STUDIES
ON
THE EFFECT OF GIBBERELLIC ACID
ON
THE GROWTH AND YIELD
IN
RICE (*Oryza sativa, L*)

By

E. SATHYA DAS

A

THESIS

Submitted in partial fulfilment of the squirements for the degree

of

MASTER OF SCIENCE (Agriculture)

in

Agricultural Botany

of

The University of Kerala

DIVISION OF AGRICULTURAL BOTANY
AGRICULTURAL COLLEGE & RESEARCH INSTITUTE
VELLAYANI
TRIVANDRUM

(1964)

CONTENTS

		PAGE
INTRODUCTION	..	1
REVIEW OF LITERATURE	..	3
MATERIALS AND METHODS	..	39
EXPERIMENTAL RESULTS	..	48
DISCUSSION	..	59
SUMMARY AND CONCLUSION	..	70
REFERENCES	..	

This is to certify that the thesis herewith submitted contains the results of bona fide research work carried out by Shri E. Sathyadas, under my supervision.

No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

Principal
Agricultural College
&
Research Institute
Vellayani, Trivandrum.
Date: 28--7--1964.

P. Kumara Pillai
Prof. of Agricultural Botany.

ACKNOWLEDGEMENTS

This investigation was carried out under the supervision and guidance of Prof. P. Kumara Pillai, Head of the Division of Agricultural Botany, Agricultural College and Research Institute, Vellayani, and Shri K. Srinivasan, Junior Professor in Botany. I am extremely thankful to Shri K.Srinivasan, for his valuable help, timely advice and guidance throughout the investigation.

I am deeply indebted to Prof. L.S.S. Kumar, former Dean and Additional Director (Research), Agricultural College and Research Institute, Vellayani for assigning this problem.

I wish to record my deep sense of gratitude to Dr. C.K.N. Nair, Principal, Agricultural College and Research Institute, Vellayani, for providing all the necessary help and facilities during the course of this study.

My grateful thanks are also due to Shri E.J. Thomas, Junior Professor of Agricultural Statistics, for suggesting proper layout of the experiment and necessary methods for analysing the data.

I extend my hearty thanks to all my colleagues for their co-operation and help.

E. SATHYADAS.

INTRODUCTION

INTRODUCTION

The story of growth regulators is one of the fascinating chapters in the modern agriculture. Many interested workers in the field of agriculture are employing the knowledge of the growth regulators for the improvement of crop production. New methods for the control of plant growth and development through the use of growth regulators constitute one of the most spectacular agricultural applications in recent times. Flowering, fruit set, fruit drop, dormancy, root formation and even the suppression of undesired plants can all be controlled by a judicious selection and application of the growth regulators. Many workers carried out their works for the study of the physiological effect of growth regulators dn cereals, vegetable crops, fibre yielding crops, sugar yielding crops and many horticultural plants, either as seed treatment or spray applications. In many casesthey found the general growth stimulation of the growth regulators.

In recent years it has been known that gibberellic acid, a white crystalline substance produced by culturing the soil fungus *Gibberella fujukuroi*, has held out good prospects in stepping up of crop plants. Hence considerable attention has been devoted by many workers on the effect of gibberellic acid in growing plants. Some of the important responses of gibberellic acid are stem elongation and growth increase, induction of early flowering and fruiting fruit set etc. Available results indicate that gibberellic acid is a potent tool for increasing production in several sub tropical fruits. But investigations regarding the utility of this plant growth regulator in the improvement of cereal crop production is still inadequate.

In the present investigation the study of the plant growth regulator namely gibberellic acid is confined on rice. Rice is the most important single article of food in India. India's annual requirement of rice exceeds her production and the deficit is met by imports. Hence efforts are being made in various direction to increase the production of rice. Here an effort is made to evaluate the effects df gibberellic acid on the morphological growth as well as yield of Oryza sativa.L.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The emergence of gibberellic acid as a potential plant growth stimulator was far from sudden. Japanese research from 1926 to 1939 had taken the gibberellin story to quite an advanced stage. A rice disease, one symptom of which was the exceptionally tall growth of infected seedlings was found in 1926 by Kurosowa, to be caused by a soil borne fungus gibberella fujikuroi, which is now known as the perfect stage of an imperfect fungus Fusarium Moniliforme. Yabuta (1939) had isolated an active crystalline substance from culture filterates of this fungus; and they called this growth promoting substance gibberellin A. There is a gap in sequence of events until approximately the 1950's, when Brian in Imperial Chemical Industries research in Britain and independent research by Stodala in U.S. Department of Agriculture, both isolated a purer substance from cultures of this fungus. The British isolate was called as gibberellic acid, and the U.S. isolate at first called gibberellin X, was later proved to be gibberellic acid.

Thus far nine distinct gibberellins have been isolated, six from the metabolic products of the fungus gibberella fujikuroi, A1, A2, A3, A4, A7, A9 and four from the immature seed of Phaseolus multiflorus Lan. A1, A5, A6, A8 according to Stuart and Cathey (1961) and Rappaport and Singh (1961). The different members differ slightly in structure and show slight differences in physiological effect. Gibberellin A3 was found to be the most active and gibberellin A2 the least under any circumstances according to Stuart and Cathey (1961).

The history of the gibberellins and reports of their physiological activities had been reviewed by Stowe and Yamaki (1951); Phinney and West (1960) Datta (1960) Stuart and Cathey (1961) and Rappaport and Singh (1961) Wittwer and Bukovac (1958) evaluated the general effects of gibberellin on growing plants.

The physiological action of gibberellic acid on growing plants has been studied in many parts of the world by many workers. It has been reported that invariably all kinds of plants responded to the treatment with gibberellic acid, but of this voluminous material, only those reports which are directly related to the present investigation are discussed in this review.

SEED GERMINATION

Since the discovery of gibberellic acid many workers have studied its effects on germination of various seeds. It has been frequently observed that seed germination time is reduced by gibberellin treatment. Hayashi (1940) found that barley and rice germinated more rapidly as gibberellin concentration increased, but since final germination percentage were nearly completion in all cases, no effect on total germination can be dicerned. Kahn, Goss and Smith (1957) observed the effect of gibberellic acid on the germination of lettuce seeds and proved that gibberellin can substitute the red light treatment required to break dormancy with seeds of lettuce. This effect was not reversed by exposure to far red light sufficient to reverse the red light effect.

Mcvey and Wittwer (1959) obtained increased rate and percentage of germination in blue grass by soaking the seeds in 100 or 1000 ppm gibberellic acid solution.

Pisani (1959) found that the application of 10 ppm gibberellin in water solution to the seeds of lettuce, spinach, egg plant, radish, marrow, bean, carrot and onion had favourable effects on the speed and amount of germination.

Pieri (1959) observed that the treatment of vine seeds by 10 days immersion in 10, 25, 50 or 100 ppm of gibberellic acid induced seedlings to grow faster than the controls for about a month. But before the end of growing season they were overtaken by the control.

Pollock (1959) found that gibberellic acid stimulated the germination of dormant barley grain and showed a synergestic effect with hydrogen sulphide. Low concentration of gibberellic acid increased the rate of germination of non dormant dehusked grain.

Herich (1960) observed that when seeds of Cannabis Sativa were soaked for 24 hours in solutions containing 5, 10, 25 and 100 ppm of gibberellic acid and increased percentage of female plants were obtained, the highest increase being caused by 10 ppm concentration.

Nekrasova (1960) found that cherry seeds soaked in 0.02% gibberellic acid for 48 hours and peach seeds for 24 hours, had no effect on the germination of unstratified seeds from which the whole seed coat was not removed; but advanced germination by 3 to 4 days in peach and sour cherry seeds from which the whole seed coat was removed.

Pauli and Stickler (1961) found that the seeds of Midland and Westland grain Sorghun were germinat ed in the laboratory in solutions containing 0, 25, 50, 75 and 100 ppm gibberellic acid. The rate of germination of all varieties was uneffected by gibberellic acid.

Zujagina (1961) found that germination of freshly harvested seeds from seven species of Nicotiana and from a hybrid of Nicotiana species x Nicotiana tobacco was greatly improved by placing them in petridishes moistened with 0.02% gibberellic acid.

Vinodhini Vasudevan and Moosa Sherif (1963) studied the effect of gibberellic acid on the germination and initial growth of paddy seeds of variety TKM6. The final germination percentage was not affected by any concentration of gibberellic acid, with the exception of 80 and 40 ppm concentration which almost completely inhibited germination. But regarding the initial growth, the pre soaking of paddy seeds in the various concentrations of gibberellic acid significantly proved superior to seedlings grown from water soaked and unsoaked seeds with regard to increase in the initial shoot height which increased with increasing concentration of gibberellic acid.

STEM ELONGATION

The most typical and striking plant response to treatment with gibberellin is stem elongation. Elongation is mainly due to linear extension of cells. Cell multiplication is also partly responsible for it. Haresloop (1961) observed that the cell number across the pith was not affected by gibberellic acid treatment; but the final number of cells in the longitudinal axis was greatly increased. It was concluded that gibberellic acid increased the rate of cell elongation.

Sachs and Lang (1957) found that the stem elongation in Hyoscyamus is the result of a great increase in the number of cell divisions in the sub apical region of the stem; thus proving that gibberellin may function as a regulator not only of cell elongation but also of cell division.

Phinney (1956) observed that application of very low concentrations of gibberellic acid to dwarf Corn plants resulted in plants indistinquishable from genetically tall plants. In 4 dwarf mutants of Maize, gibberellin brought growth rates up to that of treated normals. When treatment was stopped the mutants slowly returned to a dwarf growth rate.

Marth, Audia and Mitchell (1956) studied the effect of gibberellic acid on growth and development of 49 plant species. The heights of snap beans, soyabeans, ground nuts, peppers, egg plants, maize and barley were in most cases doubled and in some case tribled. Stem elongation was induced in most plants being slight in conifers, nil in onions and gladioli and very marked in young growth of beans, orange seedlings geranium, Japanese maple, Capsicum, Poinsettia, some rhododendrons, Sugar cane, tomato and tulip tree.

Bukovac and Wittwer (1956) observed that gibberellic acid stimulated stem elongation of pea, bean, tomato, celery, capsicum, sweet corn, squash, cucumber, lettuce and cabbage grown in nutrient solution or soil in the green house. Dwarf peas grew taller than normally tall types. Bush beans were changed to twining forms. Cabbage and lettuce responded by rapid elongation of internodes without head formation. Capsicum grew to double or trible their normal height. Squash and Cucumber plants increased in height.

Brian and Hemming (1957) found that stem extension of dwarf peas was accelerated by gibberellic acid. But stem extension of tall peas was not affected by gibberellic acid.

Hudson (1958) observed the elongation in Raspberry. If weekly treatment of gibberellic acid at low concentrations are applied to the stem apices immediately after the transfer from 18^{o} to 10^{o}, the internodes continue to elongate. Moreover, if gibberellic acid is applied after rosettes have formed, the stems will start to elongate again at once. The gibberellic acid changes the reaction of the plant to its environment, in this case causing a shoot to grow under weather conditions which would normally prevent it from elongating.

Morgan and Mees (1958) sprayed a variety of crops including grass wheat, potatoes, turnips, carrots, peas, runner beans, lettuce, celery, black currents, kale and maize at a rate of 2 ounces per acre. In all the cases growth stimulation was observed. Pronounced stimulation of vegetative growth was also observed in peas, runner beans, black currants, potatoes, carrots, turnips and lettuce. Stoddart (1958) found internode elongation in red clover when it was treated with gibberellic acid.

Kuppuswami and Narayanan (1958) observed that higher concentrations of the chemical at 50 and 100 ppm brought about increased vegetative growth of Arabica coffee seedlings mainly through the extension of internodes. The optimum concentration appeared to be 50 ppm.

Chakravarthi (1958) reported the effect of gibberellic acid at concentrations 1, 10, 100 ppm on ten days seedlings of Sesamum indicum. Most treatments resulted in elongation of internodes, the degree of which was directly proportional to the concentration.

Bonde and Moore (1958) reported that single sprays of increasing concentration of gibberellic acid in the range of 0.0015 to 15.0 mg/L had increasing stimulatory effects on stem elongation of dwarf telephone peas. Height increases at all concentrations were reported to be greater in plants treated at 20 days age than in those treated at 10 days.

Bench - Anderson (1958) observed stem elongation in azalea, chrysanthemum, coleus, dhalia, geranium, stock, sunflower, bean, maize, pea, potato, glass house and outdoor tomatoes and vine. The concentrations used were 50, 100 and 200 ppm. Gibberellin applied in lanolin induced elongation in hydrangea, holly, jumper, liliac, rose and viburnum.

Pisani (1958) observed significant lengthening of internodes in growing Zuchinis (a small type of marrow) when the seedlings were treated with aqueous solutions of gibberellin at 50 or 100 ppm. Stem length averaged 29.5 cms at 50 ppm, 35 cms at 100 ppm and only 11 cms without treatment.

Simao _et al_ (1958) reported that at the 10 or 50 ppm concentrations stem at leaves elongated rapidly in tomato plants during the 10 days following treatments. They were deficient in supporting tissues and became pendulousat the shoot tips.

Mazzani and Gonzalez (1958) observed that germination of Sesame, bean, tomato and papaw seeds was unaltered by seed treatment with gibberellin, which caused elongation of the internodes. Repeated treatments had cumulative effects and very high concentrations were phyto-toxic.

