Effect of Some Plant Growth Regulators on Growth, Flowering and Yield of Pea (*Pisum sativum*, L.) Variety Bonneville

By

Prakash Mukund Bhinge

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI

(AGRICULTURAL UNIVERSITY)

Dist. Ahmednagar (Maharashtra State)

in partial fulfilment of the requirements for the degree of

Master of Science (Agriculture)

in

Horticulture

DEPARTMENT OF HORTICULTURE

Post Graduate School, Rahuri

June, 1976

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Approved by the Advisory Committee

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: C E R T I F I C A T E :

This is to certify that the thesis entitled " Effect of Some Plant Growth Regulators on Growth, Flowering and Yield of Pea (*Pisum sativum*, L.) Variety Bonneville" submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, District: Ahmednagar (Maharashtra), India in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE embodies the results of a piece of bona fide research work carried out by Shri P.M. Bhinge, under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma or published in any other form.

The assistance and help received during the course of this investigation and sources of literature referred to have been duly acknowledged.

Sanghavi

(K. U. Sanghavi)
Research Guide

RAHURI

Dated : 14-6-76.

A C K N O W L E D G E M E N T S

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Bhinge P.M.

Dated : 14-6-76 (P.M. Bhinge)

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure

CHAPTER I

INTRODUCTION

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CHAPTER I

INTRODUCTION

Peas, (*Pisum sativum* L.) is a crop of world importance, grown particularly in Asia, Europe and the U.S.A. China possibly is the leading country for producing dry field peas. In India, pea is primarily grown in Uttar Pradesh, Bihar, Madhya Pradesh and Maharashtra.

Pea is one of the most valuable crops of India. Pea in India, as elsewhere, are consumed in a variety of ways. The fresh ones are consumed as such or canned, curried and dehydrated; the dry ones of certain green-seeded varieties are also processed for canning. The white or grey-seeded varieties are also processed for canning. The white or grey-seeded varieties with yellow cotyledons are used as split peas or in the form of Besan. Since the crop is a good source of vitamins B_1 and C, and has in it measurable quantities of other ingredients like proteins, fat, minerals, carbohydrates, riboflavin, iron, phosphorus, calcium, carotene etc; it forms an essential commodity for house-wives in day to day preparations of spicy and tasty food giving the necessary luciousness and taste. In India, the canned green peas as well as the dehydrated peas are also used to a limited scale.

The area under chick peas in the world is 10288.8 thousand hectares and 10898.0 thousand metric tons of peas are produced annually (Anon, 1975), while India produces 660.0 thousand metric tons of chick peas annually from 935.0 thousand hectares.

The role of plant growth regulators in the physiology of plants is one of the most interesting chapters in science. Many new plant growth regulators are constantly being synthesized or extracted and tested on various crops. Many of the plant growth regulating substances as reported by various workers specially on that of GA (Amdus, 1953) not only play important role in acceleration of germination (seed) or growth of the plant but also helping in the initiation of early flowering and augmentation of the produce. Certain other growth substances like cytokinis which help in breaking apical dominance stimulate branching of plants and also decrease internodal length making the plant compact in habit.

These growth substances exert influences comparable to normally occuring auxins. It is now well known that the effect of growth regulators are influenced by light, temperature, moisture and nutrients and other environmental factors. The efficacy of a plant growth regulator thus varies under different climatic and other environmental conditions. Nutritional recommendations made in one country may not prove to be of much practical value when applied in another.

Further, in these days of food crisis, any technique which can increase the yield per unit area is most welcome. Reports are available of effects of different growth substances in increasing the yield of peas. Unfortunately, the results reported are not consistent and sometimes are conflicting. The method of application of these growth substances is sometimes not of practical value for commercial use to the vegetable growers. The flower cluster-spray method which has given most consistent results cannot be adopted in the open field on commercial scale. It was, therefore, thought proper to concentrate on whole plant-spray which can be recommended to the farmers for field scale applications. It was also felt necessary to cBllect informations regarding the effects of growth regulators on peas under Rahuri conditions.

This multipurpose vegetable crop has received very little attention in India. Since soil and climate are suitable in most parts of Maharashtra its production can be extended in our State. Very little work is done about the use of growth regulators in increasing the productivity and reducing the vegetative period.

However, the scientists have reported the effects of different plant growth substances such as 4CPA, Noxa and NAA in increasing the fruit-set. GA is universally known for cell elongation and cell division. Kinetin is also known for cell division. Cycocel is a growth retardant. It was used with a view that it may check the vegetative growth and induce more flowering and fruiting. The combinations of growth regulators were also used to know their synergestic effects, if any.

Very little work is done about the use of growth regulators in increasing the productivity and reducing the vegetative period.

Thus, with the objective to study the efficacy of plant growth regulators in increasing yield, reducing the total number of days required for flowering and increasing the fruit-set and to determine the effective concentration range of different growth regulators and their combinations, the present investigation was undertaken with the popular variety of peas, the Bonneville.

CHAPTER II
REVIEW OF LITERATURE

* * *

CHAPTER II

REVIEW OF LITERATURE

The plant growth regulators have become most popular established practice in the field of horticulture within last two decades, the role of which needs no introduction.

Claims of superior growth and higher yields of treated plants have created much interest among scientists and growers. The research work done with these growth regulators on important aspects like growth, flowering, fruit-set and yield of pea is meagre. An attempt has been made here to review the work done on these aspects at home and abroad under the appropriate sub-headings.

EFFECTS OF GIBBERELLIC ACID ON PLANT GROWTH :

Brian and Hemming (1955), reported that the growth rate of seedlings of the dwarf pea variety Meteor was significantly increased by applications of 0.01 mg gibberellic acid (GA) per plant. They observed that slow growing varieties of pea e.g. dwarf varieties responded more to applications of gibberellic acid than fast growing varieties e.g. tall varieties. They also stated that suitable doses of gibberellic acid virturally eliminated the difference in growth between the tall and dwarf varieties. They further mentioned that this effect of GA was qualitatively similar but was much greater than the effect of Indoleacetic acid.

Bukovac and Wittwer (1956), studying gibberellic acid in relation to higher plants found that due to GA applications the dwarf peas grew taller than normally taller types.

Wittwer and Bukovac (1957), mentioned that the important benefits from gibberellin were then apperent with celery production and seed production in radish. They further mentioned that these beneficial effects could be forced in certain other long day annuals and for early fruiting and increased vigour in determinate tomato varieties but with peas and beans the potentially useful effects of GA might not be realized without source control of accompanying unfavourable responses.

Bonde and Moore (1958), reported that single sprays of increasing concentrations of GA in the range of 0.0015 to 15 mg per Lit had increasing stimulatory effects on the stem elongation of dwarf Telephone peas. They further reported that height increases at all concentrations were greater in plants treated at 20 days than in those treated at 10 days of age. However, the fresh and dry weight increases were greater in plants sprayed at 10 days than at 20 days at the two highest concentrations but not at the lower ones. They also observed that increasing concentrations of GA increased the number of nodes to the first flower to the maximum increase of two nodes at the highest concentrations

Morgan and Mees (1958), reported that the vegetative growth of peas and runner beans was stimulated when they were sprayed at early fruit set with 4 oz of GA/acre.

Yoda and Ashida (1958), described an experiment which showed that gibberellin made the stem less yielding to an extending force and the plasticity was also decreased. They further stated that this effect of GA was opposite to that of IAA.

Ballard et al. (1959), observed that GA at the concentration of 1000 ppm applied as a seed treatment to field grown peas reduced the stand of plants but hastened emergence and early growth. They further observed that sprays at the concentration of 60 ppm applied in the second true leaf stage resulted in temporary growth acceleration.

Sebanek (1960), reported that when the peas were given seed treatment with GA then the fresh weight of the aerial parts was reduced. He further showed that initially the internode elongation was so rapid that it led to a final growth depression. On the basis of this experiment he stated that treatment of seeds or seedlings with GA was not recommended, as it led to premature and too vigourous growth of the axis at the expense of the leaves. He further recommended that treatment with GA should be accompanyed not only by adequate nutrition but also by an ample water supply, since the treated plants lost water more rapidly and were more resistant to drought.

Bottini and Lepori (1964), carried out pot culture and field experiments and observed the biochemical effects of gibberellin on some plant species. In the pot culture experiment, the pea seeds were soaked in distilled water (control), 15 ppm GA (G_1) and 75 ppm GA (G_2). In addition to presowing treatment, eleven foliar sprays of the above concentrations were also given to the resulting seedlings. In their study, it was observed that the increase in internode growth was equally marked with G_1 and G_2 and both caused etiolation of the plants, particularly G_2. Further, it was observed by them that compared to the control, the dry weight of leaves and stems was increased 50% by G_1 and 71.5 % by G_2. In the field experiments, they observed that, the dry weight of the leaves and the stems was increased 37.3 % by G_2 and almost equally by G_1.

Nakamura (1965), stated that in shaded plants and plants treated with GA the elongation of upper internodes was very marked, but that of 2-3 basal internodes was only slightly affected. He further mentioned that in such plants the development of the lower branches was poor, and their subsiguent elongation was arrested following the enhanced elongation in the upper internodes.

Arney and Mancinelli (1966), studying the basic action of gibberellic acid in elongation of Meteor pea stems reported that the main effect of GA was to stimulate cell division.

Even, GA often re-activated cell division in the internodes which had passed into the vacuolation phases of growth. They also reported that GA stimulated the mitotic activity in the opical meristem.

Mc Comb (1966), showed that GA brought about in increase in the rate of dry weight incorporation into expanding internodes of intact dwarf pea seedlings. He reported that the amount of water present in expanding internodes was closely correlated with internode dry weight, and the slope of the relation was unaffected by GA treatment. He proposed that the effect of GA upon internode expention was mediated through the changes in dry weight. Further, he stated that the part of the increase in dry weight brought about by GA was attributable to an increase in the cell wall material. He interpreted the possibility of increased rate of wall synthesis which followed GA treatment allowing an increase in the rate of cell expention.

Pillay and Ya Ta (1971), sprayed GA at the concentration of 10^{-3} M on pea seedlings when the fifth internode had emerged. They observed that there was an increase in the cell synthesis and the growth also was increased.

Shininger (1972), reported that after removal of the cotyledons from 8 day old light-grown Alaska pea seedlings there was a reduction in the stem elongation to 50% of the intact control value. He observed that due to GA applications the elongation rate was restored to the level of the intact controls. Further, he concluded that GA increased both the rate of node formation and the rate of internode elongation.

Chakravarti and Ram (1973), reported that in the pea cultivar Sutton's Early Wonder the number of internodes increased from 16 to 23 on application of gibberellic acid and the 14th and 15th internodes on treated plants became measurable one week earlier than in the untreated control.

Laszlo (1974), observed in pea variety Petit Provencol that gibberellic acid at the rate of 10-20 ppm applied 7 weeks after sowing increased plant height by 30%.

<u>EFFECT OF GIBBERELLIC ACID ON FLOWERING AND FRUIT SET</u> :

Barber et al. (1958), studying the interaction between gibberellic acid and the effects of the Sn gene (dominent for late flowering) and the Le gene (domient for tallness) in 4 varieties of pea reported that GA delayed initiation of flowering in all 4 varieties by 1-3 days and also caused considerable abortion of flower rudiments. He also observed that the effect of gibberellic acid on flowering was less in tall than in dwarf varieties. He proposed that there was some evidence that in late flowering plants GA treatment followed by vernalisation might increase the effect of photoperiod, whereas vernalization without GA treatment reduced the photoperiodic response. Further, he interpreted that GA was not the flower inhibitor produced by the Sn gene, but the production of the flower inhibitor might be linked to gibberellin metabolism either by way of a common precurser or more indirectly by a reaction involving the production and utilization of the gibberellins.

