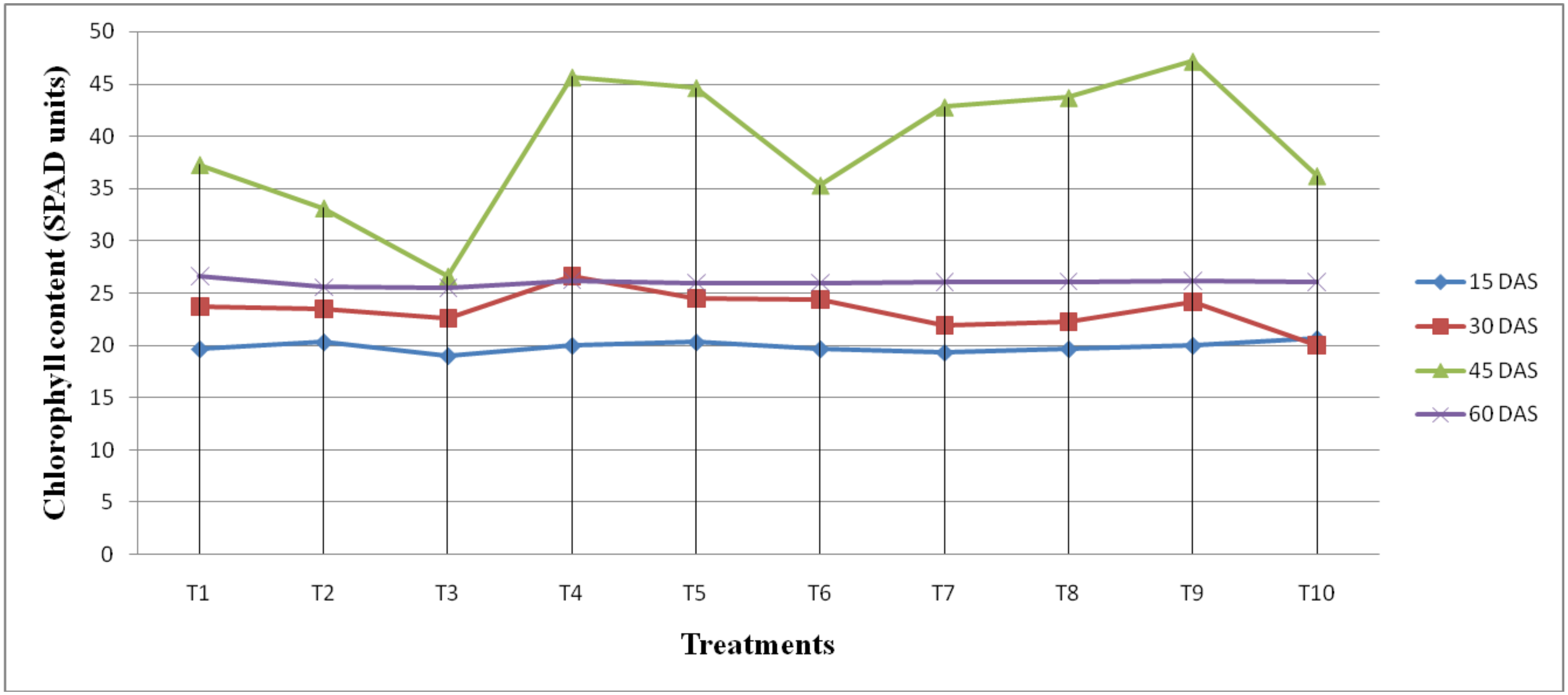

Fig. 11: Effect of foliar spray of different plant growth regulators on chlorophyll content at 15, 30, 45 and 60 days after sowing in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

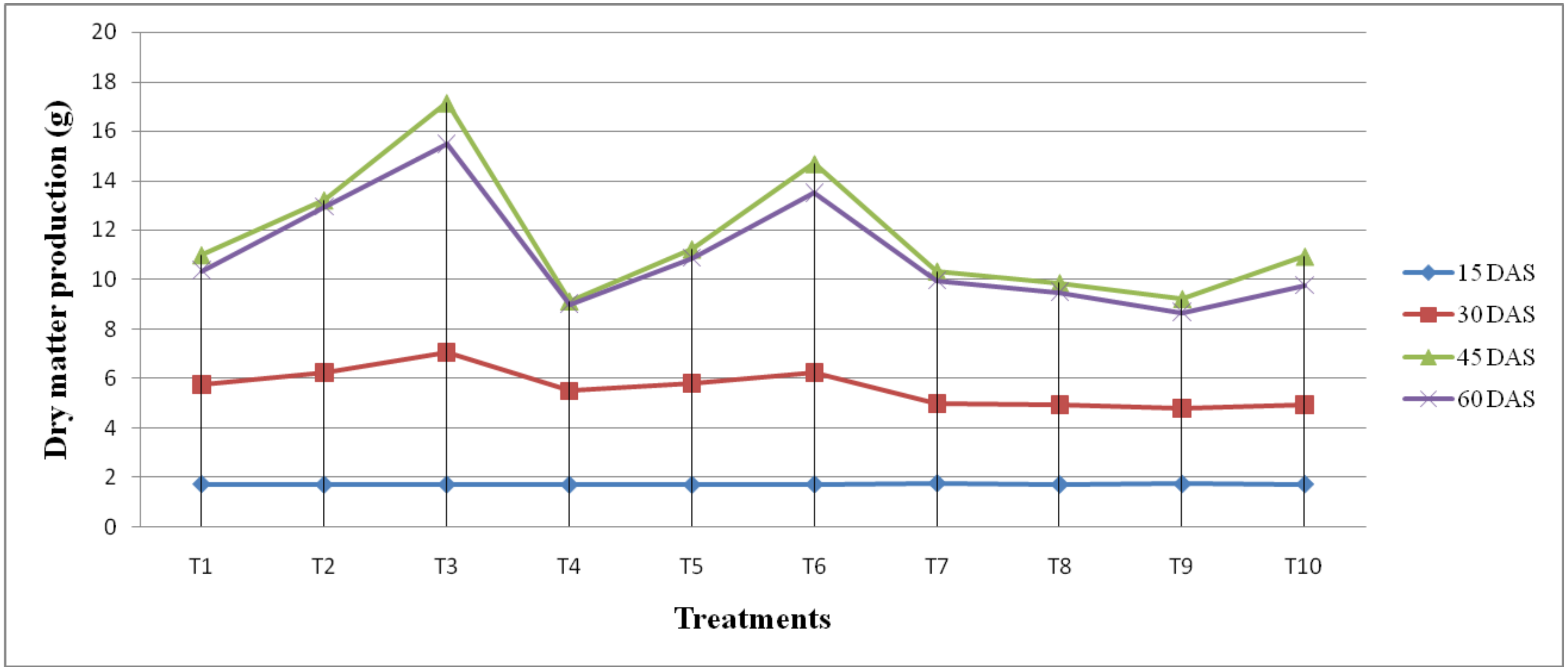

Fig. 10: Effect of foliar spray of different plant growth regulators on dry matter production at 15, 30, 45 and 60 days after sowing in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