Doljakoff - Mayber and Mayer (1959) observed that in lettuce prolonged application of gibberellic acid effects the internodes resulting is elongation and causes earlier flower formation.

Thakur and Negi (1959) found that an increase of 27.3 cms in height of the main shoots in treated sugar-cane. Each main shoot had 4 additional internodes. The tiller growth was adversely affected both in number and development. The average height of the tiller was lower by 4 cms.

Stoddart (1959) studied the response of S.123 extra late flowering red clover in the year of sowing to three sprayings of gibberellic acid at 28 days intervals. Fewer stems were formed on the treated plants, but their thickness and the number and length of the internodes were increased.

Gundersen (1959) observed that gibberellic acid promoted elongation of Begnonia stem partly by cell wall elongation and partly by acceleration of cell division.

Soost (1959) studied the effect of gibberellic acid on tomato plants of a gametic dwarf variety and a normal variety. Gibberellic acid applied in amounts of 30 and 60 mg/plant to 4th expanding leaf produced significant increases in stem elongation. The 30 mg treatment produced a relatively greater response in the normal variety than in the dwarf variety. The increase in plant height was mainly produced by elongation of nodes below the point of application.

Staut (1959) found that 100 ppm of gibberellic acid sprays increased the height, internode number and internode length of *Hibiscus Cannabinus*, *Corchorus oliforius*, *Cannabis Sativa* and *Zebrina pendula*.

Alder *et al* (1959) treated maize variety pioneer No.395 with 1 or 3 mg gibberellic acid prior to tasselling at 30% tasselling or at complete tasselling in all combinations. Gibberellic acid increased the height of all plants treated, treatment at 30% tasselling was found to have the greatest effect.

Coleman *et al* (1959) found that application of gibberellic acid in different concentration to the growing sugarcane plants increased their height but reduced stalk diameter and tillering.

Torri and Nakagawa (1959) observed growth promoting effect of gibberellin on the tea shoots. Considerable growth stimulus was observed in the young shoots of tea plants sprayed with gibberellic acid. The main effects were longer internodes and thinner and more fragile stems. The optimum concentration appeared to be 50 - 100 ppm and although 3 - 9 sprayings were made, 2 - 3 are thought to be adequate.

Mc vey and Wittwer (1959) studied that a foliar spray of 100 ppm applied to 3 weeks after the emergence of blue grass resulted in increases in growth a week after treatment which was equivalent to that made by the controls in 3 weeks.

Nickerson (1959) studied the effect of gibberellic acid on five different kinds of maize. Maize of the well defined races, parker Flint and Z-apalote Chico and the inbred variety span cross were grown in the field and treated with distilled water or aqueous solutions containing 5 ppm, or 25 ppm or 125 ppm or 625 ppm of gibberellic acid. Every 3 days through out the growing season 1 ml of appropriate solution was applied to the apical leaf cavity of each plant. Increases in plant height resulting from gibberellic acid treatment did not occur in the same nodes in different varieties of maize or to the same extent for particular nodes in plants of the same variety receiving different levels of gibberellic acid. Gibberellic acid affected inbred variety to the greatest extent.

Allan et al (1959) studied the growth responses of 6 wheat varieties injected at 6 weekly intervals with concentrations of gibberellic acid ranging from 0 to 1000 ppm under glass house conditions. The varieties were (a) Dwarf Tom Thumb (b) Semidwarf Sen. Seun 27, Norin 10 x Brevor 2238 and Norin 10 x Brevor 14; (c) Standard height, Burt and Kharkof MC.22. The effect of the treatment on plant height, size of internode and spike emergence of the 6 varieties was determined and compared. The dwarf and semi dwarf varieties were not induced to grow to normal height by treatment with gibberellic acid. Standard height varieties were stimulated significantly more than short varieties.

Janhari et al (1960) observed a marked improvement in the growth of spinach with different concentration of gibberellic acid. The maximum average height was observed under 10 ppm.

Torii and Nakagawa (1960) found that spraying with gibberellic acid increased the growth of tea shoots from 2.5 and 3.5 mm per day in the first, second and third plucking seasons to 3.9, 3.9 and 6.3 mm respectively.

Sircar and Rothin Chakravarthy (1960) pointed out that the effect of gibberellic acid on jute plant is likely to be of considerable economic importance. The treated plants showed increased height in comparison with the control after one week of application. The basal circumferance was also increased by gibberellic acid treatment, 10 ppm (with lanolin paste) showed the best effect as the quantity and percentage of fibre extracted.

Fish F (1960) observed that gibberellic acid injected into growing Datura Stramonium plants increased internode length especially on the treated side with some axial splitting.

Singh, Randhawa and Jain (1960) studied in detail the responses to the application of gibberellic acid in strawberry variety "Pusa Dwarf Early". They found that gibberellic acid sprays increased the height and spread of plants, number and length of runners, hastened flower formation and fruit maturity and increased the total yield and quality of fruits.

Narasimham (1960) tried different doses of gibberellic acid were applied to the apex of tobacco shoots by the microdrop method. Responses were noted within one week even at the lowest dosage while after 4 weeks shoots receiving 500 mg per plant had increased in height about 200% compared with the control; mainly because of longer internodes.

Misra and Sahu (1960) found that treatment with gibberellic acid stimulated elongation of an early variety of rice No. 136. The treatment consisted of soaking seeds before sowing for 72 hours, followed by a post sowing foliar spray with varying concentration 1, 10, 100, 250, 500 ppm of gibberellic acid. The spraying commenced with 28 days old seedlings and continued once a week till the time of ear emergence. Gibberellic acid brought about a decrease in the production of tillers and leaves along with a conspicuous elongation of the main shoot and tillers in comparison with the controls. The promotion or inhibition with regard to the vegetative characters strictly followed the concentration gradient of the chemical within a range 1 to 500 ppm.

Frey (1960) observed that putnam oat plants were sprayed with gibberellic acid in concentrations of 10, 100, 1000 and 2500 ppm at 24 hours before and 24 hours after anthesis caused 10 - 50% elongation of the upper internodes.

Gopalachari and Naidu (1961) found a marked increase in the height of tobacco plants treated with gibberellic acid at 50 micro grain, 100 mg and 150 mg levels.

Gardner and Kasperbauer (1961) studied the effects of gibberellic acid as a seed treatment and as a foliar spray on dwarf grain sorghum under glass house and field conditions. Concentration of 10 or 100 ppm gibberellic acid hastened emergence and increased initial height of the plants; but both of these effects were short lived.

Anupsingh Sandhu and Akhtar Husain (1961) studied the effect of gibberellic acid as a seed treatment on the growth of Bajra (Pennisetum typhoides). They observed that the concentration of 100, 250 and 500 ppm of gibberellic acid showed significant increase in seedling height at 5% level of significance.

Rabindrakrishna Mukherjee and Datta (1962) found increase in final height of brinjal plants to 32% and 62% over control in 100 and 1000 ppm gibberellic acid respectively. This was mainly due to the extension of internodes, which did not however increase the basal diameter of the stem.

Sekhara Rao (1962) observed that treatment with any concentration of gibberellic acid above 200 ppm caused considerable injury to Bermuda grass. At a concentration of 10 ppm the action of gibberellic acid was manifested in visible lengthening of the internodes. Concentrations of 50 and 100 ppm resulted in a lengthening of the internodes; the 5th internode from the apex being 0.5 cm longer than that of the controls. Gibberellic acid at 200 ppm caused some injury to the leaves visible 3 days after application. At all concentration used response of Bermuda grass to gibberellic acid was visible within 48 to 60 hours.

Appala Naidu and Satyanarayana Murthy (1962) reported that gibberellic acid had no effect on the elongation in two of the 4 mesta varieties treated. But the other two varieties which were more succulent than those that had not responded showed a significant increase in stem elongation. The increase in shoot extension is mostly due to increase in internodeal elongation and not due to production of internodes. The differential behaviour of 4 varieties seem to depend on succulence of the shoot rather than the tallness or dwarfness of the plant in its responses to treatment with gibberellic acid.

Paul Thomas, Krishnamurthy and Madhava Rao (1963) found that treatment with gibberellic acid at 10, 50 and 100 ppm increased the height of mango seedlings by 56.0, 71.3 and 80.8 percent respectively within six months, compared with a corresponding increase of 29.0 percent in the untreated plants. Concentration of 200 and 300 ppm similarly produced significantly taller plants, the higher the concentration, the taller the seedling. Three applications of gibberellic acid at 10, 50 and 100 ppm were found to be more effective than one of two applications at 10, 50 and 100 ppm. They also noted that the grape fruit seedlings treated with 100 ppm gibberellic acid recorded 76% increase in height over control with proportionately smaller increase in the lower concentratiins.

EFFECTS ON FOLIAGE

Marked changes in leaf shape, size and number have resulted in several plants from gibberellin treatment.

Yabuta (1941) found the leaves of the treated tobacco to be on the whole smaller and paler than the control. But the largest single leaf was found on treated plants. Also the number of leaves in two of the 4 tobacco varieties was more than doubled.

Marth et al (1956) reported that treated plants belonging to various genera and species developed temporarily paler leaves either narrower or broader than normal.

Pilet and Wurgler (1958) observed that

elongation of the petiole was the most obvious reaction to treatment with gibberellin. There was also an increase in length and in total leaf area in Trifolium ochroleucum.

Morgan and Meas (1958) found that the stimulation caused by gibberellin treat was accompanied by yellowing of the grass, but recovery to a normal green colour was speeded up by the application of a nitrogenous fertilizer at the same time as the gibberellic spray.

Humphries (1958) in his studies on the effect on the growth of Majestic potato observed that gibberellic acid increased lèaf area. The treatment caused a persistant chlorosis of the leaves which never became as dark green as an untreated plant.

Pisani (1958) found that treatment with gibberellin in growing Zucchinis resulted shorter leaves with longer petioles than the controls. The untreated plants had the maximum number of leaves. Treated plants were chlorotic. A month after the last treatment normal chlorophyll content was restored.

Simao (1958) sprayed tomato plants twice (19 and 25 days after transplanting) with 0, 1, 10, or 50 ppm solution of gibberellic acid. Treated plants became chlorotic to an extend depending on the concentration used, but partially recovered the green colour within 4 days of treatment. The new leaves are longer and narrower with much less indented margins than usual and the texture was softer.

Thakur and Negi (1959) observed that gibberellic acid increased the leaf area in sugarcane plant by 243.1 squire centimers. The treatment adversely affected the leaf development in the tillers. The average leaf number in tillers was lower by 2.6 and leaf area by 368.8 squire centimeters in treated plants.

Stoddart (1959) found that gibberellic acid brought about an increase in petiole length and a parellel increase in leaf area in late flowering red clover. Secondary branching was not significantly increased, but the gibberellic acid treated plants produced a large number of tertiary branches from axillary buds on the secondary branches. Cauline leaves showed an increased length/breadth ratio at each node with treatment, the ratio tending to be most marked at those nodes where leaf formation coincided with gibberellic acid spraying. Leaf thickness was also increased by gibberellic acid treatment.

Staut (1959) recorded observations on

the effects of 100 ppm. of gibberellic acid on Hibiscus Cannabinus, Corchorus olitorius, Canabis sativa and Zebrina pendula. Changes in leaf shape, petiole length and auxillary shoot length were recorded for some of the plants.

Soost (1959) observed that a reduction in the number of leaf lets per leaf and a change to entire rather than serrate leaflets occured in all gibberellic acid treated tomato plants. The gibberellin applications produced leaves and initiated indeterminate growth on the genetically non-leafy determinate inflorescences.

Mcvey and Wittwer (1959) reported a slight reduction in the blade within the spring sown Merion blue grass consequent on the application of gibberellic acid but it induced chlorosis. This would be partially alleviated by the addition of one or two lbs. of nitrogen per 1000 sq. feet.

Scarascia - Venezian (1959) reported that the gibberellic acid treated tobacco plants produced significantly longer leaves, but no increase in number of leaves. The leaves of the treated plants were narrow and had irregular margins.

Fischnich _et al_ (1959) applied gibberellic acid with the concentration ranging between 5 and 100 mg on the apices of potato plants. They observed elongation of internodes and a paler green colour of the leaves.

The universal effect of gibberellin observed on the foliage is chlorosis. But the results of an investigation carried out by Wolf and Haber (1960) demonstrated that chlorosis does not necessarily accompany growth stimulated by gibberellic acid. The paleness observed in the treated wheat seedlings was accounted for by a failure of chlorophyll synthesis to keep pace with the increased cell expansion. Beside the simple dilution of chlorophyll the apparent chlorosis in older plants must also result from delayed effects of malnutrition, not to direct action of the acid on formation of destruction of chlorophyll. Stimulation of growth by gibberellic acid without direct effect on chlorophyll metabolism in consistant with the finding that the acid does not directly affect photosynthesis.

Sircar and Rothin Chakravarthy (1960) observed that gibberellic acid treatment increased the number of leaves in Jute plant. There was the change in the shape and size of leaves after gibberellic acid treatment, but leaf fall was earlier than in control pl-

Razumov (1960) found that gibberellic acid treatment at day lengths above 6 hours most of the leaves produced by Hemp plants were simple as against the usual production of compound leaves in short days.