Bonde and Moore (1958), reported that the time required to flower in the dwarf Telephones peas was not affected by GA treatment. However, increasing concentrations of GA increased the number of nodes to the first flower to the maximum increase of two nodes at the highest concentration. Further, they observed that GA at the rate of 15 Mg/1 had no effect on the flowering in the tall variety as well. They concluded that a spray of a given concentration applied at 20 days of age was less effective than one applied at 10 days in changing the number of nodes to flower in a group of plants.

Brian et al. (1958), reported that GA treatment of plants accelerated the visible production of the first flower bud by about 4 days, however, the nodes bearing the first flower were not altered. They also observed that the total number of flower buds produced at the end of the experiment was increased as a result of GA treatment, but many of those first formed on plants receiving high doses (1-10 Mg.) withered before opening.

Bottini and Lepori (1964), in their pot culture experiment observed that GA at the rate of 15 ppm accelerated flowering in peas.

Manohar *et al.* (1969), reported that spraying of increasing concentrations of GA upto 300 ppm on 4 week-old pea seedlings resulted in early initiation and completion of flowering in peas.

Wellensiek (1970), studying the functions of gibberellins in flower bud formation applied various concentrations of a commercial preparation of GA to peas which produced no evidence that GA acted as a floral hormone. He observed that in peas the function of GA_3 was simply to prolong the Vegetative cycle, so that sub-optimal photoperiods could act long enough.

EFFECT OF GIBBERELLIC ACID ON YIELD :

Morgan and Mees (1958) reported that the vegetative growth was stimulated, but the crop size was not affected when the peas and runner beans were sprayed at early fruit-set with 4 oz of GA per acre.

Ballard *et al.* (1959), observed that GA either as a seed treatment at the concentration of 1000 ppm or as a foliar spray at the second true leaf stage at the concentration of 50 ppm did not affect the yield. They further reported that sprays applied during late bloom had no effect on yield or maturity except in the variety Perfection, in which yield was depressed and maturity delayed.

Asselbergs *et al.* (1959), reported that field application of GA at 10 ppm increased the yield of Laxton peas by 10 %, but other GA treatments lowered the yields.

Bottini and Leperi (1964), reported that seed dry weight was increased by 15 ppm GA and was depressed by 75 ppm GA. In their pot culture experiment they also observed that the number of pods per plant was greatest in the controls and least in the plants treated with 75 ppm GA. Further, in their field experiments with peas they observed that GA at 15 ppm increased the pod weight by 41.6% and GA at 75 ppm increased it by 60%. They also reported that the proportion of seed weight to pod weight was higher in plants treated with 75 ppm GA.

Maheshwar *et al.* (1969), observed that spraying increasing concentrations of GA up to 300 ppm on 4 week old seedlings resulted in increased green pod yield whereas the yields were found depressed when 8-week-old pea seedlings at the flowering stage were sprayed.

Laszlo (1974), observed that GA_3 at 10-20 ppm sprayed 7 weeks after sowing increased the number and weight of filled pods.

EFFECT OF KINETIN ON PLANT GROWTH :

Wittwer and Dedolph (1963), studying the effect of kinetin on the growth and flowering of intact green plants reported that the height of tomato, cucumber and pea plants was markedly reduced when kinetin was incorporated into the culture solution root medium in concentrations ranging from 10^{-5} to 10^{-7} M. They further reported that dry weight was markedly reduced in these plants with this treatment.

EFFECT OF KINETIN ON FLOWERING AND FRUIT-SET :

Wittwer (1961), observed that kinetin accelerated the flowering of Alaska peas in short days. Likewise, Wittwer and Dedolph (1963), also reported that kinetin accelerated flowering in peas.

EFFECT OF NAPHTHYLACETIC ACID ON PLANT GROWTH :

Singh *et al.* (1972), studying the effect of pre-sowing treatments with phytohormones on the yield of pea (*Pisum sativum* L.) observed that NAA at 10 ppm gave greatest plant height as compared to IAA or 2, 4-D.

EFFECT OF NAPHTHYLACETIC ACID ON YIELD :

Singh *et al.* (1972), reported the data on the yield and growth of peas after pre-sowing treatment with IAA, NAA or 2, 4-D at 10, 100 or 1000 ppm. They reported that NAA at the lowest rate gave greatest number of pods per plant.

EFFECT OF CYCOCEL ON PLANT GROWTH :

Adedipe *et al.* (1968), applying foliar and soil treatments using 10^{-5}M and 10^{-3}M cycocel at the 5 to 10 node stage observed that the early 10^{-3}M treatment decreased internode lengths, plant height, fresh weight and total dry matter. Further, they reported that latter foliar treatments were rather less effective. They also observed that soil treatments had little effective although the 10^{-5} M treatment at the 5 node-stage increased plant weight.

Sebanek (1968), stated that a 0.03 % solution of CCC administered to the roots of decapitaped pea seedlings significantly increased growth of the axillery buds. In this experiment IAA (0.03-0.06 %) in lanolin paste was smeared on the cut surface of dicapitated epicotyls of pea seedlings which inhibited the growth of the auxillary buds of the cotyledons. This inhibition was weakened considerably by CCC (0.03-0.06%) when applied simultaneously to the roots in the form of solution.

Will (1968), carrying out experiments on two pea varieties in 1966 and on 5 varieties in 1967 applied cycocel either once when the crop was 15 cm tall, or twice, when it was 15 and 30 cm tall. He observed that some varieties showed a slight reduction in height. He also observed that the internode length was shortened in both the varieties tested in 1966 and tenderometer measurements showed a tendency towards slightly delayed maturity.
It was observed that soaking the seeds of the variety Excellence in cycocel resulted in reduced plant height.

Adedipe and Ormrod (1972), studying the effects of CCC and phosphon on the growth of pea plants in sand culture at two rates of applied phosphorus in growth chambers reported that CCC at 1-10 mg/L stimulated growth and at 1000 mg/L retarded growth owing mainly due to shortened stems. They further interpreted that the magnitude of such effects depended on the level of applied phosphorus and the reductions in plant height by the 1000 mg/L CCC treatment were 13 to 50%, respectively, at the high (160 mg/L and low (8 mg/L) rates of appliedophosphorus.

EFFECT OF CYCOCEL ON YIELD :

Studying the responce of pea plants to soil and foliar applications of cycocel Adedipe et al. (1968), observed that the early 10^{-5} M treatment of pea plants with cycocel increased the fresh and dry weight of seeds but the early 10^{-3} M application decreased it.

EFFECT OF GIBBERELLIC ACID AND KINETIN ON PLANT GROWTH :

Wittwer and Dedolph (1963), reported that dry matter accumulation of aerial parts, and height of tomato, cucumber and pea plants, were markedly reduced when kinetin was incorporated into culture solution root medium in concentrations ranging from 10^{-5} to 10^{-7} M . They further observed that concentrations which suppressed top growth (height, dry weight) generally had lesser effects on root growth and, in some instances, enhanced it and thus top/root ratios were greatly reduced and approached unity in kinetintreated peas and tomatoes. They interpreated that kinetin had an effect which was opposit to that of gibberellins on internode, top/root ratios and flowering of dwarf peas.

EFFECT OF KINETIN AND GIBBERELIC ACID ON FLOWERING .

Wittwer and Dedolph (1963), reported that flowering was inhibited in tomatoes and accelerated in peas when the plants were sprayed with kinetin. They further reported that this effect of kinetin was opposit to that of gibberellins. The data of this experiment showed that kinetin could markedly alter the behaviour of intact plants when absorbed by the roots from culture solutions in which the concentrations were comparable to those which were biologically active as explants.

EFFECT OF GIBBERELLIC ACID AND CYCOCEL ON PLANT GROWTH :

Sebanek (1967), studying an interaction between growth retardants and gibberellins as correlated in peas and tomatoes reported that in a dwarf pea variety, with a low content of endogenous GA, soaking the seeds in 3 % CCC did not inhibit the growth of the epictyl. He further observed that GA alone strongly stimulated growth, but this stimulatery effect was significantly reduced when it was applied together with CCC at a concentration of CCC which alone had an insignificant effect.

Chailakhyan and Ivanova (1969), reported that in peas the retarding effect of various concentrations of CCC was much greater on the tall than on the dwarf variety, and the stimulation induced by 0.005 % GA was much greater on the dwarf variety. Further, they concluded that the inhibiting action of CCC was more pronounced under long-day conditions and stimulation induced by GA under short-day conditions.

Chung (1970), reported that CCC reduced plant height but GA did not. Neither substance affected leaf number or total dry weight, but GA increased and CCC markedly lowered top fresh weight.

Ockerse (1970), studying the dependence of auxin-induced pea stem growth on gibberellins reported that when tall peas were treated with CCC, the growth was reduced and they resembled the dwarf variety. He further showed that IAA induced elongation of stunted CCC-treated tall stem sections was markedly reduced, and was identical to that of IAA-treated true dwarf sections. Also he observed that with GA_3 + AAA growth of CCC-treated tall sections was synergistically restored and was identical to that induced by IAA alone in tall sections.

It is obvious from the literature cited here that GA and CCC have been rarely used in crops like peas but no much work is done on the use of NAA, 4-CPA, NOXA and kinetin in peas.

CHAPTER III

MATERIAL AND METHODS

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CHAPTER III

MATERIAL AND METHODS

The investigations were carried out during the Rabi season of the year 1975-76 at the Department of Horticulture, under Rahuri conditions. At Central Campus, the average annual rainfall is about 307 to 619 mm. Annual average maximum temperature is 37.9°C with the range of about 33°C to 43°C. The average minimum temperature is 17.2°C with the range of 3°C to 17°C. The average relative humidity at 8.00 hours and 17.00 hours is about 79 per cent and 35 per cent respectively. Agronomically this tract falls in scarcity zone of the Maharashtra State.

The site with uniform medium black soil was selected and the land was brought to fine tilth by ploughing, harrowing clod-crushing and discing. Well rotted farm yard manure was incorporated into the soil at the rate of 12 cart loads per hectare. Fertilizers at the rate of 30 kg of N per hectare in the form of Urea (46 %), 40 kg of P_2O_5 per hectare in the form of Single Super Phosphate (16 %) and 20 kg of K_2O per hectare in the form of Muriate of Potash (62 %) were also applied at the time of sowing.

The experiment was laid out in a Factorial Randomised Block Design as shown in figure 1. The treatment details were as follows :

Figure - 1

Plan of Layout and Experimental Details.