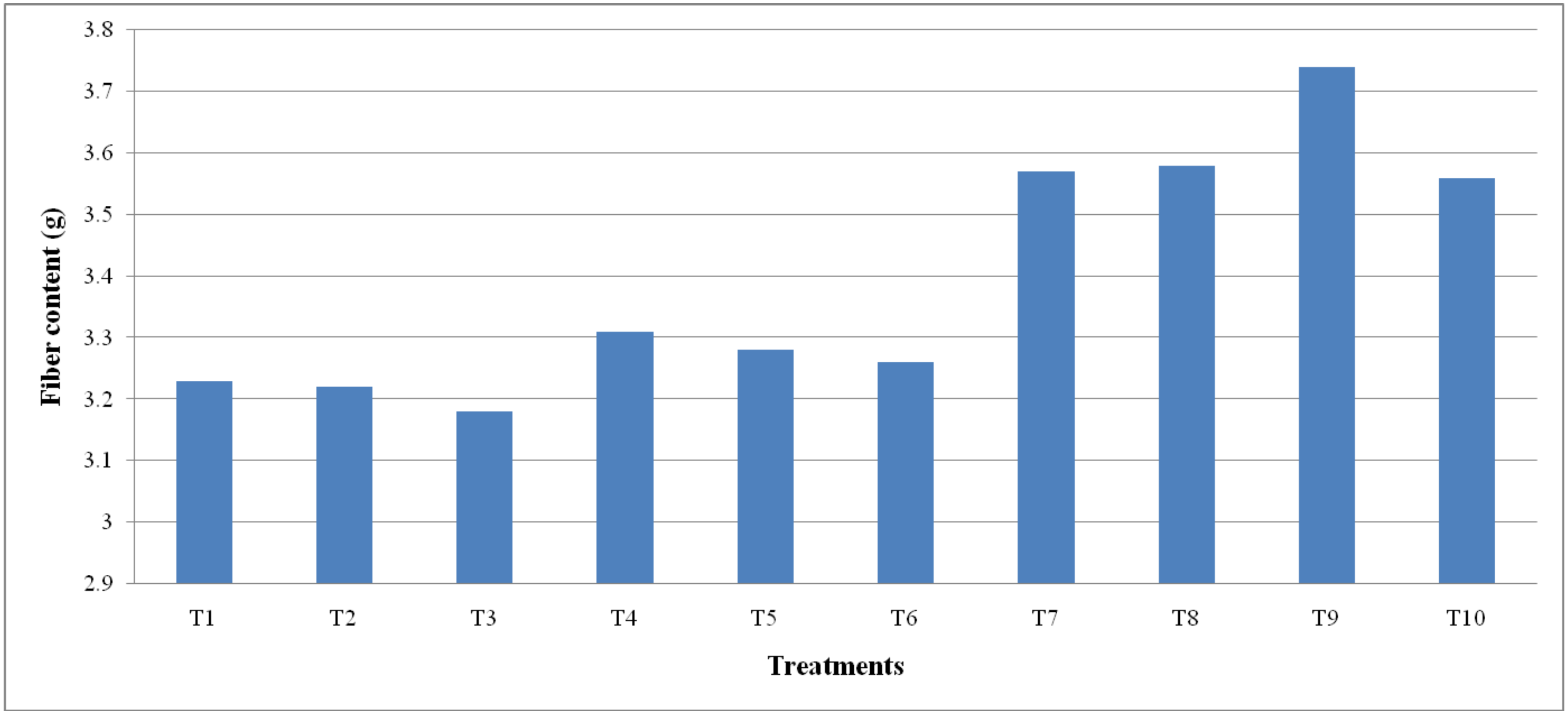

Fig. 18: Effect of foliar spray of different plant growth regulators on fiber content in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**
T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

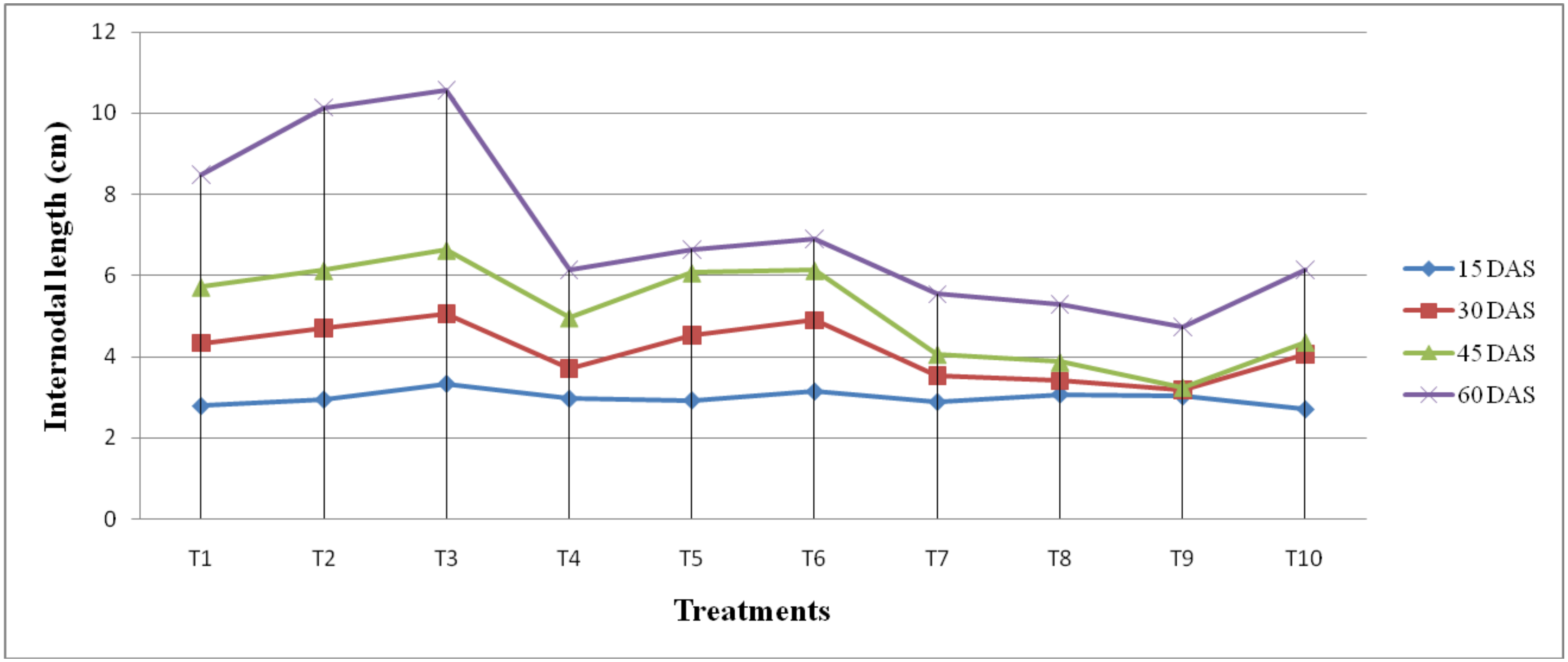

Fig. 5: Effect of foliar spray of different plant growth regulators on intermodal length at 15, 30, 45 and 60 days after sowing in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