Misra and Sahu (1960) observed that gibberellic acid brought about a decrease in the production of leaves in an early variety of rice No.136.

Gopalachari and Naidu (1960) found a marked increase in the number and size of leaves of wrapper tobacco under gibberellic acid treatment.

Torii and Nakagawa (1960) observed that the number of shoots and leaves were not increased nor were the total N; caffeine, tannin and crude fibre contents of the leaves. The chlorophyll content however was reduced. The quality of the black tea made from the sprayed leaves was higher than that of the controls.

Haresloop (1961) found that the gibberellic acid treated <u>Lycopersicum esuculantum</u> showed slight leaf chlorosis, the formation of entire margined leaves and an increased rate of leaf formation.

Lal and Singh (1961) observed that

while gibberellic acid did not inhibit or inactivate the leaf curl virus, it reversed its stunting effect on tomato plants by stimulating their growth and suppressing the symptoms of leaf curl.

Bose and Hammer (1961) observed that leaves of gibberellic acid treated tomato plants showed chlorosis; and while patches. In the size of the largest leaf no significant difference existed between the treatments.

Williams (1961) observed that the gibberellic acid treated Hop plants had a larger total leaf area than the controls, but their leaves were chlorotic, being very pale green in colour. This may have indicated a lower photosynthetic capacity than the controls; where the leaves were normal in colour, and may have been responsible for the gradual decline in the rate of elongation of the treated plants.

Appala Naidu and Satyanarayana Murthy (1962) found that the leaf output in 4 different Mesta varieties Manchigogu, red pusa gogu, Kendagogu and white pusa gogu - subjected to gibberellic acid treatment remained practically the same as that in control plants. But those varieties that showed stimulated stem elongation exhibited perceptible changes in leaf shape or area. The length of the petiole, length of lamina, leaf breadth and leaf let width were reduced considerably.

Paul Thomas et al (1963) found increase in the number of leaves following gibberellic acid treatment in mango seedlings. The shape and size of leaves were not affected. They found increase in number of leaves, theleaf surface area and the petiole length; but the shape of the leaf was not affected in gibberellic acid treated grape fruit seedlings.

ROOT GROWTH

Almost all the workers found either no effect of gibberellic acid on root growth or decreased length, number and weight. But exception to this have been observed by some investigators.

Brian et al (1954) reported consistant decrease in root weight in the treated peas and wheat.

Bench - Anderson (1958) observed that an increase in top root ratio is usually associated with the treatment. In the case of root crops the treatment proved to be injurious to the storage roots.

Kuppuswami and Narayanan (1958) obtained an increase in the weight of both shoot and root without any undue disturbancein the ratio with 100 ppm. spray of gibberellic acid on Arabia Coffee seedlings.

Gunderson (1959) observed that root growth of Sinapis alba seedlings was unaffected by gibberellic acid treatment, but root formation in Salix purpurea was considerably depressed.

Dyens (1960) found that roots of Phaseolus vulgaris showed a growth response to gibberellic acid aconcentration in the nutrient solution which, however, did not have any effect on the shoots. When equivalent concentration applied to the shoot apex or primary leaves there was a top growth stimulation but the roots were unaffected. When mature bean plants were treated with 1 ppm. occurred, but there was no stimulation of top growth. However the tops increased in dry weight with this treatment.

Gopalachari and Naidu (1961) observed a slight increase in the weight of the roots of the treated tobacco plant at 50 microgram level. But with higher concentrations, root weight correspondingly decreased.

Haber *et al*. (1961) reported less dry weight of the root system in the treated wheat plants.

Sekhara Rao (1962) observed an increase in the top/root ratio of <u>cynodon dactylon</u> pers, conseqent on gibberellic acid treatment. The plants that received 200 ppm of gibberellic acid had a few roots, only one to two inches long.

<u>FLOWERING</u>

One of the most striking effects of gibberellic acid on certain vegetable crops is stimulation of flower formation. Treatment with gibberellic acid replaces the cold requirement of certain biennial plants grown on short days. Gibberellic acid stimulates flowering only in some long day plants and delays flowering in shor t day plants.

Marth <u>et al</u> (1956) observed no evidence of increased flower bud initiation in treated plants of geranium and petunia. But existed flower buds developed more rapidly as a result of treatmwnt with gibberellic acid. On theother hand flowering was delayed in Capsicum.

Rappaport (1956) reported that seed treatment, repeated foliage sprays, injections into the bulbs and feeding gibberellin down the cylinders of detipped leaves were all ineffective in onion, in stimulating either growth or flowering. He in 1957 recorded hastened flowering by three to 10 days in tomato without affecting node number upto the first inflorescence.

Chakravarthy (1958) studied the effect of gibberellic acid on the flowering of both vernalized and normal plants of Brassica campestris L and Leus esuculanta moench. Seed treatments of all the fourr plants with gibberellic acid failed to produce any earliness in flowering. It was hence concluded that the chemical did not replace 'vernation'. Just like the effect of vernalization in gibberellic seed treatment also stem elongation and flower initiation were two separate functions.

Pisani (1958) observed that in treated plants of Zucchinis there was no change in flowering date. But the petals were longer, narrower and paler than the normal; and deformities in Stamens and pistils were common. A month after the first treatment normal flowers began to develop.

Takura et al (1958), studied the effects of gibberellins on the growth and flowering of the following crops. Solutions of gibberellic acid were applied.to pot plants at rates of 25, 50 and 100 ppm. Flowering of treated cyclamen was about 20 to 25 days earlier than that of control plants. Vegetative growth was stimulated and flowering was accelerated in Pétunia after gibberellic acid treatment. Flowering of Freisia, Narcissus and Dutchiris was accelerated about 3 to 7 days, but Easter lily was not affected by gibberellic acid. In both pancy and Prumula -

malacoides flowering was accelerated and pedunele length was also increased. Flowering in Adonis amuscusis was hastened. The viability of pollen grains from Cyclamen and Prumula malacoides was not damaged by gibberellic acid treatment.

Thoroup (1959) observed that treatment with gibberellic acid advanced flowering in Cleoma monophylla Tagetes patula and Palangodium zonale. Treatment was also found to favour fruit set in Risinus communis.

Razumov (1960) observed that Sun flowers treated for 30 days with 0.1% gibberellic acid flowered in 24 hour days, Perilla plants flowered after 35 days in 9 hour days föllowing treatment with gibberellic acid. Flowering did not occur at all in untreated plants.

Singh et al. (1960) reported that flower formation in Strawberry variety pusa dwarf early was hastened by 26-31 days and fruit maturity by 19 to 23 days after gibberellic acid treatment.

Rappaport and Bonner (1960) reported that endive, a winter annual that flowers faster after seed is vernalized, and grown under longs days, flowered with gibberellin treatment in the absence of vernalization and on short days. In this plant gibberellic acid succeeded to replace vernalization and long day requfrements for flowering.

Misra and Sahu (1960) observed that gibberellic acid at all concentrations induced a significant earliness in flowering in the treated plants of rice No.136. Maximum earliness was obtained with 100 ppm. of the chemical concentration. Higher or lower than 100 ppm. produced a lesser degree of earliness.

Gopalachari and Naidu (1961) found an earliness in flower formation in treated tobacco plants. But the seed production was considerably reduced.

Appala Naidu and Satyanarayana Murthy (1962) reported that gibberellic acid sprays had no effect on flowering in two mesta varieties. But in other two varieties the flowering was delayed and at 100 ppm. there was practically no flowering.

FERTILITY AND SEX EXPRESSION

Gibberellin induced male sterility was reported by many workers. Nickerson (1959) observed that some gibberellic acid treated maize plants developed tassels exhibiting male sterility and containing some pistillate florets. In Spancross variety of maize given 125 ppm. gibberellic acid the tassels had a jointed rachis and bore paired pistillate spikelets below the Staminate spikelets.

Bose (1959) reported the effect of gibberellic acid on the growth of pollen tubes. Germinating pollen of Pisum sativum was treated with gibberellin. Gibberellic acid increased tube growth at 0.05/mg/1 to 7 times that of the control; but had less ef effect at higher concentrations. Higher concentrations also caused broadening of the grains. Gibberellic acid had no promoting effect on germination. Gibberellic acid however stimulated the generative cell to divide and in rare cases the male gametes divided again to produce 4 sperm cells.

Atal (1959) sprayed Cannabis sativa plants at weekly intervals from the 4th leaf stage to flowering with 100 ppm of gibberellic acid. Treated female plants at first produced male flowers and only in later formed axils did female flowers appear. On male plants gibberellic acid did not affect sex, but increased the number of flowers formed.

Paterson and Alinder (1960) clearly demonstrated the induction of staminate flowers on gynocious Cucumbers by gibberellic A3. This has the practical advantage of permitting the development of F1 hybrids.

FRUITING AND YIELD

Many of the workers reported that gibberellic acid is effective for increasing fruit set, fruit size and induction of parthenocarpy in a large number of crops.

Wittwer and Bukovac (1957) found that gibberellic acid was very effective in setting tomato fruits without pollination. Cucumbers and egg plants showed similar responses to gibberellic acid. Gibberellic acid was found to be about 500 times more effective than indoleacetic acid in inducing parthenocarpy of tomatoes.

Rappaport (1957) observed that setting of fruit was increased by repeated floral sprays containing 1 to 500 micro gram per litre. There was no significant change in fruit diameter, and weight. But the size was decreased by about 50% at an optimal temperature for growth, flowering and fruiting in tomato.

Gustafson (1960) observed that only 0.5 and 1.0% gibberellic acid induced the formation of parthenocarpic fruits in tomato. When flowers and flower buds of the first three clusters were sprayed with 35 to 70 ppm. of gibberellic acid fruit setting was enhanced, but the total weight of fruits produced lower.

Ogzewalla (1960) reported that in plants sprayed weekly with 10 and 100 ppm. of gibberellic acid the fresh weight yield of peppermint herb was reduced; but the dry weight yield of peppermint was similar to that of controls. After harvest a second crop of mint was grown, without further gibberellio acid treatment. In this case the yield of oil was reduced on both a fresh and dry weight basis in the plots previously treated with gibberellic acid.

Sebank (1960) observed that tomatoes treated in the seedling stage with gibberellic acid set more fruit. But excessive stimulation of the plant resulted in retarded development and delayed ripening of the fruits.

Morgan and Meas (1958) conducted field trials with gibberellic acid on wheat, potato, turnips, carrots, peas, runner beans, lettuce, celary, kala and maize. They failed to record any increase in yields. In no case the crop yield increased, decreases were recorded in the case of potatoes and carrots. Grass was the only crop to show yield increase from the application of gibberellic acid. Repeated applications led to a progressive thinning of the sward.

Gaskins (1958) reported that spraying with aqueous solution of 10 ppm gibberellic acid, early yields of snap beans could be increased by 25%. But the treatment failed to record any increase in the total yield, and higher concentrations decreased yields.

Alder (1959) observed that gibberellic acid had no effect on the weight of maize plants pioneer No.395 cut for silage four weeks after treatment. There was no effect on the yield of grain also at maturity.

Singh and Randhava (1959) reported that gibberellic acid at 5 and 10 ppm. concentration increased the total yield per plant in the strawberry variety 'pusa dwarf early' by 48 and 62% respectively over control. The fruiting period was also extended by 8-10 days.

Sircar and Chakravarthy (1960) found that gibberellic acid increased the quantity of fibre in jute plants. 10 ppm. with lanolin paste gave the best effect as the quantity and percentage of fibre extracted were greater than with other treatments.

Krishnamurthi et al. (1959) observed that application of 10 and 25 ppm. of gibberellic acid on flower clusters of pusa seedless variety of grapes increased the fruit set by 76.5 and 59.11% respectively. But the use of 50 ppm. concentration resulted in the thinning of flowers and reduction of fruit set by 15.41%.

Spina (1960) reported no significant influence on yield, refractive index or size of fruit in four different varieties of vince subjected to gibberellic acid sprays at 50 ppm. three times at 10 day intervals.

Weaver (1960) observed that gibberellin increased size of the seedless fruit in <u>Vitis</u> <u>Vinifera</u>, but had little or no effect on seeded grapes. He found that high concentrations (100 and 1000) ppm were nontoxic to the seedless varieties, although far lower concentrations (5, 20 and 50 ppm) were highly toxic to the seed varieties.

Singh and Randhava and Jain (1960) observed that the strawberry variety 'Pusa Dwarf Early' hastened flower formation by 26 to 31 days and fruit maturity by 19 to23 days compared to control, when treated with gibberellic acid at 25, 50, 75 and 100 ppm twice as whole sprays. Duration of harvest was also prolonged to 34 to 38 days against 22 days in untreated plants. At 75 ppm this chemical increased the total yield by 144.3% over control. With higher doses of gibberellic acid (75-100 ppm) there appeared to be slight improvement of quality.

Crane <u>et</u> <u>al</u> (1961) induced parthenocarpy in prunus. Aqueous solutions of 50, 250, 500 ppm of gibberellic acid applied as sprays to the almond, apricot, cherry plum and peach to promote partheno-carpy. Sprays were applied to full bloom. Gibberellic acid at 500 ppm increased 11.8% in almond and 15.4% in apricot produced partheno-carpic fruits produced with 500 ppm of gibberellic acid, were not greatly different in size to controls.