RI

T_5l_3	T_2l_1	T_8l_2	C	T_9l_3	T_7l_2	T_9l_1	T_6l_2	T_2l_2	T_1l_2	T_8l_3	T_4l_2	T_9l_2	T_5l_1
T_1l_3	T_3l_3	T_1l_1	T_5l_2	T_3l_1	T_6l_1	T_4l_1	T_7l_1	T_2l_3	T_3l_2	T_4l_3	T_7l_3	T_6l_3	T_8l_1

RII

T_1l_1	T_4l_3	T_1l_3	T_8l_1	T_3l_1	T_3l_2	C	T_8l_3	T_8l_2	T_9l_3	T_7l_2	T_6l_3	T_4l_1	T_5l_2
T_9l_2	T_3l_3	T_7l_1	T_1l_2	T_2l_2	T_9l_1	T_7l_3	T_2l_1	T_6l_1	T_5l_1	T_4l_2	T_5l_3	T_6l_2	T_2l_3

RIII

T_9l_3	T_1l_3	T_7l_2	T_4l_3	T_5l_3	T_3l_2	T_3l_1	T_4l_1	T_9l_2	T_1l_2	T_7l_1	C	T_6l_2	T_4l_2
T_7l_3	T_5l_2	T_2l_1	T_8l_1	T_1l_1	T_8l_2	T_5l_1	T_8l_3	T_6l_1	T_2l_3	T_3l_3	T_9l_1	T_6l_3	T_2l_2

Design : Factorial Randomized Block Design. Treatments : 28. Replications : 3.

Gross Plot Size : 6.30 x 3.60 m Net Plot Size : 5.40 x 3.00 m

Plant Growth Regulator	Time of application	Level of concentration (ppm)		
		l_1	l_2	l_3
Control (C)	No. spraying	-	-	-
Naphthylacetic acid (NAA)(T_1)	At flowering	50	100	150
4-Chlorophenoxyacetic acid (4-CPA) (T_2)	At flowering	10	20	30
Beta Naphthoxyacetic acid (NOXA) (T_2)	At flowering	10	20	30
4-CPA + NOXA (T_4)	At flowering			
	4-CPA	5	10	15
	+			
	NOXA	5	10	15
Gibberellic acid(GA) (T_5)	One week after flowering	10	50	100
Kinetin (T_6)	One month after sowing	2.5	5	10
GA + Kinetin (T_7)	One month after sowing			
	GA	5	25	50
	+			
	Kinetin	1.25	2.5	5
Cycocel (CCC) (T_8)	One month after sowing	500	1000	1500
GA + CCC (T_9)	One month after sowing			
	GA	5	25	50
	+			
	CCC	250	500	750

The gross plot size was 6.30 m x 3.60 m and net plot size was 5.40 m x 3.00 m. The treatments were replicated for three times. The sowing was done on 26-10-1975 by dibbling. The spacing was 45 cm x 30 cm. A light irrigation was given after sowing. Later on the irrigations were given at an interval of 10-12 days. Plant protection measures were taken to keep the plants free from pests and diseases. Weedings were also carried out whenever necessary and plots were maintained clean. All the plants were staked with the stricks.

The stock solutions were prepared by dissolving required quantity of the material in proper solvent and then the volume was made to 1000 ml by adding distilled water so as to make the solutions of 1000 ppm concentrations.

From these stock solutions, the spraying solutions were prepared as per required concentrations. The different concentrations of each of the growth regulators were sprayed to drip on the entire plant. Precautions to prevent the spray material of one treatment spreading on another were taken by holding a piece of cloth in between two different treatment plants while the spraying as discussed above. Ganesh baby spray pump was used for the spraying operation.

Details of observations :

Although, the total number of days required for flowering, percentage fruit-set and the yield produced formed the most important subject of study, observations were also recorded on the different characters contributing to yield such as plant height, leaf area, dry weight of the shoots, length and breadth of the pods, number of grains per pod, weight of 100 grains, weight of 100 pods and number of pods per plant were also recorded. Ten plants were selected at random from each treatment per replication for detailed observations. For the purpose of observing the dry weight, 5 plants from each treatment were selected at random after final picking and the observations were recorded.

Vegetative growth studies :

Height of the plants :

The height in centimeter was measured from the ground level up to the growing tip of the plant. The first growth observation of height of each observational plant was recorded just before first spraying i.e. on 26th November, 1975 and then the height was also recorded 35 days after first observation. Absolute growth rate was calculated from this and recorded.

Number of branches :

The number of branches were recorded 65 days after sowing.

Leaf area :

The observations regarding leaf area were taken after final picking i.e. 122 days after sowing. 10th nodal leaf was selected for tracing the leaf area. The leaf area was traced on paper and was measured with the help of planimeter.

Dry weight of shoots :

The shoots were completely dried in the sun after final picking i.e. 122 days after sowing and the data regarding dry weight was recorded.

B. Flowering and fruit-set studies :

Days required for first flowering :

The number of days required from sowing upto appearance of first flower on the observational plants was recorded.

Days required for 50% flowering :

The date on which 50 % of the observational plants of the plot were flowered was taken to calculate the days required for 50 % flowering from the date of sowing. The PGRs kinetin, GA + kinetin, CCC and GA + CCC were applied before flowering. Therefore, only these growth regulators were compared to observe the effect on flowering.

Percentage fruit-set :

The number of flowers were recorded at an interval of three days for four times, i.e. from 60 days after sowing upto 69 days after sowing. The number of pods set from these flowers were counted and percentage fruit-set was calculated.

C. Pod development and yield studies :

Pod measurements :

Twenty five pods were selected at random during the second picking i.e. 82 days after sowing from each treatment.

The picking operation was carried out whenever the pods were fully developed to be used as fresh green peas. The harvesting was completed in six pickings.

The length of entire pod was measured with the help of steel tape up to the accuracy of 0.1 cm. The breadth of the pod was measured in centimeter approximately near the centre of pod by means of a vernier calliper.

Weight of 100 pods :

The weight of 25 pods selected at random from each plot was recorded and from that the weight of 100 pods was calculated in gm.

Weight of 100 grains :

From these selected 25 pods, 100 grains of peas were selected at random and their weight in gm was recorded.

Number of grains per pod :

The grains from all the 25 pods selected at random were counted and the average number of grains per pod was calculated.

Yield of pods :

Number of pods per plant :

The number of pods of the observational plants from each treatment was counted at every picking and the average number of pods per plant was calculated.

<u>Weight of pods per plant</u> :

The weight of pods of all the 10 observational plants of a treatment was taken at every picking. These weights were summed up and the average weight of pods per plant was calculated and recorded.

VI <u>Yield of pods per plot and per hectare</u> :

The total yield from all the plants in a net plot was recorded. Further, from this, the yield per hectare was calculated.

CHAPTER IV

EXPERIMENTAL RESULTS

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CHAPTER IV

EXPERIMENTAL RESULTS

The data recorded on various aspects of plant growth, flowering, fruit-set and yield of peas as influenced by the growth regulators under study are presented herewith under appropriate sub-headings.

A. <u>GROWTH STUDIES</u> :

1. <u>Absolute growth rate (AGR) of height</u> :

On perusal of table-1, it is observed that GA was significantly superior over all other PGRs and the control in increasing the absolute growth rate of height (plate - 1 and 2 and fig 1 and 2). CCC recorded the least absolute growth rate of height and was significantly inferior to all other PGRs and the control. GA + Kinetin and 4-CPA + NOXA were on par and the height recorded by them was significantly lower than that of GA, control, 4-CPA, NOXA and NAA.

Amongst GA treatments, the higher level (100 ppm) gave significantly more AGR than the lower level (10 ppm). As far as CCC is concerned, the higher level (1500 ppm) had significant effect in retarding the plant height as compared to the medium and lower levels.

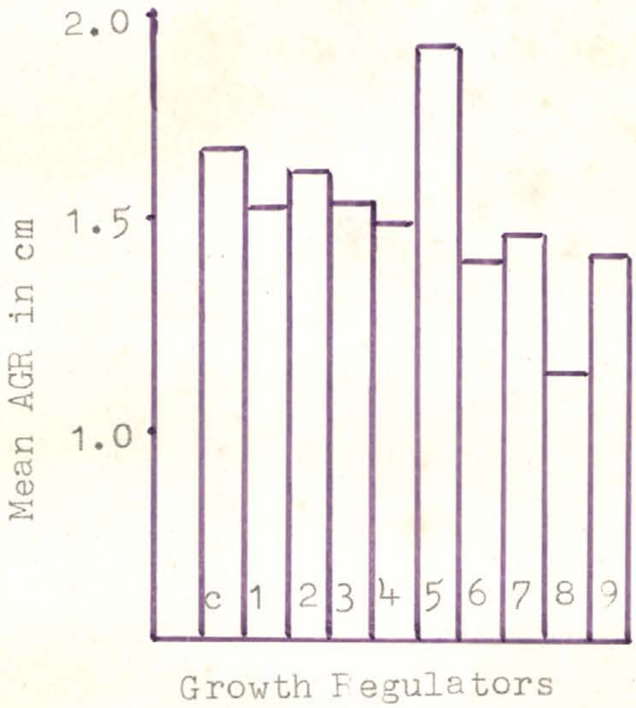
The higher and the medium levels of GA were on par and they gave significantly more AGR (or height) over all

Table : 1 Absolute growth rate (AGR) of height in cm as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
NAA	1.49	1.49	1.62	1.53
4 - C P A	1.64	1.75	1.49	1.62
NOXA	1.48	1.66	1.50	1.54
4 - C P A + NOXA	1.40	1.49	1.59	1.49
GA	1.69	1.98	2.09	1.92
Kinetin	1.29	1.40	1.50	1.40
GA + Kinetin	1.55	1.41	1.46	1.47
CCC	1.29	1.14	0.96	1.13
GA + CCC	1.50	1.57	1.21	1.42
Mean	1.48	1.54	1.49	-
Control	1.68	-	-	-

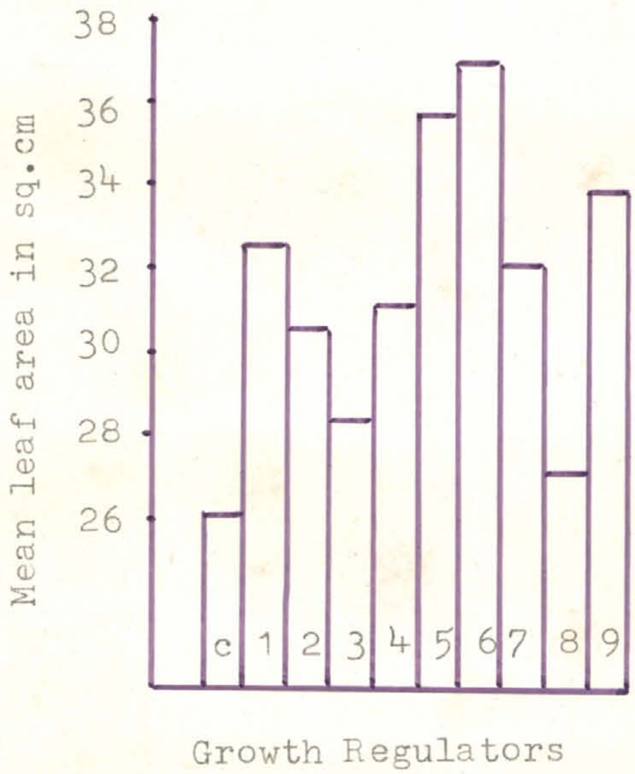
	G. R.	Level	Interaction
S. E. ±	0.02	0.0002	0.04
C.D. at 5 %	0.07	0.0004	0.13

Fig.2
Graphical representation of the mean AGR of height as affected by different growth regulators.



c : control
1 : NAA
2 : 4-CPA
3 : NOXA
4 : 4-CPA+NOXA
5 : GA
6 : Kinetin
7 : GA+Kinetin
8 : CCC
9 : GA+CCC

Fig.4
Graphical representation of the mean leaf area in sq.cm as affected by different growth regulators.



other treatments including control. CCC at it's higher level gave significantly less AGR, over all other treatments. Rest of the treatmentswere in between these treatments.