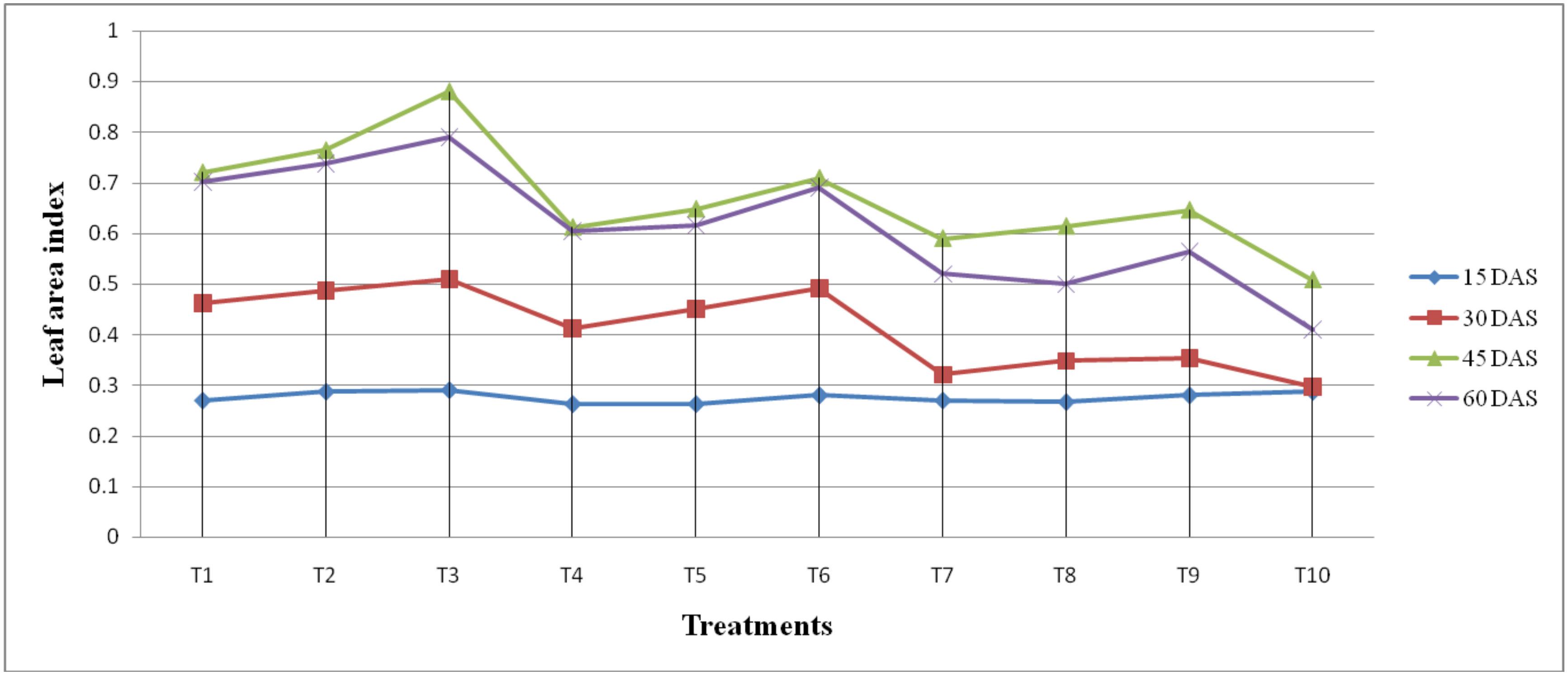

Fig. 9: Effect of foliar spray of different plant growth regulators on leaf area index at 15, 30, 45 and 60 days after sowing in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

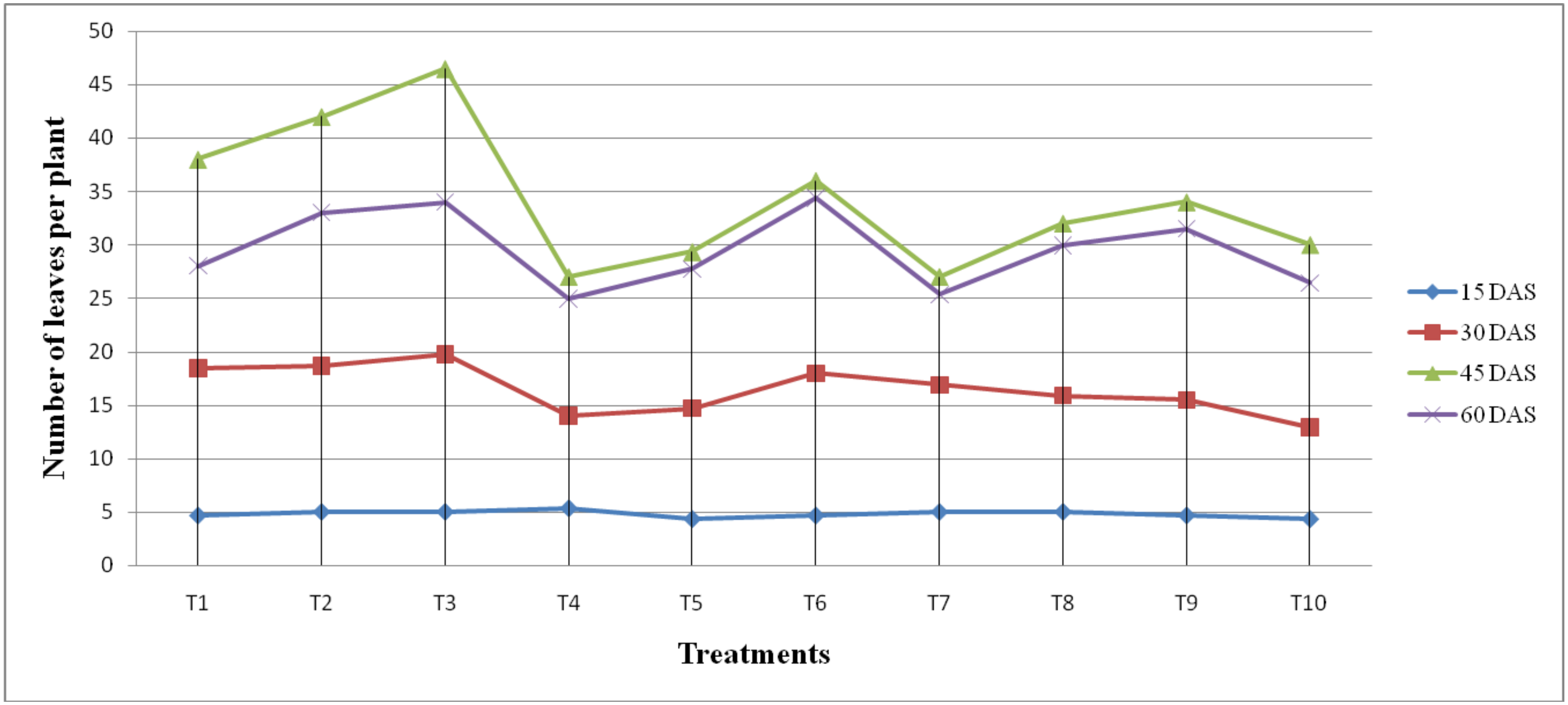

Fig. 3: Effect of foliar spray of different plant growth regulators on number of leaves at 15, 30, 45 and 60 days after sowing in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