Stuart and Cathey (1961) reported that gibberellic acid increased vegetative growth of cotton. But this response was offset by reduction in boll size; and later maturation of the crop. The increased growth rate did not affect yields of plants grown in lighter soild. It was observed that gibberellin did not increase yield of plants growing under fabourable conditions.

S.N. Rao and Subba Rao (1963) observed that the fruit set was reduced in the treated phalsa (Gravica asiatica L) trees when compared to the untreated trees. However, the reduction was not statistically significant. In the whole tree sprays, gibberellic acid 1000 and 200 ppm were effective in inducing partheno-carpic fruits upto 18.4 and 24.5 percent respectively.

S.N.Rao and Bhaskara Rao (1963) found that gibberellic acid at 400 and 600 ppm increased the fruit set to 80.00 and 96.67% respectively in Hibiscus rosa sinensis; and all the fruits were retained till harvest. It was also observed that as the concentration increased from 200 to 600 ppm there was a gradual increase in average weight and length of the fruits from 0.65 to 0.95 gms and 1.60 to 2.06 cms respectively.

=========

MATERIALS AND METHODS

MATERIALS AND METHODS

The investigation reported here was to study the effect of gibberellic acid on the growth and yield in rice (Oryza SativaL). The experiment was conducted at the Agricultural College and Research Institute, Vellayani during 1963-64.

SEED MATERIAL

The seed material used is an early maturing rice variety known as Koohuvithu. The duration of this variety is 85 to 90 days. This is a local variety popular among cultivators in Vellayani and the seeds were supplied from the Agricultural College Farm, Vellayani. The germination percentage of the seed used was tested and found to be cent percent.

GROWTH REGULATOR USED

The growth regulator used was gibberellic acid. This was obtained from British Drug House, Bombay.

The different concentrations of gibberellic acid used for this experiment were fixed as follows:

Gibberellic acid : i - o ppm.

ii - 25 ppm.

iii - 50 ppm.

iv - 75 ppm.

v - 100 ppm.

vi - 125 ppm.

Preparation of the solutions:

At first the 200 ppm gibberellic acid solution was prepared by dissolving 200 milligrams (0.2 gm) of gibberellic acid in a few drops of Isopropyl alcohol and diluted with distilled water making upto one litre of solution. From this the different concentrations of solutions were made by adding required quantities of distilled water to the stock solution prepared.

Method of application:

Application of this growth regulator at different concentrations was made at three different stages of the growing rice seedlings.

1. Foliar spraying once in a week starting with the 21 days old seedlings till the emergence of ear head.

2. Foliar spraying once in two weeks starting with the 21 days old seedlings till the emergence of ear head.

3. Foliar spraying once in three weeks starting with the 21 days old seedlings till the emergence of ear head.

Statistical lay out of the experiment

Lay out — Randomised Block Design.
Replications — Five.
Treatments — 18.

1. GA 0 ppm foliar spray once in a week.
2. GA 0 ppm foliar spray once in two weeks.
3. GA 0 ppm foliar spray once in three weeks.
4. GA 25 ppm foliar spray once in a week.
5. GA 25 ppm foliar spray once in two weeks.
6. GA 25 ppm foliar spray once in three weeks.
7. GA 50 ppm foliar spray once in a week.
8. GA 50 ppm foliar spray once in two weeks.
9. GA 50 ppm foliar spray once in three weeks.
10. GA 75 ppm foliar spray once in a week.
11. GA 75 ppm foliar spray once in two weeks.
12. GA 75 ppm foliar spray once in three weeks.
13. GA 100 ppm foliar spray once in a week.
14. GA 100 ppm foliar spray once in two weeks.
15. GA 100 ppm foliar spray once in three weeks.

16. GA 125 ppm foliar spray once in a week.

17. GA 125 ppm foliar spray once in two weeks.

18. GA 125 ppm foliar spray once in three weeks.

Preparation of pots

For this experiment 90 earthern pots of 12" diameter were selected. Five sets of pots were numbered 1 to 18 in each and they were arranged in a random order. They were filled with a well prepared potting mixture of red earth, sand and cowdung in the ratio 1:1:1.

Sowing:-

Sowing was carried out on 4-11-1963. The seeds had been soaked in water for 12 hours before sowing. In each pot 4 pits were made and in each pit 4 seeds were sown at a depth of one inch. After 10 days thinning was carried out retaining only 4 plants per pot with a spacing of 4".

Spray Treatments:

Spraying was carried out with an atomiser and it was done with utmost care to obtain a thorough uniform wetting of the plant.

First spraying was done on 6-12-1963 on the following treatments.

Treatments	Treatment No.		
Gibberellic acid 0 ppm	1	2	3
Gibberellic acid 25 ppm	4	5	6
Gibberellic acid 50 ppm	7	8	9
Gibberellic acid 75 ppm	10	11	12
Gibberellic acid 100 ppm	13	14	15
Gibberellic acid 125 ppm	16	17	18

Second spraying was carried out on 13-12-1963 on the following treatments.

Treatments	Treatment No.
Gibberellic acid 0 ppm	1
Gibberellic acid 25 ppm	4
Gibberellic acid 50 ppm	7
Gibberellic acid 75 ppm	10
Gibberellic acid 100 ppm	13
Gibberellic acid 125 ppm	16

Third spraying was done on 20-12-1963 on the following treatments.

Treatments	Treatment No.	
Gibberellic acid 0 ppm.	1	2
Gibberellic acid 25 ppm.	4	5
Gibberellic acid 50 ppm.	7	8
Gibberellic acid 75 ppm.	10	11
Gibberellic acid 100 ppm.	13	14
Gibberellic acid 125 ppm.	16	17

Fourth spraying was carried out on 27-12-1963 on the following treatments.

Treatments	Treatment No.	
Gibberellic acid 0 ppm.	1	3
Gibberellic acid 25 ppm.	4	6
Gibberellic acid 50 ppm.	7	9
Gibberellic acid 75 ppm.	10	12
Gibberellic acid 100 ppm.	13	15
Gibberellic acid 125 ppm.	16	18

Observations recorded:

The following aspects were studied.

1. Height of plants.
2. Number of tillers.
3. Time of flewring.
4. Fresh weight of stem.

5. Dry weight of stem.
6. Number of leaves.
7. Dry weight of roots.
8. Length of penicles.
9. Yield.

1. <u>Height of plants</u>:

Height of plants was recorded by measuring the height of the stem from 24 days after sowing at 7 days intervals. Measurement was recorded in centimeters from the base of the plant to the base of the terminal leaf. Different stages of measurement used in the present study were as follows:

(a) 24 days after sowing.
(b) 31 days after sowing.
(c) 38 days after sowing.
(d) 45 days after sowing.
(e) 52 days after sowing.
(f) 59 days after sowing.

The results were analysed statistically.

2. <u>Number of tillers</u>:

The number of tillers produced was counted at the time of harvest and the results were analysed statistically.

3. Time of flowering:

The ear heads were counted daily in the morning from 30-12-1963 to 7-1-1964, when emergence almost ceased completely.

4. Fresh weight of stems:

The fresh weight of the stem including all the tillers without ear heads was recorded after harvest and statistically analysed.

5. Dry weight of stem:

After the harvest the stems were sundried and weighed. The results were recorded and analysed statistically.

6. Number of leaves:

The number of leaves in the tillers were recorded and statistically analysed.

7. Dry weight of roots:

After the harvest the root system was pulled out and their dry weight was recorded. The roots were sundried and weighed. The results were statistically analysed.

8. Length of penicles:

The penicles were cut at the base and measured from the base to the tip. Results were analysed statistically.

9. Yield:

The ear heads were harvested, when the grains were ripened. Then the following observations were made:

(a) Total number of grains per plant.

(b) Weight of grains per plant.

The results were finally analysed statistically.

10. Visual observations:- were made on the colour of the leaves and the general growth of plant under each treatment.

====

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

The effect of gibberellic acid in rice was studied by observing the height of plants, number of tillers, time of flowering, fresh weight of the stem, dry weight of the stem, length of ear heads, number of leaves, dry weight of the roots and the yield. The data so obtained were statistically analysed.

TABLE I A

Analysis of variance table

Height of plants

24 days after sowing

Source	SS	DF	Variance	F
Total	460.49	89		
Block	29.94	4	7.49	2.2
Treatment	205.72	15	13.72	4.1*
Treatment Vs Control	158.19	1	158.19	47.1*
Between treatments	66.23	4	16.56	4.6*
Different stages of application of 25 ppm.	4.34	2	2.17	0.7
" 50 ppm.	14.41	2	7.25	2.1
" 75 ppm.	8.57	2	4.29	1.28
" 100 ppm.	2.57	2	1.28	0.5
" 125 ppm.	18.03	2	9.01	2.67
Error	234.83	70	3.35	

* Significant at 5% level.

TABLE I B

Analysis of variance table

Height of plants

31 days after sowing

Source	SS	DF	Variance	F
Total	2145.19	89		
Block	56.62	4	14.15	1.7
Treatments	1489.89	15	91.92	10.8*
Treatments Vs Control	1104.46	1	1104.46	129.1*
Between treatments	2670.96	4	667.74	77.8*
Different stages of application of 25 ppm.	38.41	2	19.21	2.3
" 50 ppm.	64.17	2	32.08	3.9*
" 75 ppm.	189.77	2	94.88	11.1*
" 100 ppm.	32.91	2	16.45	1.9
" 125 ppm.	598.68	70	8.55	

* Significant at 5% level.

TABLE I C

Analysis of Variance Table

Height of plants

38 days after sowing

Source	SS	DF	Variance	F
Total	9403.05	89		
Block	115.73	4	28.93	0.7
Treatment	6342.39	15	422.82	9.7*
Treatment Vs Control	2853.68	1	2853.68	65.61*
Between treatments	3995.81	4	998.95	21.59*
Between different stages of application of 25 ppm	403.00	2	201.5	4.6*
" 50 ppm	428.42	2	214.21	4.9*
" 75 ppm	1050.83	2	525.41	12.81*
" 100 ppm	913.09	2	456.54	10.49*
" 125 ppm	693.43	2	346.22	7.95*
Error	3044.93	70	43.49	

* Significant at 5% level.

TABLE I D

Analysis of variance Table

Height of Plants

45 days after sowing

Source	SS	DF	Variance	F
Total	17214.56	89		
Block	223.95	4	55.99	0.77
Treatment	11984.20	15	798.95	10.95*
Treatment Vs Control	8320.21	1	8320.21	114.05*
Between treatments	6282.36	4	1570.59	21.67*
Different stages of application of 25 ppm.	397.70	2	198.85	2.72
" 50 ppm.	286.30	2	143.15	1.96
" 75 ppm.	823.10	2	411.55	5.64*
" 100 ppm.	1288.30	2	644.15	8.83*
" 125 ppm.	772.63	2	386.32	5.29*
Error	5106.41	70	72.95	

* Significant at 5% level.

TABLE I E

Analysis of variance Table

Height of Plants

52 days after sowing

Source	SS	DF	Variance	F
Total	37726.84	89		
Block	1568.60	4	392.15	1.11
Treatment	11213.96	15	747.54	2.09*
Treatment Vs Control	32369.78	1	32369.78	90.83*
Between treatments	116405.31	4	29101.32	81.38*
Different stages of application of 25 ppm.	710.56	2	355.28	0.99
" 50 ppm.	6998.08	2	3499.04	9.83*
" 75 ppm.	469.52	2	234.76	0.65
" 100 ppm.	8268.81	2	41.34	11.6*
" 125 ppm.	18.73	2	9.37	0.03
Error	24944.28	70	356.35	

* Significant at 5% level.

TABLE I F

Analysis of variance table

Height of Plants

59 days after sowing

Source	SS	DF	Variance	F
Total	7872.98	89		
Block	417.80	4	104.45	2.1
Treatment	4056.38	15	270.42	5.5*
Treatment Vs Control	3711.45	1	3711.45	76.45*
Between treatments	4188.24	4	1047.06	21.4*
Different stages of application of 25 ppm.	92.84	2	46.42	0.9
" 50 ppm.	97.20	2	48.60	1.1
" 75 ppm.	290.57	2	145.28	2.9*
" 100 ppm.	388.44	2	194.22	3.9*
" 125 ppm.	55.87	2	27.93	0.7
Error	3399.80	70	48.57	

*Significant at 5% level.

TABLE II A

Mean height of plants in Centimeters

24 days after sowing

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	14.3	15.1	13.6	14.3
25 ppm.	16.7	17.5	16.3	16.8
50 ppm.	17.5	17.9	19.7	18.4
75 ppm.	18.2	16.5	17.9	17.5
100 ppm.	18.9	17.5	17.5	17.9
125 ppm.	18.8	18.4	16.3	17.8
Mean	17.3	17.2	16.9	

Critical difference 2.19.

TABLE II B

Mean height of plants in centimeters

31 days after sowing

Gibberellic Acid	Stages of application: Once in a week	Once in two weeks	Once in three weeks	Mean
Control	18.0	19.4	17.5	18.3
25 ppm.	25.7	22.5	22.2	23.5
50 ppm.	28.1	23.0	25.3	25.5
75 ppm.	32.3	23.9	26.2	27.4
100 ppm.	33.5	26.6	25.4	28.5
125 ppm.	33.2	29.3	25.2	29.2
Mean	28.4	24.1	23.3	

Critical difference 3.68.