2. Number of branches per plant :

On perusal of table-2, it is observed that GA + CCC gave the highest number of branches and this combination proved to be significantly superior over all other PGRs (and control) except NOXA with which it was on par (Fig.3). CCC gave lowest number of branches and was significantly inferior to all other PGRs (Fig 3). It was on par with control. The PGRs NAA, 4-CPA and GA were on par and were superior to CCC, kinetin, GA + kinetin and the control.

The medium level of GA + CCC displayed significantly more number of branches as compared to the higher level and it was superior but on ar with the lower level. Amongst CCC treatments, the higher level of CCC (1500 ppm) recorded significantly less number of branches as compared to it's lower and the medium levels.

4-CPA + NOXA at the medium level produced highest number of branches. It was significantly superior to all other treatments except the T_9l_1 and T_9l_2 treatments which were on par with it. The higher level of CCC produced least number of branches and it was significantly inferior to all other treatments.

PLATE -1

Height of the plants in control treatment

PLATE -2

Height of the GA-treated (100 ppm) plants

Table 2 : Mean number of branches per plant as affected by different growth regulators and their levels.

PGRs \ Level	l_1	l_2	l_3	Mean
NAA	3.56	3.80	3.36	3.57
4-C P A	4.06	3.50	2.80	3.45
NOXA	4.10	3.90	3.63	3.97
4-C P A + NOXA	3.00	4.60	3.70	3.76
GA	2.73	3.43	4.20	3.45
Kinetin	2.90	3.10	3.00	3.00
GA + Kinetin	3.00	3.23	2.80	3.01
CCC	3.96	2.30	1.50	2.58
GA + CCC	4.33	4.46	3.20	4.01
Mean	3.52	3.59	3.13	-
Control	2.70	-	-	-

	G.R.	Level	Interaction
S.E. ±	0.07	0.04	0.12
C.D. at 5 %	0.20	0.11	0.36

3. Leaf area :

The data in table -3 reveal that all the PGRs tried differed significantly from each other in affecting the leaf area. Kinetin produced the highest leaf area and it was significantly superior to all other PGRs (Fig. 4). The control plant produced significantly less leaf area as compared to the PGRs (Fig. 4). Though, amongst the PGRs, the CCC recorded significantly lower leaf area, it was significantly superior to the control.

The lower level of kinetin produced significantly more leaf area as compared to it's medium and the higher levels. The higher level of CCC showed significantly lower leaf area as compared to the medium and the lower levels.

The treatment T_4l_3 produced maximum leaf area and was significantly superior to all other treatments. It was followed by T_6l_1 and T_5l_1 treatments. The treatment T_8l_3 gave least leaf area and it was significantly inferior to all other treatments including control.

4. Dry weight of the shoots :

The data in table - 4 reveal that GA produced maximum dry weight of the shoots over all other PGRs and the control (Fig. 5). It was on par with NAA. The CCC recorded least dry weight of the shoots and it was on par with kinetin and NOXA.

Table 3 : Mean leaf area in square cms as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
NAA	36.30	33.03	28.86	32.73
4-C P A	32.99	32.83	26.70	30.60
NOXA	25.07	31.89	28.02	28.32
4-C P A + NOXA	23.76	26.17	43.83	31.25
GA	39.05	37.16	31.11	35.77
Kinetin	43.03	35.80	32.31	37.05
GA + kinetin	24.99	36.35	35.51	32.15
CCC	35.19	24.18	22.31	27.22
GA + CCC	38.24	34.88	28.82	33.98
Mean	33.05	32.47	30.85	-
Control	26.26	-	-	-

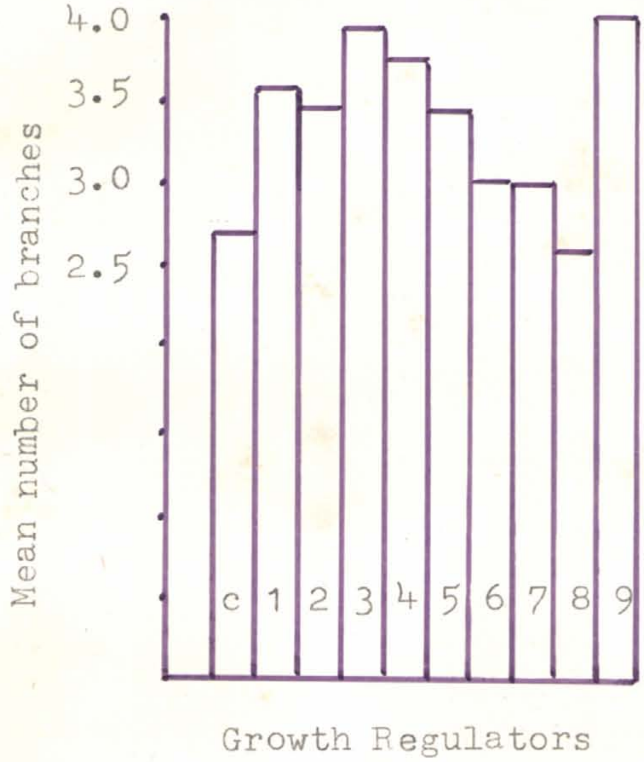
	G.R.	Level	Interaction
S.E. ±	0.06	0.03	0.11
C.D. at 5 %	0.18	0.10	0.32

Table 4 : Mean dry weight of shoots in gm as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
NAA	27.22	34.51	22.94	28.22
4-C P A	30.12	24.74	22.13	25.66
NOXA	21.88	27.44	21.57	23.55
4-C P A + NOXA	35.95	28.44	13.44	27.61
GA	35.95	28.44	13.44	27.61
Kinetin	18.96	25.60	23.13	22.50
GA + Kinetin	31.25	29.69	15.48	25.47
CCC	28.60	23.22	14.74	22.18
GA + CCC	32.25	26.67	22.24	27.08
Mean	28.23	27.80	21.41	-
Control	26.83	-	-	

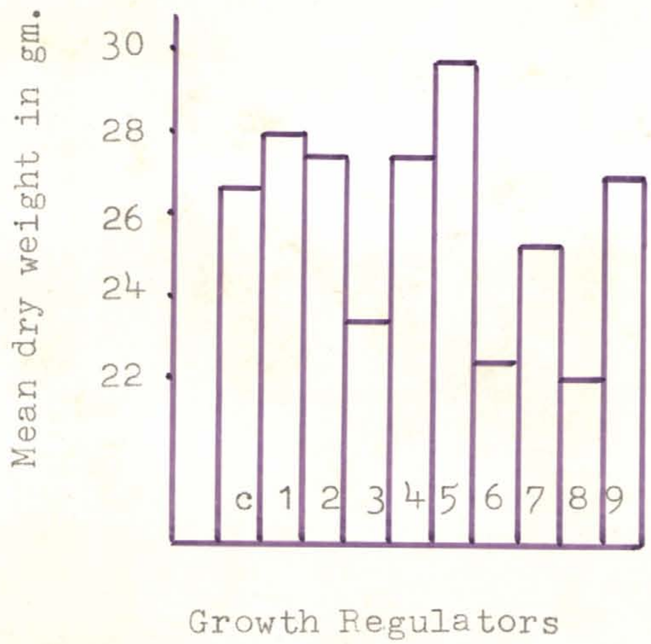
	G.R.	Level	Interaction
S. E. ±	0.76	0.44	1.32
C.D. at 5 %	2.15	1.24	3.73

Fig.3
Graphical representation of the mean number of branches as affected by different growth regulators.



c : control
1 : NAA
2 : 4-CPA
3 : NOXA
4 : 4-CPA+NOXA
5 : GA
6 : Kinetin
7 : GA+Kinetin
8 : CCC
9 : GA+CCC

Fig.5
Mean dry weight in gm of the shoots as affected by different growth regulators.



Amongst the GA levels, the higher level of GA (1000 ppm) gave significantly more dry weight as compared to the lower level and it was on par with the medium level. The higher level of CCC produced significantly less dry weight as compared to the medium and the lower levels.

The treatment T_4l_1 was significantly superior to all other treatments including control except T_9l_1 and T_1l_4 which were on par with it. It was followed by T_1l_2 , T_9l_1 and T_5l_3 treatments. The treatment T_8l_3 produced least dry weight and it was on par with T_7l_3 and T_4l_3 and was significantly inferior to all other treatments.

B. <u>FLOWERING AND FRUIT-SET STUDIES</u> :

1. <u>Days to first flower</u> :

For studying the effects of growth regulators on days to first flower and the days to 50% flowering only kinetin, GA + kinetin, CCC and GA + CCC were compared with each other because these growth regulators were sprayed before flowering and they were expected to affect the days required to first flower and the days to 50% flowering.

The data in table-5 reveal that the PGRs did not vary significantly from each other in affecting the days required to first flower.

The GA + kinetin-treated plants flowered earliest as compared to kinetin, CCC and GA + CCC and the control. The plants in control treatment took maximum time to first flower. It was followed by kinetin.

Table 5 : Mean number of days to first flower as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
Kinetin	47.00	46.66	45.33	46.33
GA + Kinetin	45.00	43.66	46.66	44.44
CCC	46.66	45.66	44.33	45.33
GA + CCC	45.00	44.00	45.66	44.88
Mean	46.16	45.08	44.50	-
Control	47.00	-	-	-
	G.R.	Level	Interaction	
S.E. ±	0.51	0.44	0.89	
C.D. at 5 %	N.S.	N.S.	N.S.	

Table 6 : Mean number of days to 50% flower as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
Kinetin	50.00	50.00	49.66	49.88
GA + Kinetin	47.33	46.66	49.33	47.77
CCC	47.66	49.33	50.00	49.00
GA + CCC	50.00	50.00	45.66	48.55
Mean	49.50	48.75	48.16	-
Control	48.00	-	-	-
	G.R.	Level	Interaction	
S.E. ±	0.42	0.36	0.73	
C.D. at 5 %	N.S.	N.S.	2.06	

The plants treated with the medium level of GA + kinetin flowered earlier as compared to the lower and the higher levels. The plants treated with the lower level of kinetin took more time to first flower as compared to the higher and the medium levels.

Though, the interactions were not statistically significant, the treatment T_7l_2 has tended flowering and the treatments control and T_6l_1 delayed it as compared to all other treatments.

2. Days to 50% flower :

The data in table-6 reveal that though, the PGRs, did not vary significantly from each other in affecting the days to 50% flowering, GA + kinetin took least time to 50% flower and the kinetin treated plants took maximum time to 50% flowering as compared to all other growth regulators and the control.

The plants treated with kinetin, irrespective of any concentration took more time for 50% flowering. Amongst GA + kinetin treatments, the medium level of its concentration was significantly superior to the higher level of its concentration.

The higher level of GA + CCC took significantly less time for 50% flowering as compared to all other treatments (except T_7l_2, T_7l_1 and T_8l_1 with which it was on par).

3. Percentage fruit-set :

On perusal of table-7, it can be seen that the 4-CPA

Table 7 : Mean per cent fruit-set as affected by different growth regulators and their levels.