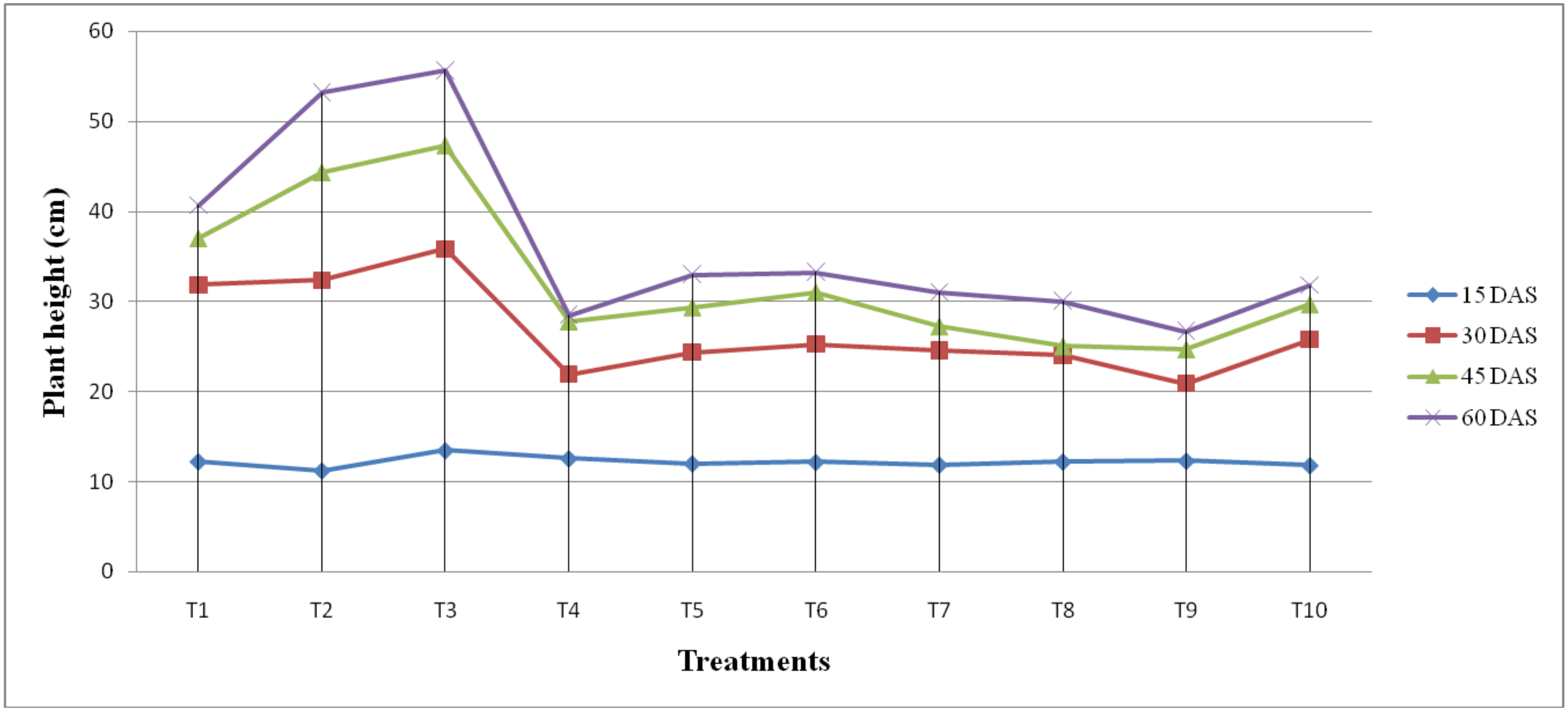

Fig. 2: Effect of foliar spray of different plant growth regulators on plant height at 15, 30, 45 and 60 days after sowing in French bean cv. Arka Komal

T_1 : GA_3 at 150 ppm **T_3 : GA_3 at 250 ppm** **T_5 : NAA at 15 ppm** **T_7 : CCC at 250 ppm** **T_9 : CCC at 350 ppm**

T_2 : GA_3 at 200 ppm **T_4 : NAA at 10 ppm** **T_6 : NAA at 20 ppm** **T_8 : CCC at 300 ppm** **T_{10} : Control (water spray)**

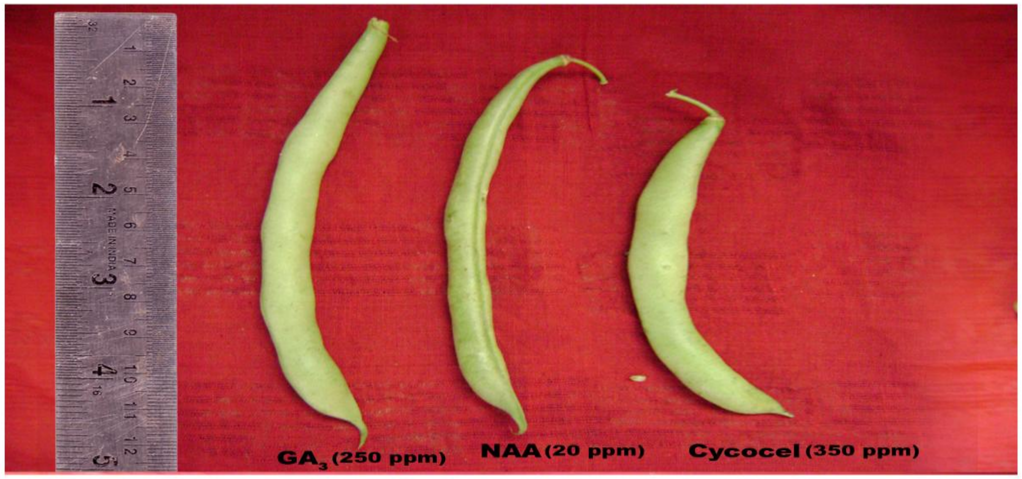

Plate9: Pod length as effected by plant growth regulator treatments (GA_3, NAA and cycocel)

Plate10: Pod diameter as effected by plant growth regulator treatments (GA_3, NAA and cycocel)

Plate7: GA_3 250 ppm treated plant at pod setting stage

Plate8: NAA 20 ppm treated plant at pod setting stage

Plate5: GA_3 250 ppm treated plant at flowering stage

Plate6: NAA 20 ppm treated plant at flowering stage

Plate3: Control plant at 60 DAS

Plate4: NAA 20 ppm treated plant at 60 DAS

Plate2: Effect of plant growth regulators on plant height

Chapter-V

Discussion

CHAPTER V

DISCUSSION

The bio-regulation of growth, yield and quality of plants by application of plant growth regulators is one of the most exciting research areas of the present time. Physiological and bio-chemical role of plant growth regulators in crop production is a well-known phenomenon. The use of plant growth promoters like GA_3 and NAA promote growth along the longitudinal axis, increase number of leaves, early flower formation, fruit set and subsequently contributes towards higher production and productivity when applied at various concentrations. Plant growth retarding substances like Cycocel not only decreases plant height but also facilitates branching, early flowering and yield (Arora *et al.*, 1990).