TABLE II C

Mean height of plants in centimeters

38 days after sowing

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	23.8	24.7	23.2	23.9
25 ppm.	38.4	30.8	26.0	31.4
50 ppm.	42.7	37.1	30.5	36.8
75 ppm.	49.9	39.4	29.4	39.6
100 ppm.	49.9	38.6	30.1	39.5
125 ppm.	43.9	43.2	29.1	38.7
Mean	41.3	35.6	28.1	

Critical difference 8.25.

TABLE II D

Mean height of plants in centimeters

45 days after sowing

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	36.3	39.7	34.2	36.7
25 ppm.	55.8	45.7	44.3	48.6
50 ppm.	67.4	50.2	50.8	56.1
75 ppm.	69.5	58.0	51.6	59.7
100 ppm.	73.5	62.0	50.8	62.1
125 ppm.	68.7	67.4	52.9	63.0
Mean	61.9	53.8	47.4	

Critical difference 3.68.

TABLE II E

Mean height of plants in centimeters

52 days after sowing

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	63.9	63.6	60.6	62.7
25 ppm.	85.2	70.6	70.7	75.5
50 ppm.	93.8	82.4	85.3	87.1
75 ppm.	91.2	74.8	90.1	85.4
100 ppm.	101.2	85.3	83.1	89.8
125 ppm.	88.6	91.2	89.1	89.6
Mean	87.3	77.9	79.7	

Critical difference 8.73.

TABLE II F

Mean height of plants in centimeters

59 days after sowing

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	96.5	92.9	96.8	95.4
25 ppm.	107.8	105.5	101.7	105.0
50 ppm.	111.8	106.5	107.6	108.6
75 ppm.	112.1	102.5	111.5	108.7
100 ppm.	116.2	109.1	105.7	110.3
125 ppm.	113.1	108.5	109.7	110.4
Mean	109.6	104.2	105.5	

Critical difference 8.73.

Height of plants

The height of plants for the different treatments was measured at weekly intervals from 24 days after sowing (3 days after the first spraying) to 59 days after sowing. The data were analysed statistically and the analysis of variance tables are given in Tables I A to F. All the treatments are found to be significant over the control. Mean height of the plants is given in Tables II A to F.

These tables clearly show that gibberellic acid increased the height of the plants significantly. The most vigourous response was obtained from 100 ppm. concentration; the difference in effect among the levels of gibberellic acid being significant.

It was found from the general mean height of the plants treated with gibberellic acid that, of all the 5 levels of gibberellic acid application, the heighest response was shown by the plants treated with 50 ppm. on the 24th day after sowing. (Table II A), while 125 ppm. showed the maximum response on the 31st and 45th days (Tables II B and Table II D). 75 ppm. showed the maximum response on the 38th day (Table II C) and the 100 ppm. showed the maximum response on the 52nd day. (Table II E) But the mean hight of the plants reveals that plants receiving 100 ppm. concentration applied at weekly intervals showed the maximum response to gibberellic acid. Another interesting feature is that the response from weekly spraying of the solution is significantly superior to those of spraying once in two weeks and once in three weeks (Tables II A to F).

TABLE III

Number of Tillers

Analysis of variance table

Source	SS	DF	Variance	F
Total	179.70	89		
Block	4.24	4	1.06	0.5
Treatments	24.15	15	1.61	0.7*
Error	151.31	70	2.15	

*Not significant

TABLE IV

Mean number of tillers per plant

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	9.4	8.7	9.3	9.1
25 ppm.	7.0	7.3	7.4	7.2
50 ppm.	5.4	6.5	7.1	6.3
75 ppm.	5.9	6.5	6.7	6.4
100 ppm.	5.9	6.2	7.2	6.4
125 ppm.	6.1	5.9	5.8	5.9
Mean	6.6	6.8	7.2	

Critical difference 1.84.

The number of tillers corresponding to different treatments was analysed and the analysis of variance table is given in Table No.II. No treatments was found to be having any significant effect in increasing the number of tillers. Mean number of tillers is given in Table No.IV. It was found from this table that the maximum number of tillers was obtained in the control plants. Thus it was observed that none of the levels of gibberellic acid, or the method of application adopted, was capable of producing any increase in the number of tillers. Even though the treatments are not significant statistically the mean table shows that there is clear difference between treatments. Of the five levels of gibberellic acid used the maximum number of tiller was from the 25 ppm. gibberellic acid treated plants and minimum from the 125 ppm. concentration. There difference between other concentrations that is, for 50 ppm., 75 ppm., and 100 ppm. is negligible. It is also found that the plants receiving gibberellic acid once in three weeks produced more number of tillers than spraying at weekly intervals and once in two weeks.

TABLE V

Analysis of variance Table

Date of flowering

Source	SS	DF	Variance	F
Total	376.72	89		
Block	25.11	4	6.28	3.9*
Treatment	238.19	15	15.89	9.7*
Treatment Vs Control	104.73	1	104.73	64.6*
Between treatments	262.31	4	65.56	40.4*
Different stages of application of 25 ppm.	7.0	2	3.5	2.2
" 50 ppm.	6.4	2	3.2	2.0
" 75 ppm.	19.7	2	9.85	6.1*
" 100 ppm.	22.5	2	11.25	7.0*
" 125 ppm.	8.2	2	4.1	2.5
Error	113.42	70	1.62	

Significant at 5% level.

TABLE VI

Mean number of days of flowering

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	51.8	51.8	51.6	51.7
25 ppm.	48.8	50.4	49.2	49.5
50 ppm.	47.6	49.2	48.4	48.3
75 ppm.	46.0	47.6	48.8	47.5
100 ppm.	46.2	48.8	48.8	47.9
125 ppm.	49.4	48.4	50.2	49.6
Mean	48.3	49.4	49.0	

Critical difference 1.68.

The data on the date of flowering observed as and when each plant came to flower were analysed and the analysis of variance table is given in the Table No.V. All the treatments had significant influence on the flower initiation. Mean number of days of flowering is given in Table No.VI. Maximum earliness was obtained with 75 ppm. of chemical concentration followed by 100, 50, 25 and 125 ppm. concentrations. The plants receiving gibberellic acid weekly showed earlier flowering than those receiving gibberellic acid once in two weeks and once in three weeks.

TABLE VII

Fresh weight of the shoot

Analysis of variance table

Source	SS	DF	Variance	F
Total	5226.48	89		
Block	268.73	4	67.18	1.4
Treatment	1457.78	15	97.18	1.8*
Error	3499.97	70	49.9	

*Not significant

TABLE VII

Mean Fresh weight of the shoot

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	34.9	36.9	37.4	36.4
25 ppm.	30.9	36.2	37.6	34.9
50 ppm.	27.1	31.8	35.7	31.5
75 ppm.	29.4	29.6	34.3	31.1
100 ppm.	25.4	24.8	36.2	28.9
125 ppm.	32.7	31.8	27.8	30.6
Mean	30.1	31.8	34.6	

Critical difference 8.9.

The fresh weight of shoot was recorded immediately after harvest and analysed statistically and the analysis of variance table is given in Table No.VII. The treatments were found to be having no significant effect on the weight. Mean fresh weight of the shoot corresponding to different treatments is given in table No.VIII. Control plants showed maximum fresh weight. This data reveals that the fresh weight of the shoot of the plant, treated with 25 ppm. gibberellic acid had only slight difference in weight from the control. The fresh weight of shoot for different treatments steadily decreased with increasing concentration of gibberellic acid until 100 ppm. But the fresh weight at 125 ppm. showed an upward trend giving more fresh weight.

TABLE IX

Dry weight of the shoot

Analysis of variance table

Source	SS	DF	Variance	F
Total	957.88	89		
Block	56.87	4	14.22	1.3
Treatment	142.85	15	9.52	0.87*
Error	758.16	70	10.8	

* Not significant.

TABLE X

Mean dry weight of the shoot

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	13.4	14.1	13.8	13.8
25 ppm.	13.9	15.1	15.8	14.9
50 ppm.	11.9	13.6	13.3	12.9
75 ppm.	13.7	12.3	13.0	12.9
100 ppm.	12.2	11.9	13.6	12.8
125 ppm.	13.5	13.0	11.3	12.8
Mean	13.1	13.5	13.6	

Critical difference 4.07.

Dry weight of the shoot corresponding to different concentrations was analysed and the analysis of variance table is given in Table No.XI. This shows clearly that there was no significant difference between the treatments and the control. But the mean dry weight of the shoot corresponding to different treatments presented in the Table No. XII reveals that dry weight 25 ppm. gibberellic acid treated plants gave higher dry weight than the control. There is no marked difference between other concentrations or between the different stages of application of gibberellic acid.

TABLE XI

Number of Leaves

Analysis of variance table

Source	SS	DF	Variance	F
Total	21.09	89		
Block	0.83	4	0.21	0.84
Treatments	1.94	15	0.13	0.52*
Error	18.32	70	0.25	

* Not significant.

TABLE XII

Mean number of leaves

Gibberellic Acid	Stages of application			Mean
	Once in a Week	Once in two weeks	Once in three weeks	
Control	5.4	5.6	5.8	5.6
25 ppm.	5.5	5.7	5.6	5.6
50 ppm.	5.6	5.6	5.3	5.5
75 ppm.	5.6	5.7	5.5	5.5
100 ppm.	5.5	5.5	5.6	5.5
125 ppm.	5.5	5.5	5.6	5.5
Mean	5.5	5.6	5.5	

Critical difference 0.63.

The total number of leaves corresponding to different treatments was analysed and the analysis of variance table is given in Table No.XI. The treatments were found to be having no significant effect on the number of leaves. Mean number of leaves is given in Table No.XII. These tables show that neither the concentrations of gibberellic acid nor the stages of application influenced the number of leaves compared to that of the control.

TABLE XIII

Dry weight of roots

Analysis of variance table

Source	SS	DF	Variance	F
Total	91.26	89		
Block	12.48	4	3.12	3.5
Treatments	17;15	15	1.14	1.4*
Error	61.63	70	0.88	

* Not significant.

TABLE XIV

Mean dry weight of roots

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	4.4	4.4	4.1	4.3
25 ppm.	3.9	3.4	4.4	3.9
50 ppm.	3.7	4.0	4.8	4.2
75 ppm.	3.1	3.5	4.2	3.6
100 ppm.	3.6	3.7	4.0	3.8
125 ppm.	3.4	3.8	3.8	3.7
Mean	3.6	3.8	4.2	

Critical difference 1.6.

The dry weight of the roots was analysed statistically and the analysis variance table is given in Table No.XIII and the mean dry weight of the roots corresponding to different concentrations is given in Table No.XIV. These data show that there was no significant difference in dry weight between treatments and control. However there was a slight increase in the dry weight at 25 and 50 ppm. compared to other concentrations. Roots of plants receiving gibberellic acid weekly showed the minimum weight.

TABLE XV

Length of ear head

Analysis of variance table

Source	SS	DF	Variance	F
Total	209.21	89		
Block	19.94	4	4.98	2.1
Treatments	27.46	15	1.84	0.9*
Error	161.82	70	2.31	

* Not significant.

TABLE XVI

Mean length of ear head

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	19.7	19.2	18.7	19.1
25 ppm.	19.0	18.4	17.9	18.1
50 ppm.	18.2	18.3	18.9	18.5
75 ppm.	17.9	17.9	18.6	18.1
100 ppm.	18.7	18.2	18.3	18.4
125 ppm.	19.1	17.8	17.7	18.2
Mean	18.6	18.4	18.3	

Critical difference 1.9.

The length of the ear heads was measured after harvest. The date were analysed and the analysis variance table is given in Table No. XV, and the mean length of ear head is given in Table No.XVI. The treatments were found to be producing no significant effect on the length of ear heads. Thus it was observed that neither the concentrations nor the method of application adopted was capable of producing any significant ehange in the length of ear heads.

TABLE XVII

Number of grains

Analysis of variance table

Source	SS	DF	Variance	F
Total	1435052.9	89		
Block	80689.0	4	20172.25	1.9
Treatments	353824.3	15	23588.3	1.6*
Error	1000539.6	70	14293.4	

* Not significant.

TABLE XVIII

Mean number of grains

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	843.4	842.0	822.4	835.6
25 ppm.	807.8	788.0	785.6	783.8
50 ppm.	764.4	741.0	736.9	748.6
75 ppm.	740.8	668.2	684.0	697.3
100 ppm.	661.2	709.8	688.4	686.4
125 ppm.	729.2	682.2	573.6	661.7
Mean	758.3	738.5	713.6	

Critical difference 149.59.

Number of grains was counted and analysed. The analysis of variance table and the mean number of grains (Table XVII and XVIII) showed that there was no significant difference between treatments and control in yield. The maximum yield was obtained from the control plants. Therefore different concentrations of gibberellic acid were found to be ineffective in increasing the yield more than the control. But there was significant difference between the yield of different treatments. Out of five levels of gibberellic acid applied 25 ppm. showed maximum yield and there was a steady fall in the yield with increasing concentration with the stages of application. Weekly applications gave the maximum yield and application once in three weeks gave the lowest yield.

TABLE XIX

Weight of grains

Analysis of variance table

Source	SS	DF	Variance	F
Total	1384.92	89		
Block	78.32	4	19.58	1.3
Treatments	284.60	15	18.97	1.2*
Error	1022.00	70	14.60	

* Not significant.