PGRs \ Level	l_1	l_2	l_3	Mean
NAA	66.71	82.66	70.64	70.00
4-C P A	94.00	91.33	91.00	92.24
NOXA	83.66	85.31	84.53	84.50
4-C P A + NOXA	96.38	65.51	64.24	75.38
GA	91.54	77.03	66.61	78.41
Kinetin	65.54	65.56	64.41	65.17
GA + Kinetin	71.56	79.47	55.61	68.88
CCC	59.72	82.81	77.59	73.37
GA + CCC	70.41	72.33	69.68	70.80
Mean	77.73	78.56	71.62	-
Control	76.57	-	-	-

	G. R.	Level	Interaction
S.E. ±	0.72	0.41	1.25
C.D. at 5 %	2.05	1.18	3.55

proved to be significantly superior to all other PGRs and the control in increasing the fruit-set (Fig.6). Kinetin was significantly inferior to all other PGRs and the control.

The lower level of 4-CPA (10 ppm) was superior to the medium (20 ppm) and the higher (30 ppm) levels. The higher level of kinetin (10 ppm) was inferior to the medium (5 ppm) and the lower (2.5 ppm) levels.

The treatment $T_4 l_1$ recorded maximum percentage of fruit-set and it was significantly superior to all other treatments including control except the treatment $T_2 l_1$ with which it was on par. The treatment $T_7 l_3$ produced minimum percentage of fruit-set and it was significantly inferior as compared to all other treatments including control.

C. POD CHARACTERISTICS AND YIELD STUDIES :

1. Pod Length :

The data in table 8 indicate that though, the PGRs did not differ significantly from each other in affecting the pod length, the NOXA gave maximum length of the pods than all the PGRs and the control (plate - 3). Kinetin gave minimum length of pods as compared to all other PGRs but it was superior to the control.

The medium level of NOXA (20 ppm) was superior to the lower (10 ppm)and the higher (30 ppm) levels. The higher level of kinetin (10 ppm) was inferior to the medium (5 ppm) and the lower (2.5 ppm) levels. The differences however, were

Fig.6
Graphical representation of the mean percentage of fruit set as affected by different growth regulators.

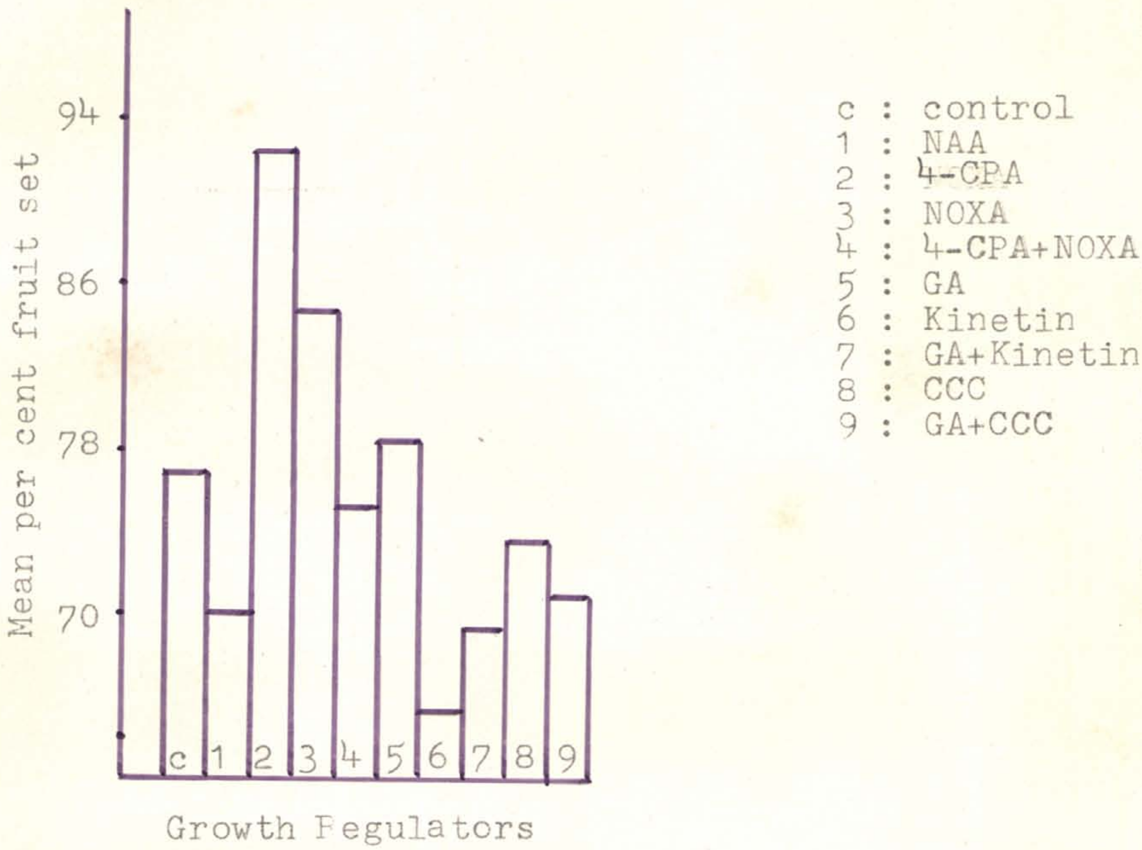


Fig.7
Graphical representation of the mean weight of 100 grains in gm as affected by different growth regulators.

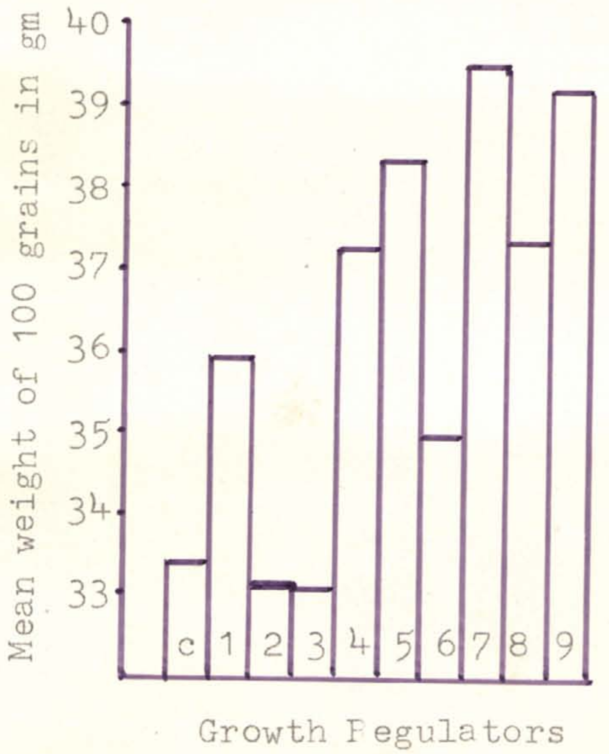


Table 8 : Mean length of pods in cm as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
NAA	7.70	7.43	7.36	7.50
4-C P A	7.33	7.66	7.50	7.50
NOXA	7.23	7.86	7.46	7.52
4-C P A + NOXA	7.60	7.40	7.30	7.43
GA	7.36	7.46	7.10	7.31
Kinetin	7.13	7.63	7.10	7.29
GA + Kinetin	7.30	7.40	7.20	7.30
CCC	7.10	7.73	7.36	7.40
GA + CCC	7.33	7.60	7.20	7.37
Mean	7.34	7.57	7.29	-
Control	7.10	-	-	-
	G.R.	Level	Interaction	
S.E. ±	0.12	0.07	0.21	
C.D. at 5 %	N.S.	N.S.	N.S.	

not statistically significant.

Though, the interactions were not significant, the treatment T_3l_2 recorded maximum pod length where as the treatments T_5l_3, T_6l_3, T_8l_1 and the control recorded minimum pod length as compared to all other treatments.

2. <u>Pod breadth</u> :

The data in table-9 indicate that the various PGRs did not differ significantly from each other in affecting pod breadth. However, 4- C P A + NOXA and GA + Kinetin produced least breadth of the pods and were inferior as compared to all other PGRs and the control.

The lower level of 4 - C P A (10 ppm) produced more pod breadth as compared to the higher (30 ppm) and the medium (20 ppm) levels. The lower level of 4 - C P A + NOXA gave lower pod breadth than the medium and the higher levels. The higher level of GA + kinetin was inferior to both the medium and the lower levels. Though, the interactions were not significant, the treatment T_2l_1 was superior as compared to all other treatments including control. The treatment T_4l_1 and T_7l_3 showed least pod breadth as compared to all other treatments including control.

3. <u>Number of grains per pod</u> :

On perusal of table-10, it can be seen that though, statistically the results were not significant, 4 - C P A

Table 9 : Mean breadth of pods in cm as affected by different growth regulators and their levels.

Level / GRs	l_1	l_2	l_3	Mean
NAA	1.24	1.27	1.27	1.26
4-C P A	1.29	1.28	1.27	1.28
NOXA	1.28	1.28	1.26	1.26
4 C P A + NOXA	1.14	1.25	1.23	1.21
GA	1.18	1.25	1.26	1.23
Kinetin	1.26	1.25	1.26	1.25
GA + Kinetin	1.25	1.25	1.14	1.21
CCC	1.25	1.26	1.21	1.24
GA + CCC	1.24	1.28	1.23	1.25
Mean	1.23	1.26	1.23	-
Control	1.27	-	-	-

	G.R.	Level	Interaction
S.E. ±	0.017	0.010	0.030
C.D. at 5 %	N.S.	N.S.	N.S.

Table 10 : Mean number grains per pod as affected by different growth regulators and their levels.

PGRs / Level	l_1	l_2	l_3	Mean
NAA	5.57	5.52	5.21	5.43
4-CPA	5.74	5.78	5.25	5.59
NOXA	5.66	5.12	4.97	5.25
4-C P A + NOXA	5.05	5.28	5.25	5.19
GA	5.09	5.26	5.06	5.14
Kinetin	4.97	4.98	5.48	5.14
GA + Kinetin	5.10	5.13	5.56	4.94
CCC	4.82	5.93	5.56	5.44
GA + CCC	4.89	5.32	4.86	5.02
Mean	5.21	5.37	5.13	-
Control	4.99	-	-	-

	G. R.	Level	Interaction
S. E. ±	0.17	0.10	0.30
C. D. at 5 %	N. S.	N.S.	N. S.

exhibited the highest number of grains per pod as compared to all other PGRs and the control (Plate - 4). GA + Kinetin showed least number of grains per pod as compared to all other PGRs and the control.

The medium level of 4 - C P A (20 ppm) produced more number of grains per pod as compared to the higher (30 ppm) and the lower (10 ppm) levels. The higher level of GA + kinetin was inferior to both the lower and the medium levels.