The plant growth regulators have brought about spectacular results both in the yield and quality of vegetable crops (Ries and Houtz. 1983). Apart from the normal manuring and cultural practices, the growth and yield of french bean can be improved with the help of growth regulators (Medhi, 2000).

Keeping the above facts in view, the present investigation entitled **"EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, FLOWERING, YIELD AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.) cv. Arka Komal."** was carried out during Rabi (2009-2010) in student farm at College of Agriculture, Rajendranagar, Hyderabad. The results obtained in the experiments are discussed here under the light of existing supportive literature.

5.1 EFFECT OF GA_3, NAA AND CYCOCEL ON MORPHOLOGICAL PARAMETERS

5.1.1 Plant height

Increase in plant height is a major indication of growth. Application of plant growth regulators significantly influenced the plant height. The data on plant height presented in table 2 indicates that increasing concentrations of GA_3 and NAA had significantly increased the plant height whereas increasing concentrations of Cycocel had significantly reduced the plant height at 30, 45 and 60 days after sowing.

Among different plant growth regulators, GA_3 recorded maximum plant height followed by NAA, where as minimum plant height was observed with Cycocel. Gibberellins promote stem elongation which might be due to the hormonal action of enhancing cell division and cell elongation in growing portion of plants and increased uptake of nutrients by increased photo synthetic activity, enhancement in the mobilization of photosynthates and change in the membrane permeability (Pandita *et al.*, 1980). At higher concentration of GA_3 the increased plant height might be due to quick cell multiplication and cell elongation (Sharma and Lashkari, 2009). These results are in conformity with the results reported by Vijay Kumar and Ray (2000) in cauliflower, Balraj *et al.* (2002) in chilli, Pandey *et al.* (2004) in garden pea, Purbey and Sen (2005) in fenugreek, Panchbhai *et al.* (2005) in spine gourd, Kokare *et al.* (2006) in okra and Nawalagatti *et al*. (2008) in french bean.

The increase in plant height by the application of NAA is attributed to an increased rate of photosynthetic activity, accelerated transport and efficiency of utilizing photosynthetic products, thus resulting in cell elongation and rapid cell division in the growing portion of the plant (Phinney *et al*., 1957 and Sargent, 1965). Similar results were reported by Dod *et al.* (1989) in chilli, Sharma *et al.* (1992) in brinjal and Khare *et al.* (1993) in broad bean, Pandey *et al*. (2004) in garden pea, Purbey and Sen (2005) in fenugreek, Sharma and Lashkari (2009) in cluster bean.

Reduction in plant height with cycocel application could be due to its effect in reducing cell division, cell expansion in the sub-apical meristem and synthesis of diffusible endogenous growth substances (Cathey, 1964). Similar results were reported by Kokare *et al.* (2006) in okra, Rajendra Prasad and Srihari (2008) in okra, Sharma and Lashkari (2009) in cluster bean.

5.1.2 Number of leaves/plant

There was a differential reaction of plant growth regulators in respect of number of leaves at 30, 45 and 60 DAS (Table 3). Number of leaves were improved with increasing level of plant growth regulators.

Among the different plant growth regulators, GA_3 recorded maximum number of leaves per plant followed by NAA and Cycocel. The production of more number of leaves per plant by GA_3 might be due to rapid growth and differentiation. Similar findings were also reported by Bagde *et al*. (1993) in fenugreek, Vijay Kumar and Ray (2000) in cauliflower, Sharma and Lashkari (2009) in cluster bean.

The increase in number of leaves by the application of NAA due to active role of NAA in cell division, cell differentiation and cell elongation (Kokare *et al*., 2006). NAA may delay senescence through its effect on the mobilization of metabolites to the leaves. This may be the reason of maintenance of higher number of leaves up to the maturity of the plant. These results are in conformity with the results reported by Bagde *et al.* (1993) in fenugreek, Kokare *et al.* (2006) in okra, Aurovinda Das and Rajendra Prasad (2003) in mungbean, Sharma and Lashkari (2009) in clusterbean.

The increased number of leaves per plant with higher concentration of Cycocel might be due to its effectiveness in suppressing apical dominance and diversion of carbohydrates to the lateral buds, thereby promoting growth of axillary buds into new shoots, so also Cycocel has pronounced effect on formation of more number of nodes and branches, thereby increasing the number of leaves per plant (Rathod and Patel, 1996). Similar results were reported by Kokare *et al.* (2006) in okra, Narse Gowda and Mundappa Gowda (1980) in okra, Rajendra Prasad and Srihari (2008) in okra and Sharma and Lashkari (2009) in cluster bean.

5.1.3 Number of branches

The data on number of branches presented in table 4 indicated that sifnificant differences were observed among the plant growth regulators for number of branches at 30, 45 and 60 DAS. Number of branches were improved with increasing concentration of plant growth regulators.

Among the different plant growth regulators GA_3 recorded maximum number of branches per plant followed by NAA and Cycocel. The production of more number of branches per plant by GA_3 might be due to rapid cell elongation and cell division in growing portion of plants and increased uptake of nutrients which resulted into maximum plant height and leading to the production of more number of branches. Bhople *et al.* (1998) in radish, Balaraj *et al.* (2002) in chilli, Rai *et al.* (2004) in french bean, Panchabhai *et al*. (2005) in spine gourd and Nawalagatti *et al.* (2008) in french bean reported similar results.

The increase in number of branches by the application of NAA might be due to increased rate of photosynthetic products that increased the rapid cell division and cell elongation in the growing portion of the plant which resulted in increased plant height and leading to production of more number of branches. Similar results were reported by Balaraj *et al.* (2002) in chilli, Kore *et al.* (2003) in bottle gourd, Pandey *et al.* (2004) in garden pea.

The increase in number of branches by the application of Cycocel might be due to its effectiveness in suppressing the apical dominance, thereby promoting growth and axillary buds into new shoots (Narse Gowda and Mundappa Gowda, 1980). These results are also in accordance with the results of Rajendra Prasad and Srihari (2008) in okra and Sharma and Lashkari (2009) in clusterbean.

5.1.4 Internodal length

The data on internodal length presented in table 5 indicates that increasing concentrations of GA_3 and NAA had significantly increased the internodal length whereas increasing concentrations of Cycocel significantly reduced the internodal length at 30, 45 and 60 days after sowing.