TABLE XX

Mean weight of grains

Gibberellic Acid	Stages of application			Mean
	Once in a week	Once in two weeks	Once in three weeks	
Control	20.5	20.6	21.1	20.7
25 ppm.	20.4	19.5	18.8	19.6
50 ppm.	17.7	18.5	18.8	18.4
75 ppm.	16.7	18.5	17.5	16.6
100 ppm.	16.8	16.9	16.0	16.5
125 ppm.	17.4	16.3	14.7	16.2
Mean	18.5	18.1	19.0	

Critical difference 4.79.

Regarding the weight of grains also, the analysis of variance table and mean weight of grains (Table XIX and Table XX) reveal that there was no significant difference between the treatments and control.

Visual observations

The response to gibberellic acid was manifested by an increase in the length of inter-nodes and leaves. The effect on shoot elongation became apparent on the 3rd day after the first spraying. The leaves of treated plants were longer and narrower and paler in colour.

DISCUSSION

DISCUSSION

The results presented in the preceding chapter show the response of rice to gibberellic acid. The findings recorded are discussed below:

Height of the plants:-

In the present investigation it was noticed that the height of the plants was significantly increased by gibberellic acid treatment. The maximum height was obtained in 100 ppm concentration followed by 75 ppm concentration of gibberellic acid.

The outstanding effect of gibberellic acid in plants ie., the elongation of the stem was obtained in the present study also. The plants which had been treated with 100 ppm concentration at weekly intervals showed an increase in height of 37.2 cms above the controls on the 45th day after sowing, while the increase in height was only 17.7 cms at the time of ear emergence. Increased shoot elongation by spray application of gibberellic acid had been reported earlier in four dwarf varieties of rice by Kachroo (1961) and in an early variety of rice N.136 by Misra and Sahu (1962).

A great number of investigators observed stem elongation in several economic plants. Marth, Audia and Mitchell (1956) noted marked stem elongation in Soyabeans, Maize, barley and tulips; Buckovac and Wittwer (1956) in pea, sweet corn, and cabbage; Morgan and Mees (1958) in wheat andmaize; Anup Singh Sandhu (1961) in bajra and many others in several plants. According to Appala Naidu and Satyanarayana Murthy (1962) Chakravarthi (1962) and Narasimham (1960) the increased height was due to internodal elongation. The present investigation also agrees with this view.

It is stated by Stowe and Yamaki (1951) that in general the elongation of stem is limited to younger tissues, andmay be influenced by external conditions. Gibberellin applied to any part of the plant will apparently affect all grwoing parts throughout the plants. However gibberellin does not usually change the number of internodes nor is the growth produced exceptionally abnormal. The general impression is that it produces more rapid and extensive but not uncontrolled growth. But Marth et al (1956) reported that in onions and gladioli gibberellic acid had no effect and in conifers there was a slight effect.

The action of gibberellin on stem elongation has been inter preted by various workers. Their initial interpretation was that the elongation was mainly due to linear extension of cells. Haresloop (1961) observed that though treated bean plants grew twice as tall and produced longer internodes, the pith was smaller in diameter resulting in significantly thinner stems. The general consensus seems to be that growth promotion by gibberellin resulted from both cell division and the consequent stem elongation. Sachs and Lang (1957) found that gibberellin caused increased cell elongation andcell division. Gunderson (1959) also observed stem elongation in Begnonia stem partly by the acceleration of cell division. But Soost (1959) recorded that the increase was mainly produced by elongation of nodes below the point of application. In the present study the stem elongation may be due to cell elongation.

Hyper elongation has been mainly reported in dwarf plants and rarely in tall plants. Phinney (1957) found stem elongation in dwarf corn plants. Similarly treated bush beans assumed a twining pole habit and elongated more than taller plants. But extreme dwarf tomato plants, though responsive to gibberellin did not grow as tall as the normal tall variety. (Rappaport - 1959). Brian et al (1957) observed stem elongation in dwarf plants and not in tall plants. They interpreted that the lack of response to gibberellic acid in tall plants was due to their greater capacity to synthesise a "gibberellic acid like hormone" than the dwarf beans. But Appala Naidu and Satyanarayana Murthi (1962) explained the response as being due to the succulance of the stem rather than the tall or dwarf character of the plants. In the present study the response was probably due to the former cause. It was also found that some of the treated plants developed thin weak stems due to the length of internodes. The observation of Marth et al (1956) also agrees with this present findings.

Results presented in the tables II.A to F reveal that the stem elongation observed following gibberellic acid application did not persist after the emergence of the ear head. The height of the control plants was almost the same as those of most of the treated plants. (Table II.F). The observations of several workers like Siamao et al (1958) and Morgan (1958) and Mees (1958) also agree with the present findings. This is probably due to the subsequent break down and disappearance of the acid absorbed by the plant. It is quite possible that virtually all the absorbed gibberellic acid gets transformed into other substances within a few days. This idea is supported by Stuart and Cathey (1961)

Number of tillers:-

Number of tillers was reduced with the gibberellic acid treatment to a great extent. (Table. IV). The maximum number of tillers was obtained in the control plants. It is interesting to note that the number of the tillers was found to be reduced with the increase of the concentration. Thakur and Negi (1959) and Coleman et al (1959) reported the reduction of tillers in gibberellic acid treated sugarcane plants and Misra and Sahu (1960) in rice. But Singh et al (1960) observed increased number of runners over the control in a strawberry variety "Pusa dwarfearly".

Number of nodes and Leaf out put:-

In the present study no significant difference was obtained in the final number of nodes and leaves (Table XII). The leaf out put in both treated and control plants remained practically the same. This finding is confirmed by the observations of several workers like Yabuta (1939) working on tobacco, Humphries (1958) in potato, Thakur (1959) in sugarcane and Misra and Sahu (1960) in rice. But Soost (1960) observed a reduction in the number of leaflets per leaf and a change to entire rather than serrate leaf lets in tomato. Sarcar and Chakravarthy (1960) observed increase in the number of leaves in jute plant.

The accelerated growth rate observed in the gibberellic acid treated plants is entirely due to internodal elongation. The production of more nodes was not observed because the leaf out put and the number of nodes were not different from those of the controls (Table XII). In the review of the history and physiological action of gibberellin usually does not change the number of internodes, but causes the increase of leaf size. This general conclusion holds true in the present investigation.

The universal effect of gibberellic acid observed on the foliage namely chlorosis was found in the present study also. The leaves in the treated plants were paler in colour. Appearance of chlorosis on gibberellin acid treated plant was observed earlier by Yabuta et al (1949) in tobacco, Morgan and Mees (1958) in wheat, potato, turnips, carrot, peas, runner beans, lettuce, celery and maize, Pisani (1958) in zuchnis, Humphries (1958) in majestic potato and several other workers in many plants. Wolf and Haber (1960) demonstrated that chlorosis was due to a failure of chlorophyll synthesis to keep pace with the increased cell expansion. Bishop and Wittingham

(1961) while explaining the effect of gibberellic acid in causing chlorosis concluded that this was not due to a lower chlorphyll content per cell, but due to an artefact arising from the effect of gibberellic acid on leaf expansion. The appearance of chlorosis in the present study may be by the failure of chlorophyll synthesis to keep pace with the increased cell expansion caused by the gibberellic acid application.

FLOWERING

Results presented in the table No. VI. clearly show that gibberellic acid had significant influence on the date of flowering. The results obtained in the present study is confirmed by the works of Singh et al (1960) Misra and Sahu (1962) Gopalachari and Naidu (1961) and Rappaport (1957). But Chakravarthi (1958) found no earliness in flowering in Brassica compestris and Leus esuculanta. It was observed that gibberellic acid in all concentrations induced significant earliness in flowering in the treated plants in comparison with the contrds. The maximum earliness was obtained with 75 ppm concentration. Higher or lower than 75 ppm concentration produced a lesser degree of earliness.

Though gibberellic acid appears to have no florigenic properties, one of the most striking effects of gibberellic acid on certian vegetable crops is the stimulation of flower formation. But the earliness has to be related to the elongation releasing the flowering response rather than to the direct effect on flowering. Gibberellic acid stimulates flowering only somelong day plants and delays flowering in short day plants. Rice is a long day plant and hence significant earliness is explained.

FRESH AND DRY WEIGHT OF THE SHOOT

In the present investigation, most of the gibberellic acid treated plants did not increase the fresh or dry weight of the shoot. (Table Nos. VII & X). However there was slight increase both in the fresh weight and in the dry weight of shoot at 25 ppm concentration. Some workers like Brian and Heming (1957) Bukovae and Wittwer (1957) observed fresh weight increase in gibberellic acid treated peas and celery. But Ogzewalla (1960) recorded decrease of fresh weight in peppermint plant by spray application of gibberellic acid; The reduction of fresh weight and dry weight in gibberellic acid treated rice plant is probably due to the reduction of the number of tillers.

LENGTH OF EARHEAD

In the present study the length of the penicles had no significant increase over the control (Table No.XVI). Rappaport (1958) observed about 5% decrease in the fruit size of tomato. S.N.Rao and Bhaskar Rao (1963) found increase in average length of the fruits 1.60 to 2.06 cms over the control in Hibiscus rosasinesis.

YIELD

Results in the present study (Tables XVIII & XX) show that gibberellic acid had no significant influence on the increase of yield either in the number or weight of the grains. The maximum yield was obtained from the control plants. D.P.Hopkins (1958) observed reduction of yield in gibberellic acid treated wheat plants, and Hayashi et al (1956) found 2mg/l gibberellic acid reduced rice grain production 32%, although the yield of straw increased by 14%. The observations of Gustafson (1960) in tomato, Morgan and Mees (1958) in wheat, trunip, carrot, runner bean, lettuce and maize and Ballard (1959) in peas agree with the findings of the present investigation. But increase in yield was obtained in peas by Asselbergo et al (1959) in tomatoes, by

Sebank (1960), in grapes by Krishnamurthi (1959), in strawberry by Singh and Randhawa (1960), and increase in the quantity of fibre in jute plant by Sircar and Chakravarthi (1960).

It is also interesting to note that the yield was found to be reduced with the increase of concentration. Of the five concentrations maximum yeild was obtained from the plants receiving 25 ppm gibberellic acid and the minimum from 125 ppm gibberellic acid. It can be assumed that the reduction of yield in the present investigation was due to the reduction of tillers.

============

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present investigation is undertaken to study the effects of gibberellic acid on the cereal, rice (*Oryza sativa*. L). The hormone was used at concentrations of 25,50, 75, 100 and 125 ppm., as spray application on the 21 days old seedlings. Three stages of applications namely spraying once in a week, once in two weeks and once in three weeks were tried. A pot culture experiment was conducted adopting a randomised block design.

The effect of gibberellic acid on the height of plants, number of tillers, time of flowering, fresh and dry weight of stem, length of ear heads, number of leaves, dry weight of the roots and the yield were studied. Of these only height of the plants was influenced significantly by the treatments.

Marked shoot elongation was observed in the gibberellic acid treated plants. The maximum response was at the level of 100 ppm. Weekly spraying is better than spraying once in two weeks and once in three weeks.

Gibberellic acid had no significant influence either on the final leaf output or on the node number. The leaves in the treated plants are paler in colour and longer.

Gibberellic acid was found to be having no significant effect in increasing the number of tillers.

Earliness was obtained in the gibberellic acid treated plants. All the treatments had significant influence on the flower initiation, but maximum earliness was obtained with 75 ppm. of gibberellic acid followed by 100, 50, 25 and 125 ppm.

Fresh and dry weight of the stem were not altered by gibberellic acid treatment.

Gibberellic acid failed to increase the yield. The length of the ear head was more or less equal in all plants. There was no significant increase in the yield also. The maximum yield was obtained from the control plants.

REFERENCES

REFERENCE

Alder *et al.*	1959	Effects of gibberellic acid on corn. Agron: Jan. 51(5) 307-308.
Allan R.E. *et al.*	1959	Comparative response to gibberellic acid of dwarf, semi-dwarf and standard shoot and tall winter wheat varieties. Agro: Jan: 51 (12) 737-40.
Anup Singh Sandhu and Akhtar Husain	1961	Effect of seed treatment with gibberellic acid on germination and growth of bajra. Indian Jou: Agro: 5 (4) 269-72.
Appala Naidu and Satyanarayana Murthy	1962	Effect of gibberellic acid on growth and yield of Mesta varieties. A.A.J.9 (2) 90-98.
Atal C.K.	1959	Sex reversal in hemp by application of gibberellin. Current Science 28. 408-09.
Brain and Heming	1957	The effect of M.H. on the growth response of plants to gibberellic acid. Ann: App: Biol: 45 (3) 489-97.
Brain *et al.*	1954	The plant growth promoting properties of gibberellic acid. J. Sci. Food Agri: 5(12) 602-12.
Bench Anderson	1958	Preliminary studies on gibberellin. Horticultura. 12. 153-59.
Bonde and Moore	1958	Effects of gibberellic acid on the growth and flowering of Telephone peas. Physio: Plant 11. 451-56.
Bose P.C. and Hammer.	1961	Effects of various concentrations of gibberellin on growth, flowers, fruits, Mineral composition and mineral uptake of tomato plants. Ind. Jou: Agri: Sci: 31(3), 213-24.