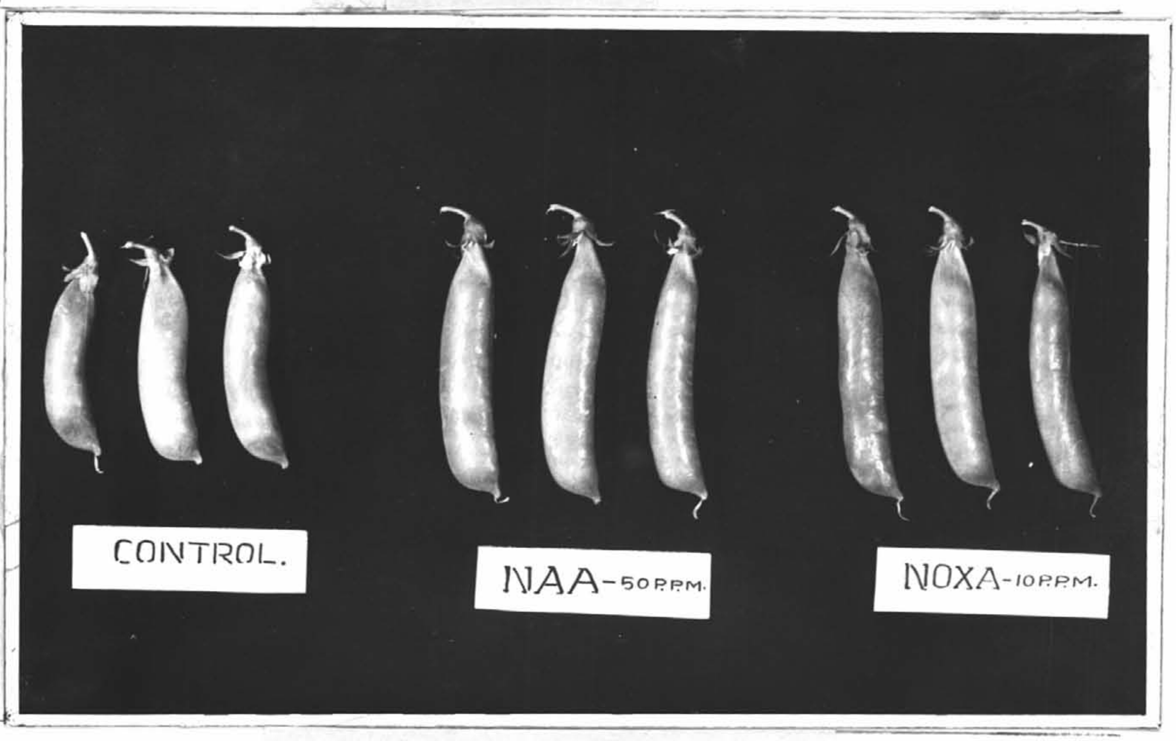
Though, the interactions were not statistically significant, the treatment T_8l_2 was superior to all other treatments including control and the treatment T_7l_3 was inferior to all other treatments including control. Rest of the treatments were in between these treatments.

4. <u>Weight of 100 grains</u> :

The data in table-11 reveal that GA and kinetin in combination gave maximum weight of 100 grains and was significantly superior over all other PGRs and the control (Fig. 7). It was followed by GA + CCC. 4-C P A and NOXA were on par and they were significantly inferior to all other PGRs and the control.

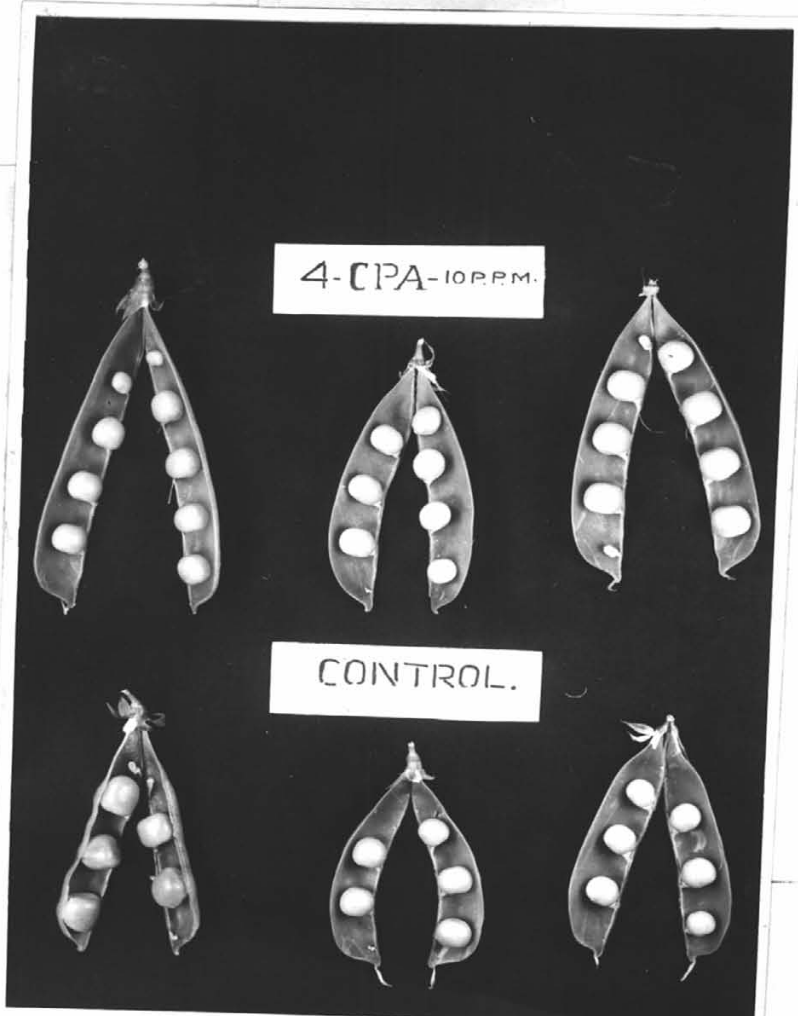
The medium level of GA + kinetin displayed significantly more weight of 100 grains as compared to the higher and the lower levels. The higher level of NOXA (30 ppm) was significantly inferior to both the lower (10 ppm) and the medium (20 ppm) levels.

PLATE -3



Length of the pods

PLATE -4



Number of grains per pod

Table 11 : Mean weight of 100 grains in gm as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
NAA	33.46	35.53	38.76	35.92
4-C P A	32.10	34.96	32.23	33.10
NOXA	34.63	38.13	26.50	33.08
4 - C P A + NOXA	34.40	40.70	36.66	37.25
GA	45.23	37.73	31.93	38.30
Kinetin	37.26	36.50	31.20	34.98
GA + Kinetin	38.56	44.10	35.80	39.49
CCC	39.43	36.30	36.13	37.28
GA + CCC	38.36	39.40	39.80	39.18
Mean	37.05	38.15	34.33	-
Control	33.40	-	-	-

	G.R.	Level	Interaction
S.E. ±	0.05	0.03	0.10
C.D. at 5 %	0.16	0.09	0.28

The treatment $T_5 l_1$ was significantly superior over all other treatments including control and the treatment $T_3 l_3$ produced significantly less weight of 100 grains over all other treatments . Rest of the treatments were in between these treatments .

5. <u>Weight of 100 pods</u> :

The data in table-12 reveal that in general, the PGRs did not vary significantly from each other in affecting the mean weight of 100 pods. However, the plants treated with NOXA gave lightest pods as compared to all other PGRs and the control.

The medium level of 4-CPA (20 ppm) produced heavier pods as compared to the lower (10 ppm) and the higher (30 ppm)levels. The higher level of NOXA (30 ppm) gave lighter pods as compared to the lower (10 ppm) and the medium (20 ppm) levels.

Table 12 : Mean weight of 100 pods in gm as affected by different growth regulators and their levels.

Level / GRs	l_1	l_2	l_3	Mean
NAA	412.00	403.66	363.33	394.66
4-C P A	412.00	440.00	412.00	421.33
NO XA	400.66	406.00	331.33	379.33
4-C P A + NO XA	388.00	444.00	398.00	410.00
GA	427.66	420.66	383.33	410.55
Kinetin	406.66	430.66	367.33	400.88
GA + Kinetin	409.33	398.66	355.33	387.77
CCC	388.00	431.33	413.33	410.77
GA + CCC	401.33	412.00	381.33	397.77
Mean	404.85	421.29	378.22	-
Control	398.66	-	-	-

	G.R.	Level	Interaction
S.E. ±	9.26	5.34	16.04
C.D. at 5 %	N.S.	15.10	N.S.

However, the results were not significant.

Though, the interactions were not significant, the treatment T_4l_2 produced heaviest pods and the treatment T_3l_3 gave lightest pods as compared to all other treatments including control.

6. Number of pods per plant :

The data in table 13 reveal that though, the results were not significant, in general, control recorded maximum number of pods per plant as compared to the PGRs. Amongst the PGRs GA + CCC gave maximum number of pods per plant and GA produced least number of pods per plant.

The medium level of GA + CCC produced more number of pods per plant as compared to the higher and the lower levels. The lower level of GA was inferior to both the higher and the medium levels. However, the differences were not statistically significant.

The treatment T_9l_2 gave maximum number of pods per plant as compared to all other treatments including control. It was followed by T_3l_2 and T_7l_2 treatments. The treatment T_5l_1 showed least number of pods per plant.

7. Weight of pods per plant :

The data in table-14 reveal that the PGRs did not vary significantly from each other in affecting the weight of pods per plant. The plants in control treatment produced maximum

Table 13 : Mean number of pods per plant as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
NAA	31.36	33.13	30.20	31.63
4 - C P A	27.66	28.63	28.26	28.18
NOXA	32.80	38.00	28.46	33.08
4 C P A + NOXA	34.73	35.40	30.10	33.41
GA	25.73	29.13	27.46	27.44
Kinetin	27.86	32.13	29.33	29.77
GA + Kinetin	29.96	36.20	28.36	31.51
CCC	29.10	35.76	26.50	30.45
GA + CCC	32.76	38.23	32.16	34.38
Mean	30.24	34.02	29.02	-
Control	34.96	-	-	-

	G. R.	Level	Interaction
S. E. ±	2.02	1.17	3.51
C.D. at 5 %	N. S.	N.S.	N. S.

Table 14 : Mean weight of pods in gm per plant as affected by different growth regulators and their levels.

Level / PGRs	l_1	l_2	l_3	Mean
NAA	122.16	137.66	124.06	127.96
4 - CPA	117.50	118.00	112.26	116.13
NOXA	104.00	135.63	125.76	121.80
4-CPA + NOXA	122.40	155.50	118.80	132.23
GA	116.50	123.90	95.60	112.00
Kinetin	92.83	113.23	148.13	118.06
GA + Kinetin	108.43	142.50	125.33	125.42
CCC	146.00	125.66	114.60	128.75
GA + CCC	132.43	152.13	115.10	133.22
Mean	118.02	133.87	119.96	-
Control	137.80	-	-	-

	G. R.	Level	Interaction
S. E. ±	5.78	3.33	10.0
C. D. at 5 %	N.S.	9.41	N.S.

weight of pods per plant as compared with the PGRs. Amongst the PGRs the plants treated with GA + CCC showed maximum weight of pods per plant and the plants treated with GA produced least weight of pods per plant.

In general, the medium levels of all the PGRs applied were most beneficial in increasing the weight of pods per plant as compared to their higher and the lower levels except for the PGRs kinetin and CCC.

Though, the interactions were not statistically significant, the treatment T_4l_2 was superior as compared to all other treatments. It was followed by the treatment T_9l_2 and T_6l_3. The treatment T_6l_1 was the inferior most.

8. <u>Yield of pods per plot</u> :

On perusal of table-15, it can be seen that in general, the control exhibited maximum yield per plot as compared to the PGRs, GA + CCC produced maximum yield per plot. It was followed by 4-C P A + NOXA. The GA treated plants yielded the least.

In general, the medium level of all the PGRs, were found more beneficial as compared to their lower and the higher levels except for the PGRs CCC and kinetin.

The interactions between the plant growth regulators and their levels were not significant. The plants treated with T_4l_2 produced the highest yield as compared to all other

Table 15 : Total yield in kg per plot as affected by different growth regulators and their levels.