Among the different plant growth regulators GA_3 recorded maximum internodal length followed by NAA where as minimum internodal length was observed with Cycocel. The increase in internodal length by the application of GA_3 might be due to rapid cell division and increased elongation of individual cell (Sachs *et al.,* 1958). These results were in tune with the results reported by Arora *et al.* (1994) in long melon and Rai *et al.* (2004) in french bean.

The increase in internodal length by the application of NAA might be due to increased rate of cell division, cell elongation by softening of cell wall and increased plasticity of cell wall (Balraj *et al.*, 2002). Similar results were reported by Arora *et al.* (1994) in long melon and Kore *et al.* (2003) in bottle gourd.

A reduction in internodal length by the application of Cycocel might be due to a reduction in cell division, cell enlargement, osmotic solute in the cell, permeability of water, wall pressure and wall synthesis (Singh and Sarkar., 1976). These results are in accordance with the results of Narse Gowda and Mundappa Gowda (1980) in okra and Rajendra Prasad and Srihari (2008) in okra.

5.2 EFFECT OF GA_3, NAA AND CYCOCEL ON FLOWERING AND FRUIT SET

The data on number of days taken to flower bud initiation, 50% flowering and days taken to first pod appearance presented in table 6, 7 and 8 indicates that application of GA_3, NAA and Cycocel significantly influenced the flowering and fruit set in french bean. Among the different plant growth regulators Cycocel recorded minimum number of days taken to first flower bud initiation, 50% flowering and days taken to first pod appearance where as GA_3 recorded maximum number of days to first flower bud initiation, 50% flowering and days to first pod appearance followed by NAA.

The decrease in number of days taken to flower bud initiation, 50% flowering and days to taken to first pod appearance by Cycocel application compared to control might be due to restriction of growth by Cycocel application presumably altered the metabolism and created conditions conducive to early flower formation (Cathey 1964). Arora and Dhankar (1992) in okra, Ibrahim *et al.* (1996) in tomato and Kokare *et al.* (2006) in okra reported similar results.

The decrease in number of days taken to first flower bud initiation, 50% flowering and days taken to first pod appearance by NAA application compared to control might be due to NAA probably increased the endogenous auxin content of plant which hastened the flowering and automatically induced the earliness of flowering and fruit set (Baruah and Das, 1997). These results are in accordance with the results Aurovinda Das and Rajendra Prasad (2003) in green gram and Kokare *et al.* (2006) in okra.

The increase in number of days taken to flower bud initiation, 50% flowering and days taken to first pod appearance by GA_3 application compared to control might be due to diversion of food material for vegetative growth which leads to the delaying of flowering and fruiting. Similar results were reported by Patil *et al.* (2005) in mungbean.

5.3 EFFECT OF GA_3, NAA AND CYCOCEL ON PHYSIOLOGICAL PARAMETERS

5.3.1 Leaf area index

The data on leaf area index presented in table 9 indicates that application of GA_3, NAA and Cycocel significantly influenced the leaf area index. Leaf area index was improved with increasing level of plant growth regulators at 30, 45 and 60 days after sowing.

Among the different plant growth regulators, GA_3 had recorded maximum leaf area index followed by NAA and Cycocel. The increase in leaf area index by the application of GA_3 might be due to increased rate of cell division, cell elongation due to which there was an increase in internodal length. Cumulative effect of these phenomenon resulted into increased plant height, number of leaves and leaf area which resulted into increased leaf area index. Similar findings were reported by Medhi (2000) in french bean and Nawalagatti *et al.* (2008) in french bean.

The increase in leaf area index by the application of NAA might be due to stimulatory effect of NAA on cell division and cell enlargement which lead to enhanced leaf area. Dod *et al*. (1989) in chilli, EL-Abd *et al.* (1989) in broad bean and Medhi (2000) in french bean reported similar results.

The increase in leaf area index by the application of Cycocel might be due to increase in leaf number. Similar results were reported by Rajendra Prasad and Srihari (2008) in okra.

5.3.2 Dry matter production

The data on dry matter production presented in table 10 indicates that application of GA_3, NAA and Cycocel significantly influenced the dry matter production.

Among the different plant growth regulators GA_3 recorded maximum dry matter content followed by NAA where as minimum dry matter content was observed with Cycocel. Increase in total dry matter production by the application of GA_3 might be due to its effect in stimulating cell division, cell elongation, auxin metabolism, cell wall plasticity and permeability of cell membrane leading to enhanced vegetative growth characters like plant height, number of leaves, number of branches, leaf area index (Nawalagatti *et al*., 2008). These results are in conformity with the results reported by

Purbey and Sen (2005) in Fenugreek, Kokare *et al.* (2006) in okra and Nawalagatti *et al*. (2008) in french bean.

Significant increase in dry matter production by the application of NAA might be due to enhance source to sink relationship, accumulation of photosynthates and efficient utilization of food reserves for retention of flowers and fruits which resulted into reduced leaf, flower and pod shedding and retention of more number of leaves, flower, and pods (Balaraj *et al*., 2002). Similar results were reported by Alagukanna and Vijay Kumar (1999) in fenugreek, Purbey and Sen (2005) in fenugreek and Kokare *et al*. (2006) in okra.

Reduction in dry matter production by Cycocel application might be due to reduced vegetative growth which resulted into reduced plant height, intermodal length and leaf size. These results were in tune with the results reported by Narse Gowda and Mundappa Gowda (1980) in okra, Aurovinda Das and Rajendra Prasad (2003) in green gram.

5.3.3 Chlorophyll content (SPAD units)

The data on chlorophyll content (SPAD units) presented in table 11 indicates that application of GA_3, NAA and Cycocel significantly influenced the chlorophyll content.

Among the different plant growth regulators, Cycocel recorded maximum chlorophyll content followed by NAA and GA_3.

The increase in chlorophyll content in leaves with higher concentration of Cycocel might be increased in number of chloroplasts in palisade and spongy cells of leaves

(Narse Gowda and Mundappa Gowda, 1980). Similar result was also reported by Rajendra Prasad and Srihari (2008) in okra.

5.4 EFFECT OF GA_3, NAA AND CYCOCEL ON YIELD AND YIELD ATTRIBUTES

5.4.1 Number of pickings

The data on number of pickings presented in table 12 indicates that application of GA_3, NAA and Cycocel significantly influenced the number of pickings.

Among the different plant growth regulators, GA_3 recorded maximum number of pickings followed by NAA and Cycocel. The increase in number of pickings by the application of GA_3 might be due to more number of leaves, more number of nodes which might have accounted for more pods at less intervals. These results are in conformity with the findings of Rajendra Prasad and Srihari (2008) in okra.

5.4.2 Number of pods per plant

The data on number of pods per plant presented in table 13 indicates that application of GA_3, NAA and Cycocel significantly influenced the number of pods per plant.