Bose N.	1959	Effects of gibberellin on the growth of pollen tubes. Nature. 184. 1577.
Bukovac and Wittwer	1956	Gibberellic acid and higher plants: I. General Growth responses. Quar: Bull: Mich: Agri: Expt. Station. 39, 307-20.
Chakravarthi S.C.	1958	Gibberellic acid and vernalization. Nature. 182 (4649) 1612-13.
Crane *et al*.	1961	Gibberellin induced parthenocarpy in prunus. Proc: An: Socie: Hor: Sci: 75, 129-37.
Coleman *et al*.	1959	The effect of Gibberellic acid on sugar cane. Proc: 10th Cong: Int: Soc: Sugar Cane, Tech: Hawai. 775-781.
Datta S.C.	1960	Gibberellins and plant growth. Indi: Agriculturist 4 (2) 1-2.
Doljakoff-Mayber and Mayer A.M.	1959	Joint action of gibberellic acid and Coumarin in germination. Nature 184, 826-27.
Dycas A.M.	1960	Studies on root response in *phaseolus vulgaris* to applications on gibberellic acid to stem tip primary leaves and in the nutrient solution. Plant Physio. 35 (Supple) 34-35.
Fish F.	1960	Effects of gibberellic acid on the growth and alkaloid content of *Datura stramonium*. Jou: Pharm: Pharmacol. 12, 428-36.
Fischnick *et al*.	1959	Influence of gibberellin in the development of the potato plant. Landbanforschung Volkenrode.9(1) 1244.
Frey K.J.	1960	Effects of gibberellic acid on oats. Pro. Iowa. Acad: Scie: 67. 92-97.

Gunderson	1959	Some experiments with gibberellic acid Acta. Hist. Gotoburg. 22, 87-110.
Gaskins M.H.	1958	Gibberellin and their effects on yield and quality of beans and southern peas. Diss. Abstract: 19, 927-28.
Gardner F.P. and Kasperbauer M.J.	1961	Seedling emergence and growth responses of dwarf grain Sorghum as affected by gibberellic acid. Iowa. State Jou. Sci. 35. 311-18.
Gopalachari and Naidu.	1961	Response of wrapper tobacco to gibberellic acid, and M.H. Ind. Jou. Agro: 6(1) 15-21.
Gustafson F.G.	1960	Influence of G.A. on the setting and development of fruits in tomato. Plant Physio: 35, 521-23.
Haber *et al*.	1961	Gibberellin action on growth of seedlings in the absence of photosynthesis. Nature. 190, 1034-35.
Haresloop J.G.	1961	The effect of gibberellic acid on cell division and cell elongation in stems of *Lycopersicum esculantum*. Diss. Abst. 21. 1723.
Hayashi T.	1940	Jou: Agri: Chem: Socie: Japan, 16, 531-38.
Herich R.	1960	Action of gibberellic acid on lettuce seed germination. Plant Physio. 35, 557-66.
Hopkins D.P.	1958	Gibberellic acid. World crops. 10. 407-09.
Hudson J.P.	1958	Effects of weather on plant behaviour. Nature. 182. 1337-40.

Humphries	1958	The effect of gibberellic acid on the growth of Majestic potato. Ann: App. Bio. 46(3) 346-51.
Janhari *et al*.	1960	Preliminary studies on the effect of G.A. on growth of spinach. Current science. 29(12) 484-85.
Kachroo	1961	Gibberellin. Indian Farming 10: 33-34.
Kahn, Goss and Smith	1957	Effect of gibberellin on germination of lettuce seed. Science 125. 645-46.
Kuppuswami and Narayanan	1958	Preliminary studies on the effect of G.A. on Arabica coffee seedlings. Culture and Science. 24(4) 184-225.
Krishna Murthi *et al*.	1959	Effect of G.A. on fruit set, size and quality in the pusa seedless variety of grapes. Ind. Jou: Horti: 16(1) 1-4.
Lal and Singh	1961	A note on stimulation of growth of leaf curl infected tomato plants with G.A. Science and Culture. 27(11) 547-48.
Marth P.C. *et al*.	1956	Effects of G.A. on growth and development of plants of various genera and species. Bota: Gaz: 118,106-111.
Mazzani and Gonzalez	1958	Besults of preliminary experiments with G.A. on Sesame, Bean and Potato. Agro: Jou: 7, 175-89.
Mc Vey and Wittwer	1959	Responses of certain lawn grasses to gibberellin. Quar: Bulletin: Mich: Agri: Expt. Sta: 42. 176-96.

Misra and Sahu	1960	Effects of G.A. on the flowering and growth of an early rice. Proc. 47th Sess. Ind. Sci. Con. Asso: Part III.
Morgan and Mees	1958	Gibberellic acid and the growth of crop plants. Jou: Agri: Science: 50, 49-59.
Narasimham	1960	The influence of GA in growth of tobacco. Indian Tobacco. 10, 263.
Nekrasova J.V.	1960	The effect of G.A. on seed germination and seedling growth of fruit trees. Fiziol. Rast. 7. 106-109;
Nickerson N.H.	1959	Sustained treatments with G.A. on five different kinds of maize. Ann: Mo. Bot. Gdn. 46(1-2) 19-37.
Ogzewalla	1960	Effects of G.A. on _Mentha piperita_. Diss: Abstra: 20. 22.
Pauli and Stickler	1961	Effects of seed treatment and foliar spray applications of G.A. on grain Sorghum. Agro: Jou: 3, 137-139.
Phinney and West	1960	Gibberellin as native plant growth regulator. Ann: Plant: Physio: 11. 411-436.
Pisani	1959	Tests on the use of gibberellin in growing Zuchnis. Rev. Ortofloro fruttic ital. 42, 320-24.
Pilet and Wurgler	1958	The effect of G.A. on the auxin oxydase activity in _Trifolium Ochroleucum_. Ber. Scheveiz. Bot. Gaz. 68. 54-63.

Pieri	1959	The effect of gibberellic acid on various crops. Rev. Vittie. Enol. 12, 409-18.
Pollock J.R.A.	1959	Growth substances and other compounds in relation to dormancy in Barley. Jou. Inst. Brew. 65(4) 334-37.
Paul Thomas *et al.*	1963	Effect of G.A. on nursary stocks of mango and citrus sp. South Indian Horticulture 11(1-2) 18-30.
Paterson and Alinder	1960	Induction of staminate flowers on gynoecious cucumber with gibberellin A_3. Science. 131, 1673-74.
Phinnay	1956	Growth response of single gene dwarf nutants in maize to G.A. Proc. Natu: Acad: Sci. 42. 185-89.
S.N. Rao and Subba Rao	1963	Studies on the effect of G.A. on phalsa. South Indian Horticulture. 11, 31-34.
----- and Bhaskara Rao	1963	The effect of G.A. on *Hibiscus rosa-sinensis*. Sou: Ind: Hort. 11. 37-38.
Rappaport L.	1956	Growth regulating metabolites. Calif: Agri: 19. 4-11.
----- and Bonner	1960	Interaction of gibberellin vernalization in the flowering of endive. Plant Physio. 35, 95-102.
------ and Singh	1961	Gibberellic acid and vegetable crops. Ind. Jou. Horticulture. 18. 230-40.
Rabindrakrishna Mukharjee and Datta	1962	Effect of G.A. on growth and fruit set in Brinjal and tomato. Culture and Science. 18(2) 36.
Razumov V.I.	1960	The importance of gibberellin in the Development of Plants. Agrobiologica. No.3, 406-19.

Sachs R.M. and Lang A.	1957	Effect of gibberellin on cell division in Hyoseyamus. Science. 125. 1144-45.
Scarascia-venezian M.E.	1959	Effect of G.A. on tobacco plants. Tobacco 62. 363-70.
Sebank J.	1960	A contribution to the practical use of gibberellin in Czechoslovakian agriculture with respect to the water regime of the plant. Sporn. Vys. Sk. Zened. V. Brene. Rada A. No.3-4. 277-92.
Sekhara Rao J.	1962	A study of the effect of G.A. on the phototaxicity, of dalpon on <u>cynodon dactylon</u>. Mad. Agri. Jour. 49: 209-221.
Simao <u>et</u> <u>al</u>.	1958	Action of G.A. on tomato plants. Rev. Agri. Piracicaba. 33. 153-56.
Sircar and Rothan Chakravarthy	1960	The effect of G.A. on Jute. Science and Culture 26(3). 141-43.
Singh and Randhawa	1959	Effect of G.A. and paraphenoxy acetic acid on growth and fruitfulness in strawberry. Ind. Jou. Horticulture. 16(1) 14-17.
------ -------- and Jain	1960	Response of strawberry to G.A. Ind. Jou. Horti. 17(1) 21-29.
Spina	1960	Experiment with gibberellin. Fruiticoltura. 22. 27-34.
Staut M.J.	1959	Some growth responses to gibberellic acid. J. Linn. Soc. (Bot) 56. 249-50.
Stuart N.W. and Cathey H.M.	1961	Applied aspects of gibberellin. Ann. Rev. Plant Physio. 12. 369-94.

Stoddart	1959	The effect of G.A. upon growth habit and heading in late flowering red clover. Jou; Agri: Sci: 52(2) 161-67.
Stowe and Yamaki	1954	The history and physiological action of gibberellin. Ann. Rev. Plant Physio. 8. 181-216.
Soost R.K.	1959	Effect of G.A. in genetic characters in two tomato lines. Bot. Gaz. 121. 114-118.
Takura et al.	1958	Effect of gibberellin on growth and flowering of several flower crops. Jou: Hort: Anan: Japan. 27. 186-92.
Thakur C. and Negi N.S.	1959	Effect of G.A. on growth, Sucrose and nitrogen content in sugar cane plant. Science and culture 24. 522-23.
Thorup	1959	Results obtained in experiments with gibberellin. Horticultura 13. 27-31.
Torii and Nakagawa	1959	The growth promoting effect of gibberellin on tea shoot. Study of Tea. 22: 23-24.
Vinodhinivasudevan and Moosa Sherief	1963	Preliminary studies on paddy with G.A. Madras. Agri. Jou. 50, 2.
Wittwer and Bukovac	1958	The effect of gibberellin in economic crops. Eco. Bot: 12: 213-55.
Wolf T. and Haber H.	1960	Chlorophyll content of gibberellin treated wheat seedlings. Nature. 186(4720) 217-18.
William I.H.	1961	Treatments of Hops with G.A. Nature. 191 (4786) 360-62.

Weaver	1960	Toxicity of gibberellin to seedless variety, of _Vitis virifera_. Nature 187 (4743) 1135-36.
Yabuta	1939	J. Agri. Chemi: Soci: Japan. 15 (175) 403-13.
Zujagina	1961	The effect of gibberellin on tobacco. Tebak 21: 41-42.

FIGURE: 1

The date of flowering.

(Table VI)

FIGURE : 2

Dry weight of the roots.

(Table [illegible])

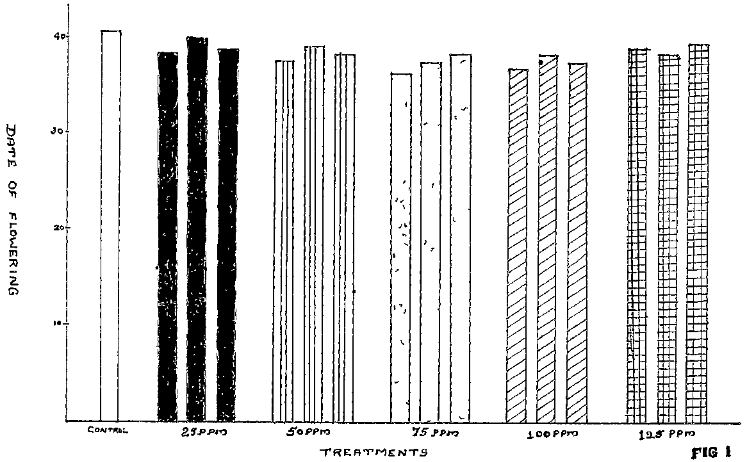

DATE OF FLOWERING
40
30
20
10
CONTROL
25 PPM
50 PPM
75 PPM
100 PPM
125 PPM
TREATMENTS

FIG 1

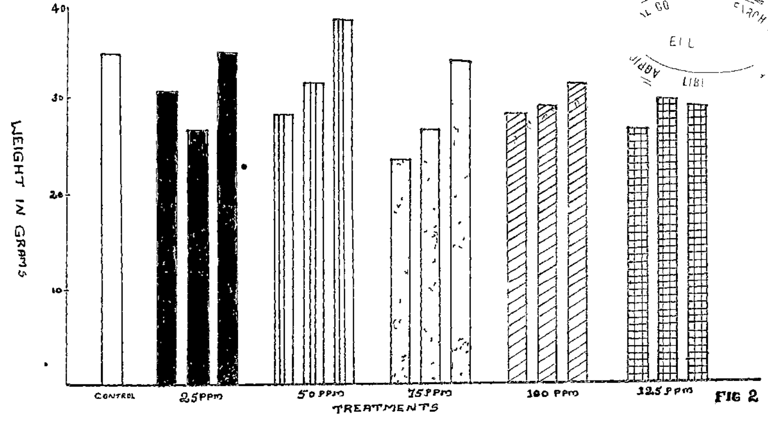
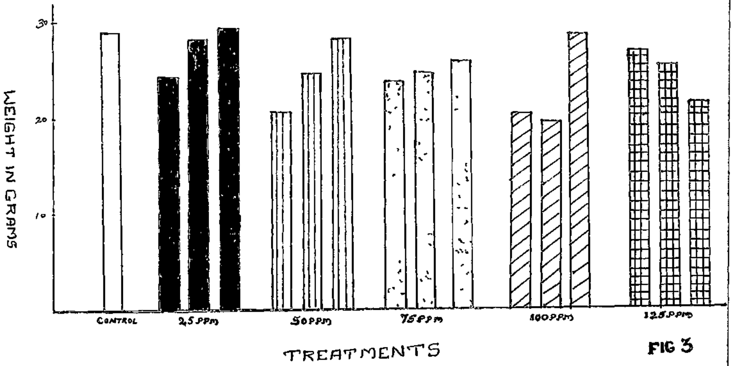
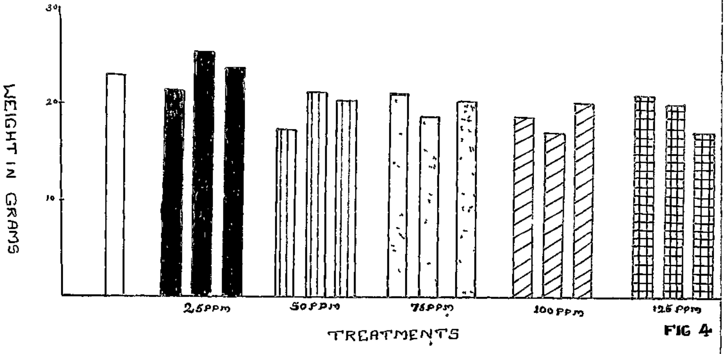