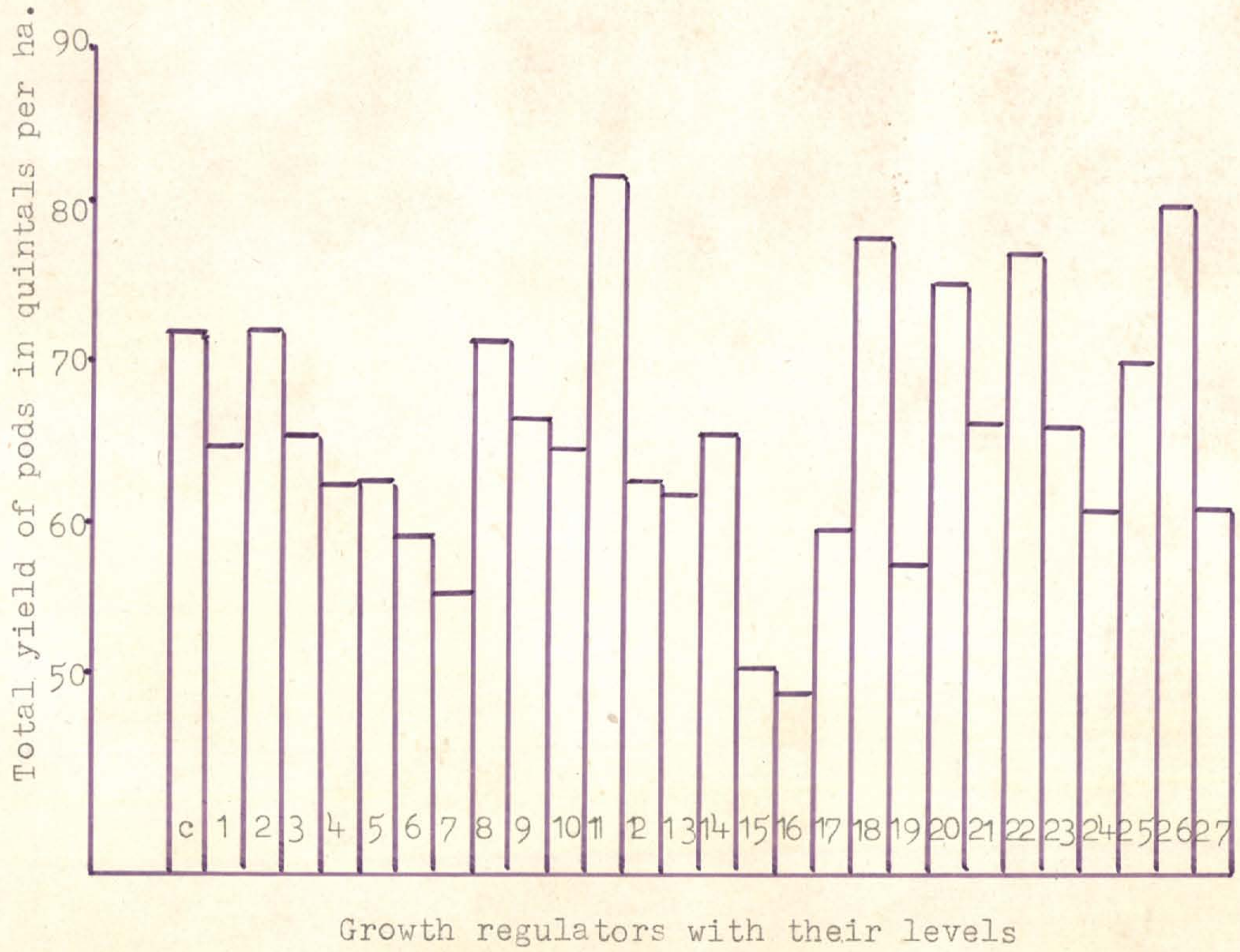
Level / PGRs	l_1	l2	l_3	Mean
NAA	14.65	16.51	14.88	15.35
4- C P A	14.09	14.23	13.47	13.93
NOXA	12.48	16.27	15.09	14.61
4- C P A + NOXA	14.68	18.64	14.25	15.86
GA	13.97	14.86	11.47	13.43
Kinetin	11.14	13.53	17.77	14.16
GA + Kinetin	13.01	17.09	15.03	15.04
CCC	17.51	15.08	13.74	15.44
GA + CCC	15.99	13.25	13.30	15.98
Mean	14.16	15.06	14.39	-
Control	16.53	-	-	-

	G.R.	Level	Interaction
S.E. ±	0.69	0.40	1.20
C.D. at 5 %	N.S.	1.13	N.S.

Table 16 : Yield in quintals per hectare as affected by different growth regulators and their levels.

PGRs \ Level	l_1	l_2	l_3	Mean
NAA	64.61	77.82	65.63	67.68
4-CPA	62.14	62.75	59.38	61.42
NOXA	55.02	71.74	66.52	64.43
4-CPA + NOXA	64.75	82.18	62.84	69.92
GA	61.62	65.54	50.96	59.46
Kinetin	49.11	59.90	78.36	62.45
GA + Kinetin	57.35	75.38	66.29	66.34
CCC	77.23	66.48	60.60	68.10
GA + CCC	70.05	80.47	60.87	70.46
Mean	62.43	70.80	63.45	-
Control	72.89	-	-	
	G. R.	Level	Interaction	
S. E. ±	3.06	1.76	5.3	
C.D. at 5 %	N. S.	4.99	N. S.	

Fig.8
Graphical representation of the total yield of pods in quintals per hectare as affected by different growth regulators and their levels.



c : control
1 : NAA 50 ppm
2 : NAA 100 ppm
3 : NAA 150 ppm
4 : 4-CPA 10 ppm
5 : 4-CPA 20 ppm
6 : 4-CPA 30 ppm
7 : NOXA 10 ppm
8 : NOXA 20 ppm
9 : NOXA 30 ppm
10 : 4-CPA 5 ppm + NOXA 5 ppm
11 : 4-CPA 10 ppm + NOXA 10 ppm
12 : 4-CPA 15 ppm + NOXA 15 ppm
13 : GA 10 ppm
14 : GA 50 ppm
15 : GA 100 ppm
16 : Kinetin 2.5 ppm
17 : Kinetin 5.0 ppm
18 : Kinetin 10,0 ppm
19 : GA 5 ppm + Kinetin 1.25 ppm
20 : GA 25 ppm + Kinetin 2.5 ppm
21 : GA 50 ppm + Kinetin 5 ppm
22 : CCC 500 ppm
23 : CCC 1000 ppm
24 : CCC 1500 ppm
25 : GA 5 ppm + CCC 250 ppm
26 : GA 25 ppm + CCC 500 ppm
27 : GA 50 ppm + CCC 750 ppm

treatments (Fig. 8). It was followed by T_5l_3 and T_3l_1 treatments.

9. <u>Yield of pods per hectare</u> :

The data of yield of peas in quintals per hectare is presented in table 16. The trend of results was the same as the trend of yield per plot because of the fact that the yield per hectare is calculated on the basis of yield per plot.

CHAPTER V

DISCUSSION

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CHAPTER V

DISCUSSION

The results obtained with respect to growth, flowering, fruit-set, pod characters and yield of pea plants as influenced by various plant growth regulators (PGRs) and their combinations, presented in Chapter IV are discussed hereunder.

A. Growth :

1. Absolute growth rate (AGR) of height :

The results obtained as regards the increase of absolute growth rate of plants treated with GA might be due to the fact that GA stimulated cell elongation and to some extent cell division. This fact is universally accepted. The results are in conformity with those obtained by Laszlo (1974) in variety Petiit Provencol and Chakravarti and Ram (1973) with the variety Sutton's Early Wonder.

CCC is universally accepted as growth retardant which slows down cell division and cell elongation in shoot tissues (Sirkar, 1971). The decreased height of the plants treated with CCC are also in agreement with the results obtained by Adedipe *et al*. (1968) and Will (1968).

As the concentration of GA increased there was also an increase in the AGR because the increasing concentrations of GA might have an increasing stimulatory effect on the cell elongation and cell division and consequently the stem elongation. This effect of GA is also in confirmity with that obtained by Bonde and Moore (1958). With CCC, there was an increased inhibitory effect on plant height with increasing concentrations. Similar results were obtained by Adedipe and Ormrod (1972) where the highest concentration (1000 ppm) had given the retarding effect.

In general, all the PGRs except GA gave lower AGR (of height) over the controls by checking the growth.

2. Number of branches :

GA and CCC in combination gave more number of branches at its medium level of concentration. Application of CCC with GA might have caused synergistic effect on branching at that particular level of concentration.

CCC applied seperately at the concentration of 1500 ppm produced least number of branches. This might be because of the fact that CCC might have checked cell division and cell elongation in the meristems and the branching was reduced or inhibited due to CCC.

The interaction between 4- C P A and NOXA applied in combination at the medium level of its concentration was the most beneficial one in increasing the number of branches. This could be attributed to the fact that these two PGRs had a synergistic effect of interaction at that particular concentration.

3. Leaf area :

4-C P A and NOXA at the higher concentration of their combination exhibited maximum leaf area. This might be because of the fact that 4-C P A and NOXA in combination had an interaction producing synergistic effect on increasing the leaf size.

Kinetin had maximum effect in increasing leaf area as compared to all other PGRs. This could be attributed to the ability of kinetin in inducing cell division and also their enlargement to some extent.

CCC at 1000 ppm and 1500 ppm reduced the size of the leaves. This might be due to the inhibition of cell division and cell elongation induced by CCC at the two higher levels of its concentration.

4. Dry weight of shoots :

GA produced maximum dry weight of the shoots amongst all PGRs and the control. This could be attributed to the fact that as GA had produced maximum growth, had given fairly more number of branches and had increased the leaf size, the dry weight of such plants (treated with GA) might have ultimately increased due to GA applications. Bottini and Lepori (1964) also obtained increased dry weight of the shoots and the leaves by about 50% with 15 ppm GA and 71.5 % with 75 ppm GA as compared to the controls.

In the experiment conducted, it could be seent that the dry weight increased with increasing concentrations of GA. This could be attributed to the fact that as the height and the number of branches increased with increasing concentrations of GA, the dry weight also increased by following the same path.

As the concentmation of CCC increased, the dry weight of the shoots decreased progressively. It might be due to the fact that as the concentration of CCC increased, there was decreased plant height, the number of branches and the leaf size. This might have accounted for the decreased dry matter. Adedipe (1968) also reported that CCC had reduced the dry matter of the shoots.

4-C P A and NOXA at their lower level of concentration displayed greatest dry matter of the shoots as compared tho all other treatment combinations. This might be due to the fact that these two growth regulators at the lower level of the concentration (4-C P A - 5 ppm + NOXA - 5 ppm) might have an interaction which had produced a pronounced synergistic effect in increasing the dry matter of the shoots.

As the concentration of 4-C P A + NOXA increased, the dry weight of the shoots decreased progressively. The higher level of their concentration reduced the dry matter to a great extent. From this, it could be concluded that 4-C P A 5 ppm + NOXA -5 ppm were in optimum concentration in increasing the dry weight of the shoots and the levels higher than that were above optimum and had caused unfavorable effect so far as the dry weight was concemmed.

B. <u>Flowering and fruit-set studies</u> :

1. <u>Days to first flower</u> :

The PGRs kinetin, GA + kinetin, CCC and GA + CCC were sprayed before flowering. It could be observed that they had no significant effect in affecting the days to first flower. In general, the plants sprayed with the PGRs took less time to first flower as compared to the controls.