Among the different plant growth regulators, GA_3 had recorded maximum number of pods per plant followed by NAA and Cycocel. The increase in number of pods by the application of GA_3 might be due to increased number of branches and fruiting points, which lead to better utilization of sunlight and the plants remained physiologically more active to build up sufficient food material for developing more number of pods. These results were supported by Medhi (2000) in french bean, Pandey *et al.* (2004) in garden pea, Rai *et al.* (2004) in french bean, Purbey and Sen (2005) in fenugreek and Kokare *et al.* (2006) in okra.

The increased number of pods per plant by the application of NAA might be due to reduction in flower and fruit drop which resulted in retention of more flowers and fruits. (Resmi and Gopalakrishnan, 2004). These results were in accordance with the results of Arora *et al.* (1994) in long melon, Alagukannan and Vijay Kumar (1999) in fenugreek, Medhi (2000) in french bean, Aurovinda Das and Rajendra Prasad (2003) in green gram, Pandey *et al*. (2004) in garden pea, Purbey and Sen (2005) in fenugreek and Kokare *et al.* (2006) in okra.

The increased number of pods per plant by the application of Cycocel might be due to an increase in the number of branches and number of leaves which were physiologically more active to produce more number of fruits. These results are in conformity with the results reported by Aurovinda Das and Rajendra Prasad (2003) in green gram and Resmi and Gopalakrishnan (2004) in yard long bean.

5.4.3 Pod length

The data on number of pod length presented in table 14 indicates that application of GA_3, NAA and Cycocel significantly influenced the pod length.

Among the different plant growth regulators GA_3 recorded maximum pod length followed by NAA where as minimum pod length was observed with cycocel. The increase in pod length by the application of GA_3 and NAA might be due to rapid cell division and increased elongation of individual cell. Similar results were reported by Medhi (2000) in french bean, Pandey *et al.* (2004) in garden pea, Rai *et al.*

(2004) in french bean, Panchbhai *et al*. (2005) in spine gourd and Kokare *et al.* (2006) in okra.

The reduction in pod length by the application of Cycocel might be due to a retarded cell division and cell elongation. These results were supported by Arora *et al.* (1990) in Okra and Resmi and Gopalakrishnan (2004) in yard long bean.

5.4.4 Pod diameter

The data on pod diameter presented in table 15 indicates that application of GA_3, NAA and Cycocel significantly influenced the pod diameter.

Among the different plant growth regulators Cycocel recorded maximum pod diameter followed by GA_3 and NAA. The increase in pod diameter by the application of Cycocel might be due to retard cell elongation. Arora *et al*. (1990) in okra, Arora and Dhankar (1992) in okra and Kokare *et al*. (2006) in okra reported similar results.

The increase in pod diameter with increasing concentrations of GA_3 and NAA might be due to rapid cell division and increased elongation of individual cell. These results were in accordance with the results of Pandey *et al*. (2004) in garden pea, Panchbhai *et al*. (2005) in spine Gourd and Kokare *et al.* (2006) in okra.

5.4.5 Weight of 10 pods

The data on weight of 10 pods presented in table 16 indicates that application of GA_3, NAA and Cycocel significantly influenced the weight of 10 pods.

Among the different plant growth regulators GA_3 recorded maximum weight of 10 pods followed by NAA and Cycocel. The increase in weight of 10 pods by the application of GA_3 might be due to increased size of photosynthetic apparatus in terms of number of leaves which increased assimilation rate contributing for better pod weight. These results are in conformity with the results reported by Pandey *et al.* (2004) in garden pea.

The increase in weight of 10 pods by the application of NAA might be attributed to the greater mobilization of metabolites from source (leaves) to sink (pods). Similar results were reported by Pandey *et al.* (2004) in garden pea and Kokare *et al.* (2006) in okra.

The increased weight of pods by the application of Cycocel might be due to greater accumulation of carbohydrates owing to photosynthesis that resulted in increased weight of 10 pods. (Sharma and Lashkari, 2009). Similar findings were reported by Kokare *et al.* (2006) in okra.

5.4.6 Yield/plant; yield/plot and yield/ha

The data on yield/plant, yield/plot and yield/ha presented in table 17 indicates that application of GA_3, NAA and Cycocel significantly influenced the yield/plant, yield/plot and yield/ha.

Among the different plant growth regulators GA_3 recorded maximum yield/plant, yield/plot and yield/ha followed by NAA and Cycocel. The increase in yield by the application of GA_3 might be due to that the plant growth regulator enter into the plant system and increase the net photosynthetic rate by increasing number of branches, increasing number of leaves and leaf area index which might have resulted in increased number of pods, pod length and pod diameter. Ultimately, the increased number of pods, pod length and pod diameter, resulted in the increased pod yield per plant, pod yield per plot and pod yield per hectare. Arora *et al*. (1994) in long melon, Vijay Kumar and Ray (2000) in cauliflower, Medhi (2000) in french bean, Pandey *et al.* (2004) in garden pea, Rai *et al.* (2004) in french bean, Kokare *et al*. (2006) in okra and Nawalagatti *et al.* (2008) in french bean reported similar results.

The increase in yield by the application of NAA might be attributed to its unique role in delaying senescence process, hastening root and shoot growth, higher fertility rate of reproductive organ due to creation of favourable balance of hormones and setting more fruits. These results were in tune with the results reported by Arora *et al*. (1994) in Long melon, Alagukannan and Vijaykumar (1999) in fenugreek, Medhi (2000) in french bean, Balraj *et al*.(2002) in chilli, Pandey *et al*. (2004) in garden pea and Kokare *et al.* (2006) in okra.

The increase in yield by the application of Cycocel might be due to reduced plant height and increased branching resulting in diversion of food material for the improvement of flowering and fruiting (Kuraishi and Muri, 1962). Similar results were reported by Aurovinda Das and Rajendra Prasad (2003) in mungbean, Resmi and Gopalakrishnan (2004) in yard long bean and Sharma and Lashkari (2009) in cluster bean.

5.5 EFFECT OF GA_3, NAA AND CYCOCEL ON BIOCHEMICAL OBSERVATIONS

The data on fiber content, protein content and ascorbic acid content presented in table 18 indicates that application of GA_3, NAA and Cycocel significantly influenced the fiber content, protein content and ascorbic acid content.

Among the different plant growth regulators, GA_3 recorded minimum fiber content followed by NAA and where as maximum fiber content was observed with Cycocel. The decrease in fiber content by the application of GA_3 and NAA might be due to the growth promoters increased xylem thickness and increased the number of tracheary elements while the growth retardants decreased the xylem thickness and induced fiber formation (Martins *et al.*, 1998). These results are in conformity with the findings of Mishriky (1990) in celery and Jayachandran and Sethumadhavan (1988) in ginger.

Among the different plant growth regulators NAA recorded maximum protein content followed by GA_3 and Cycocel. Increase in protein content by the application of plant growth regulators might be due to increased uptake of nutrient particularly nitrogen from the soil and its further assimilation led to the synthesis of protein. Bioregulators are known to promote the metabolism of assimilates or food materials by enhancing the various enzymatic activities leading to the production or conversion into mobile amino acids (Akazawa and Miyata, 1982). Similar results were reported by Alagukannan and Vijayakumar (1999) in fenugreek, Pandey *et al.* (2004) in garden pea and Purbey and Sen (2005) in fenugreek.