2. <u>Days to 50 % flower</u> :

The earliest completion of 50% flowering observed with GA + CCC at the higher level of its concentration might be because of the fact that GA 50 ppm + CCC 750 ppm might be optimum for inducing early and uniform flowering of the plants.

3. <u>Fruit-set</u> :

That the key factor liming the fruit-set lied in the presence of production of auxin at the time of fertilization and fruit development had been appreciated from early times.

Gustafson (1939) explained that the auxin from the pollen grains and pollen tube might be responsible for the early stages of fruit growth. However, small amount of pollen necessary to pollinate a flower may not carry enough auxin to account for early fruit development.

In the present study, the observed results of increased percentage of fruit-set in the 4-C P A over rest of the PGRs and the control might be due to the ability of the chemical to induce the set of the pods from the important flowers, which would have dropped without setting in the absence of the growth regulator. Whitaker and Pryor (1946) got 22 % increase in fruit set of Cucumis melo by the use of 4-C P A at the time of pollination.

The growth regulator 4-C P A was followed by NOXA. In California, 29 experiments were carried out on tomatoes in 11 countries and the chemicals used were NOA (NOXA), 2, 4-D and the sodium salts of 4-C P A. All those chemicals were proved effective in increasing fruit-set. Hemphill (1949) also obtained increased fruit-set in tomatoes with the use of NOA (NOXA).

4-C P A and NOXA sprayed in combination at its lower level of concentration exhibited highest percentage of fruit set as compared to all other treatment combinations. It might be due to the fact that these auxins at their lower level of concentration (4-C P A 5 ppm + NOXA 5 ppm) had synergistic effect in increasing the fruit-set. In Tasmania, Raphael and Richards (1953) had already shown that the fruit setting could be significantly increased by using NOA (NOXA) and number of other commercial hormone preparations.

In general, the PGRs sprayed at the time of flowering showed increased percentage fruit-set (except NAA) as compared to those which were sprayed before flowering.

C. <u>Pod characteristics and yield studies</u> :

All the PGRs applied did not have any significant effect on pod length, pod breadth and the number of grains per pod. However, all the PGRs exhibited more length of pods and more number of grains per pod but they showed less breadth of the pods than the control. (In general, breadth was reciprocally proportional to the weight of pods). Thus, in general, the PGRs had shown a beneficial effect so far as these characters were concerned.

The medium level of NOXA (20 ppm) produced more pod length than all other treatment combinations. This might be because of the fact that NOXA at 20 ppm might be optimum in inducing more pod length.

2. <u>Weight of 100 grains</u> :

The size of the grains in terms of weight per 100 grains was significantly affected by the PGRs. GA and kinetin in combination recorded maximum grain weight. It was followed by GA + CCC and GA alone. It showed that GA alone or in combination with other PGRs was responsible for increasing the grain weight. GA and kinetin in combination might have stimulated cell elongation and cell division. The increase in weight of 100 grains obtained with GA + CCC could be attributed to the increased cell size due to GA application and CCC might have increased the chlorophyll content of leaves and there by there might be more production of photosynthates and hence the grain size might have been increased. It could also be further confirmed from the fact that these three PGRs were closely followed by CCC.

3. Weight of 100 pods :

The pod size in terms of weight per 100 pods was not significantly affected by different PGRs. 4-C P A recorded maximum number of grains per pod and therefore, it might have given maximum weight of pods as compared to all other PGRs. Similarly, PGR CCC was second best in increasing the weight of 100 pods and was also the second best for increasing the number of grains per pod. NOXA had produced least weight of 100 pods because it had given the least size of the grains.

4. Number of pods per plant :

It was expected that as there was a significant difference in percentage fruit-set of the plants treated with different PGRs, there would also be a significant difference in the number of pods per plant. But the number of pods per plant did not vary significantly by application of different PGRs. This might be because of the fact that the percentage fruit-set calculated was based only on the observations recorded during 60 to 69 days after sowing. The total number of flowers produced during the whole reproductive phase of the plant was not recorded. This would be clear from the fact that although, 4 - CPA showed maximum percentage of fruit-set, it did not produce maximum number of pods per plant.

Amongst the PGRs, GA + CCC showed maximum number of pods per plant. This might be because of the fact that there might be a synergistic effect of the interaction due to combination of these two PGRs in increasing the number of pods per plant. It could be seen from the previous discussions that the percentage fruit-set was not increased much more by GA + CCC but it had produced maximum number of branches. Therefore, there might be production of maximum number of flowers which resulted in maximum number of pods per plant.

The plants in control displayed more number of pods per plant as compared to those of all the PGRs. This might be because of the fact that in many cases the medium level of concentration of the PGRs showed more number of pods per plant as compared to the controls. But the results of obtaining more number of pods per plant at the medium levels were marked by less number of pods produced due to these PGRs at the lower and the higher concentrations.

GA produced least number of pods per plant. This effect of GA is in agreement with those obtained by Ballard et al. (1959) and Manohar et al. (1969).

5. Weight of pods per plant :

Appearently it is seen that plants in control produced some what more weight of pods per plant as compared to those treated with the PGRs. But after going through the details, it could be seen that the treatments $T_4 l_2$, $T_9 l_2$, $T_6 l_3$, $T_8 l_1$ and $T_7 l_2$ displayed more weight of the pods per plant as compared to the control.

Amongst the PGRs, GA + CCC showed maximum weight of pods per plant. It was followed by 4-C P A + NOXA. This was because of the fact that these PGRs in combination with each other might have produced a synergistic effect in increasing the number of pods per plant and it is clear that as the number of pods were increased by application of these PGRs in combinations, the weight per plant also increased.

GA gave least weight of pods per plant. It was followed by 4 - C P A . These two PGRs produced less number of pods per plant and ultimately the weight per plant also decreased.

4 - C P A + NOXA at the medium level of its concentration produced maximum weight of pods per plant amongst all the treatment combinations. It was followed by GA + CCC at it's medium level. It would indicate that the medium level of concentration was the optimum level in obtaining more yield of pods per plant.

6. Yield of pods :

Appearently, the control showed maximum yield peas per plot and per hectare. But on critical screening of the results, it could be seen that this statement is a deciving one. 4- C P A + NOXA and GA + CCC at their medium levels, kinetin at it's highest level, CCC at the lowest and GA + kinetin at the medium levels produced more yields over the control (Fig. 8). These treatments were responsible for producing increased number and weight of pods per plant than the control and thus, they were responsible for obtaining more yield of green peas.

GA produced least yield of peas. It was followed by 4-C P A. This was because of the fact that the plants treated with GA and 4- C P A had less number and weight of pods per plant.

4- C P A 10 ppm + NOXA 10 ppm and GA 25 ppm + CCC 500 ppm yielded 9.29 and 7.58 quintals of extra produce per hectare respectively over the control.

CHAPTER VI

SUMMARY AND CONCLUSIONS

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CHAPTER VI

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Peas (*Pisum sativum* L.), is an important vegetable crop which is in every-day use in almost every home in India. It is rich in vitamins and minerals. Maharashtra is one of the leading states in producing green peas for vegetable purpose. However, the production per hectare is less. Further, in these days of food crisis, any technique which can increase the yield per unit area is most welcome. Reports are available of role of different plant growth regulators in increasing the yield of peas. Unfortunately, the results reported are not consistent. With a view to study the effect of the growth regulators on the vegetative growth, flowering, fruit-set and yield of green peas the various growth regulators were tried as discussed under. An experiment was set up with various levels of concentrations in a Factorial Randomized Block Design. This study was undertaken at the Central Campus of Mahatma Phule Krishi Vidyapeeth, Rahuri during the Rabi season of the year 1975-76. The treatment details were as given below.

Control	-	No spraying			
NAA	-	50,	100,	150	ppm
4 - C P A	-	10,	20,	30	ppm
NOXA	-	10,	20,	30	ppm
4 C P A + NOXA	-	5 + 5,	10 + 10,	15 + 15	ppm
GA	-	10	50	100	ppm
Kinetin	-	2.5,	5,	10	ppm

GA + kinetin 5 + 1.25, 25 + 2.5, 50 + 5 ppm
CCC - 500, 1000, 1500 ppm
GA + CCC 5 + 250, 25 + 500, 50 + 750 ppm

There were three replications.

The data collected about the various characteristics as given above was statistically analysed. The conclusions drawn on the basis of these findings are summarized below.

1) The Absolute growth rate (of height) was significantly increased by GA and it was significantly decreased by CCC. 100ø ppm GA gave maximum height of the plants and 1500 ppm CCC gave least height of the plants.

2) GA + CCC gave more number of branches and CCC alone gave less number of branches amongst all PGRs and the control. As compared to all treatment combinations, GA + CCC at the medium levels of it's concentration (GA 25 ppm + CCC 500 ppm) gave the highest number of branches and CCC at it's highest concentration (1500 ppm) gave least number of branches.

3) Amongst all PGRs tried, kinetin produced more leaf size and the plants in control gave lower leaf size. Compared to all other treatment combinations, 4-CPA + NOXA at it's highest level of concentration (4- C P A 15 ppm + NOXA 15 ppm) gave highest leaf size and CCC at it's highest concentration gave least leaf size.

4) GA gave more dry weight of the shoots and CCC gave less dry weight of the shoots as compared to all other PGRs and the control. 4- C P A + NOXA at it's lower concentration (4- C P A 5 ppm + NOXA 5 ppm) produced the highest dry weight of the shoots and CCC at 1500 ppm produced the least dry weight of the shoots.

5) The time required to first flower was not significantly affected by the plant growth regulators.

6) The plants treated with the higher level of GA + CCC (GA 50 ppm + CCC 750 ppm) gave earliest 50 % flowering as compared to those in all other treatment combinations.

7) Amongst the PGRs, 4- C P A increased the percentage of fruit-set and kinetin reduced the fruit set. 4-C P A and NOXA in combination at the lower level of it's concentration (5 ppm 4- C P A + 5 ppm NOXA) gave the maximum percentage of fruit-set and kinetin at 10 ppm reduced the percentage of fruit-set to the least.

8) The pod length, pod breadth and the number of grains per pod were not significantly affected by various growth regulator sprays. However, Noxa at 20 ppm gave maximum pod length, 4-C P A at 10 ppm gave maximum pod breadth and CCC at 1000 ppm gave maximum number of grains per pod.

9) GA at 10 ppm produced heaviest grains and 4-CPA and NOXA in combination at it's medium level of concentration (4- C P A 10 ppm + NOXA 10 ppm) produced heaviest pods.

10) NOXA at 20 ppm gave the greatest number of pods per plant and 4 - C P A and NOXA in combination at it's medium level of concentration produced the greatest weight of pods per plant.

11) On the whole, 4-C P A + NOXA at it's medium level (4 C P A 10 ppm + NOXA 10 ppm), GA + CCC at its medium level (GA 25 ppm + CCC 500 ppm), kinetin at its highest level (10 ppm), CCC at the lowest level (500 ppm) and GA + kinetin at its medium level (GA 25 ppm + kinetin 2.5 ppm) produced heavier yields of green pods as compared to that of the control.

From this, it can be concluded that 4 C P A + NOXA at medium level (4 C P A 10 ppm + NOXA 10 ppm) and GA + CCC at medium level (GA 25 ppm + CCC 500 ppm) gave 9.29 and 7.58 quintals of extra yield of green pods of peas respectively over the control.

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