Among the different plant growth regulators GA_3 recorded maximum ascorbic acid content followed by NAA and Cycocel. Similar results were reported by Mishriky *et al*. (1990) in peas, Belakbir *et al*. (1998) in pepper, Pandey *et al*. (2004) in garden pea, Purbey and Sen (2005) in fenugreek, Kokare *et al*. (2006) in okra, Sharma and Lashkari (2009) in cluster bean and Deka and Shadeque (1996) in sweet pepper.

5.6 EFFECT OF GA_3, NAA AND CYCOCEL ON BENEFIT COST RATIO OF FRENCH BEAN

The data on cost of cultivation, gross returns, net returns and benefit cost ratio was presented in table 14. Even though the gross returns was maximum in GA_3 250 ppm, net returns was maximum in NAA 20 ppm. This may be because of high cost of GA_3 which worked out low benefit cost ratio when compared to NAA, which is cheaper than GA_3.

Chapter-VI

Summary

CHAPTER – VI

SUMMARY

The present investigation entitled **"Effect of plant growth regulators on growth, flowering, yield and quality of french bean (*Phaseolus vulgaris* L.) cv. Arka komal."** was carried out during *Rabi* (2009-2010) in student farm at College of Agriculture, Rajendranagar, Hyderabad. There are 10 treatments, each replicated thrice in RBD. The experimental results are summarized as follows.

Out of the plant growth regulators used, GA_3 and NAA showed increase in plant height and internodal length with increase in concentrations, while reduction in plant height and internodal length were observed with increased concentration of Cycocel at 30,45 and 60 days after sowing. The maximum plant height (55.66 cm) and internodal length (10.56 cm) at 60 DAS was observed with GA_3 250 ppm where as minimum plant height (26.66 cm) and internodal length (4.74 cm) was recorded with Cycocel 350 ppm.

The data collected at 60 days after sowing had revealed that the maximum number of branches per plant (15.08) were recorded with GA_3 250 ppm while maximum number of leaves per plant (34.40) were recorded in NAA 20 ppm. The minimum number of branches per plant (9.50) were observed in CCC 250 ppm and number of leaves per plant (24.90) were recorded with NAA 10 ppm.

Among the plant growth regulator treatments studied, foliar spray of Cycocel 350 ppm recorded minimum number of days to flower bud initiation (31.50 days), days to

50% flowering (36.46 days) and days to first pod appearance (35.95 days). The maximum number of days to flower bud initiation (37.50 days), days to 50% flowering (40.37 days) and days to first pod appearance (45.20 days) was recorded by GA_3 250 ppm.

Maximum leaf area index (0.79) per plant and dry matter production (15.50 g) per plant was observed in GA_3 250 ppm. Minimum leaf area index (0.41) per plant was observed in control treatment. Whereas Cycocel 350 ppm recorded minimum dry matter production (8.67 g) per plant.

At 60 DAS, there was no significant difference observed among the treatments for chlorophyll content. At 45 DAS, maximum chlorophyll content (47.18 SPAD units) was recorded in Cycocel 350 ppm and minimum chlorophyll content (26.62 SPAD units) was recorded in GA_3 250 ppm.

Among the plant growth regulator treatments studied, foliar spray of GA_3 250 ppm recorded maximum number of pickings (3.50) and maximum number of pods per plant (12.53). While control recorded minimum number of pickings (2) and 10.02 pods per plant.

Among the plant growth regulator treatments studied, GA_3 250 ppm recorded maximum pod length (11.68 cm) where as maximum pod diameter (1.07 cm) was observed in Cycocel 350 ppm. Cycocel 350 ppm was recorded minimum pod length (9.41 cm) where as minimum pod diameter (0.96 cm) was observed in NAA 10 ppm.

GA_3 250 ppm recorded maximum values for weight of 10 pods (52.33 g), yield per plant (67.21 g), yield per plot (3.52 kg) and yield per ha (40.44 q). Minimum weight of 10 pods (35.26 g) recorded by cycocel 250 ppm and minimum yield per plant (37.18 g), yield per plot (2.05 kg) and yield per ha (28.10 q) was recorded by control.

Cycocel 350 ppm recorded maximum fiber content (3.74 g) per 100 g of fresh pod whereas minimum fiber content (3.18 g) per 100 g of fresh pod was recorded in GA_3 250 ppm.

Among the plant growth regulator treatments the maximum protein content (3.021 g) per 100 g of fresh pod was observed in NAA 20 ppm. The minimum protein content (2.01 g) per 100 g of fresh pod was observed in control.

Among the plant growth regulator treatments studied foliar spray of GA_3 250 ppm recorded maximum ascorbic acid content (12.40 mg/100g of fresh pod). Minimum ascorbic acid content (10.00 mg/100g of fresh pod) was recorded in Cycocel 250 ppm and CCC 300 ppm.

Even though the gross returns was maximum in GA_3 250 ppm (1,21,320 Rs/ha), net returns was maximum (68,007 Rs/ha) in NAA 20 ppm. This may be because of high cost of GA_3 which worked out low benefit cost ratio when compared to NAA, which is cheaper than GA_3.

Future line of work

1. Still higher concentrations of NAA may be studied for their efficacy.
2. The similar studies are to be conducted during summer also to get concrete results.
3. Instead of laboratory grade of gibberellic acid, analytical grade may be tried.

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Appendices

APPENDIX-II

Cost of cultivation, gross returns, net returns per ha and benefit cost ratio as influenced by the different plant growth regulators in French bean cv. Arka Komal

Particulras	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Land preparation	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Seed cost	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Sowing	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050
Chemical fertilizer	2164.5	2164.5	2164.5	2164.5	2164.5	2164.5	2164.5	2164.5	2164.5	2164.5
Thinnig	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050
Weeding	5250	5250	5250	5250	5250	5250	5250	5250	5250	5250
Irrigation	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Plant protection	500	500	500	500	500	500	500	500	500	500
Harvesting	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050
Cost of GA_3 @ Rs.1213/10 g	40432.929	53910.57	67388.215	-	-	-	-	-	-	-
Cost of NAA @ Rs.140/25 g	-	-	-	124.432	186.648	248.864	-	-	-	-
Cost of Cycocel @ Rs.199/10 g	-	-	-	-	-	-	11055.246	13266.534	15477.623	-
Total cost of cultivation	75497.43	88975.07	102452.72	35188.93	35251.15	35313.36	46119.75	48331.03	50542.123	35064.50
Yield (q per ha)	33.44	34.54	40.44	31.96	32.18	34.44	28.18	30.10	33.29	28.10
Gross returns	100320	103650	121320	95800	96540	103320	84540	90330	99870	84330
Net returns	24823	14675	18867	60691	61289	68007	38420	41999	49328	49265
Benefit cost ratio	0.33	0.16	0.18	1.72	1.74	1.92	0.83	0.87	0.97	1.40.