WEIGHT IN GRAMS
40
30
20
10
CONTROL
25 PPM
50 PPM
75 PPM
100 PPM
125 PPM
TREATMENTS

FIG 2



WEIGHT IN GRAMS
30
20
10
CONTROL
25 PPM
50 PPM
75 PPM
100 PPM
125 PPM
TREATMENTS

FIG 3



WEIGHT IN GRAMS
30
20
10
25 PPM
50 PPM
75 PPM
100 PPM
125 PPM
TREATMENTS

FIG 4

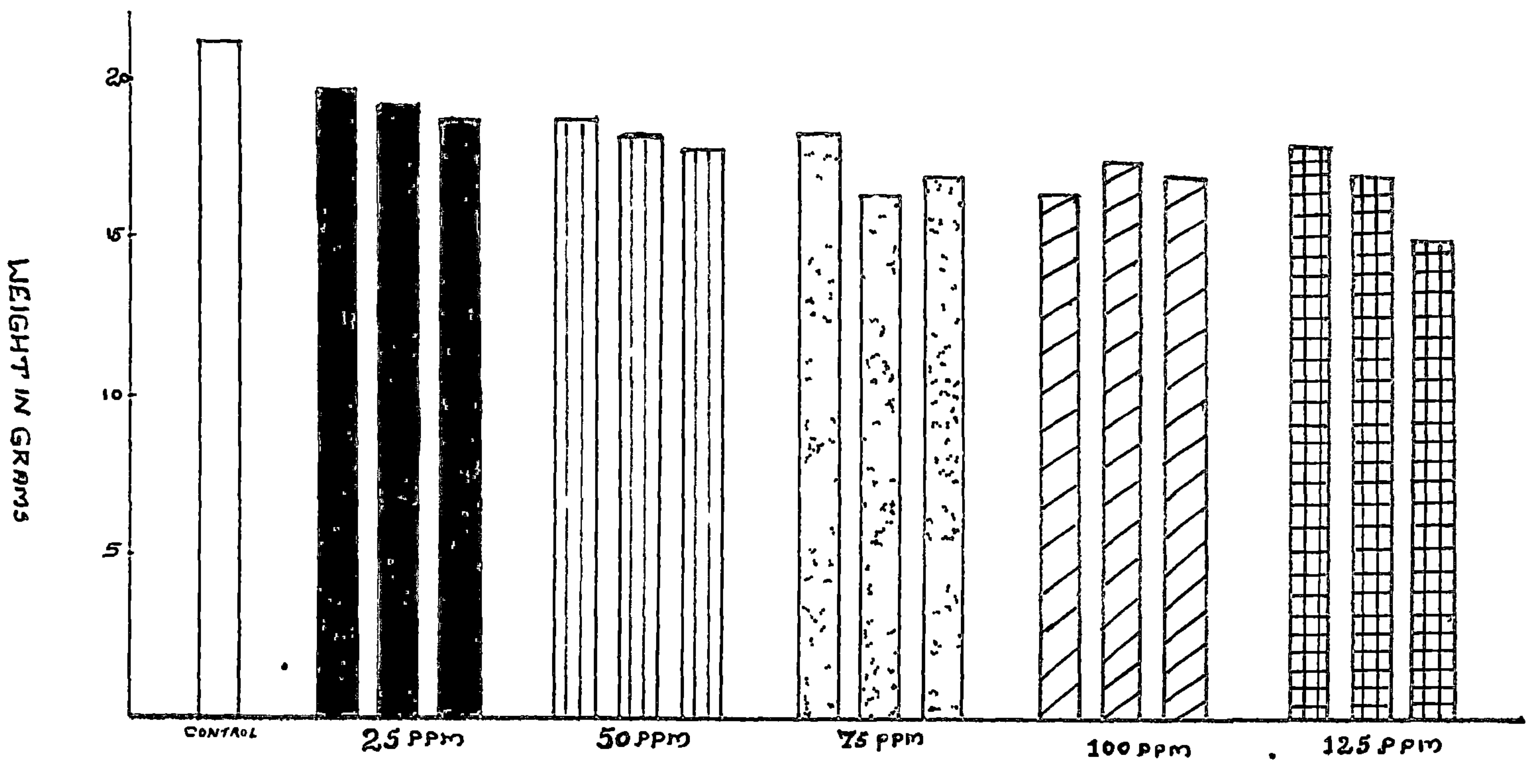

WEIGHT IN GRAMS
20
15
10
5
CONTROL
25 PPM
50 PPM
75 PPM
100 PPM
125 PPM
TREATMENTS

FIG 5

FIG VI

AVERAGE HEIGHT OF PLANTS DUE TO

GIBBERELLIC ACID TREATMENT

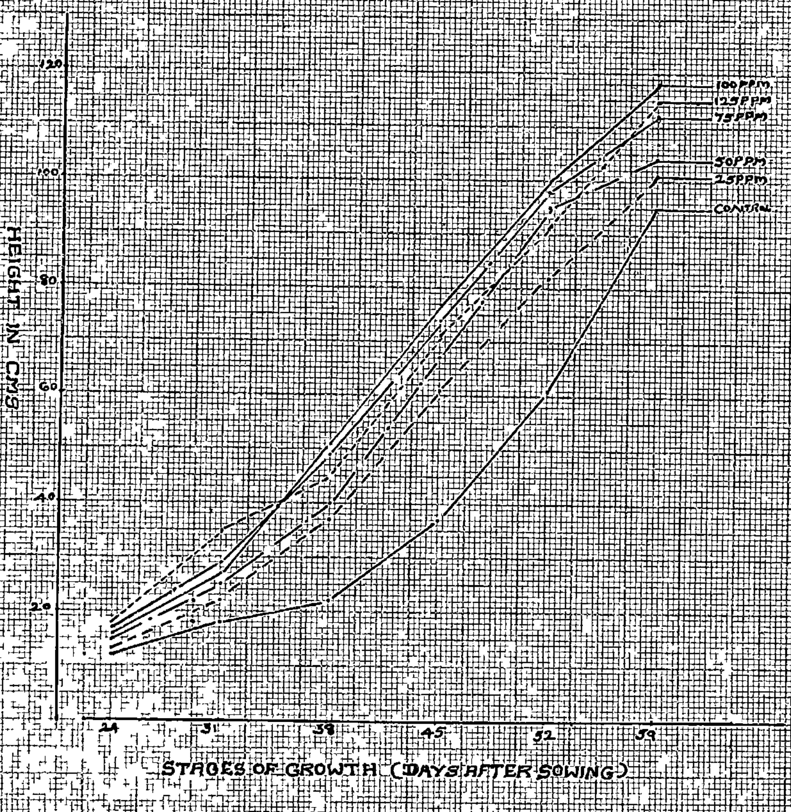


PLATE I

PLATE 2

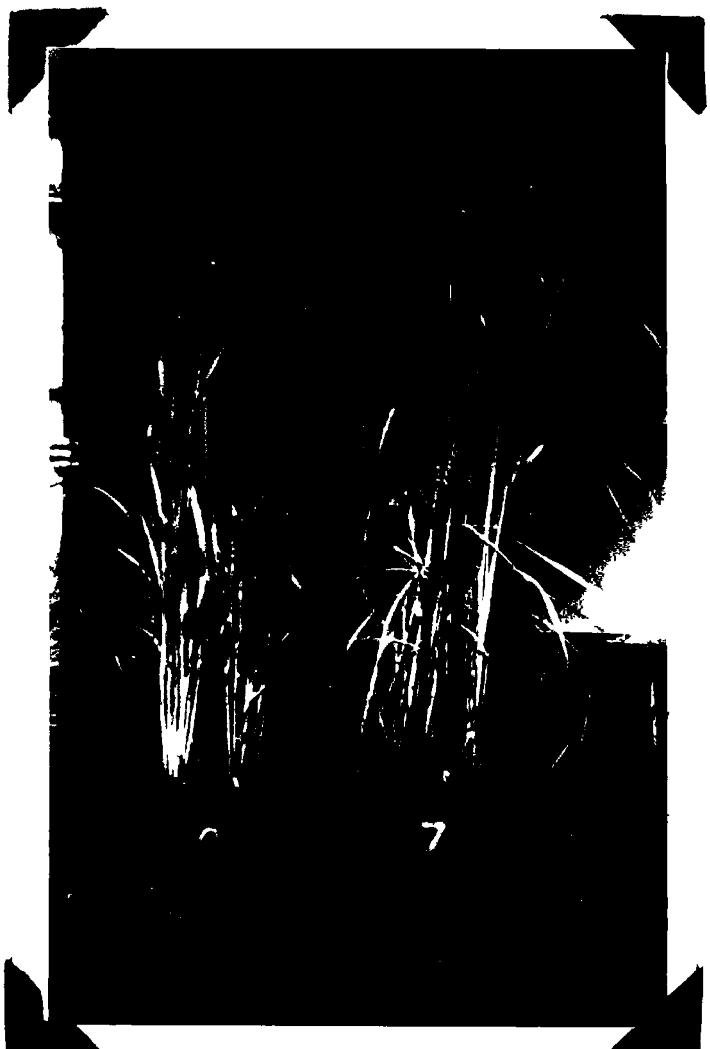


PLATE 3

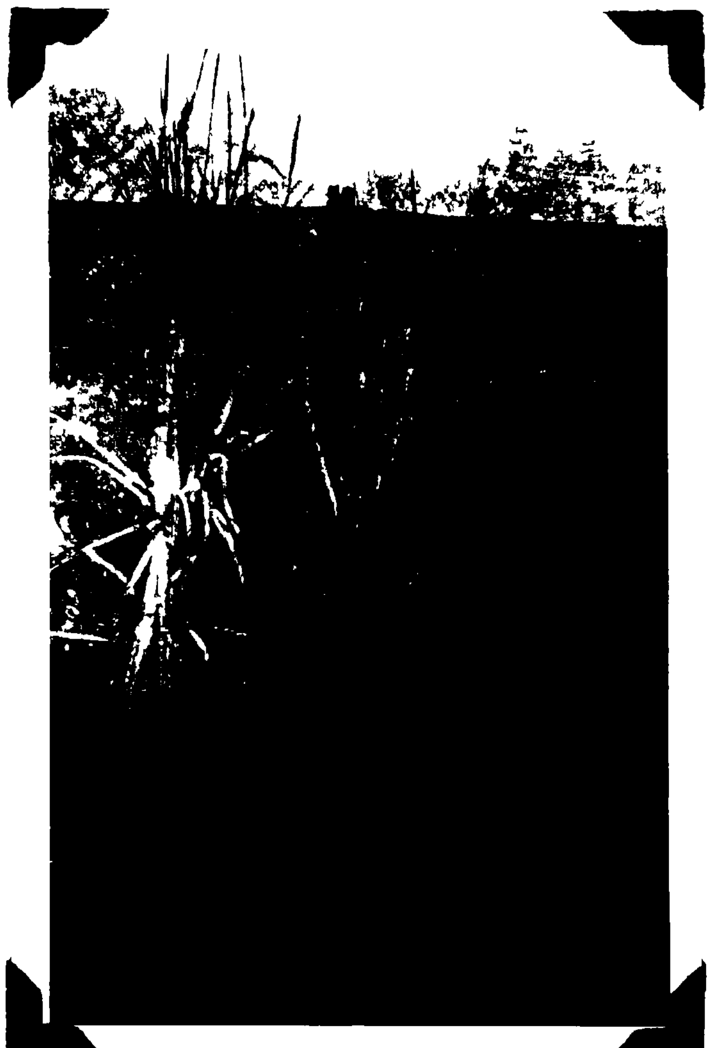


PLATE 4

Comm [illegible]

the [illegible]

9. [illegible]

10. [illegible]

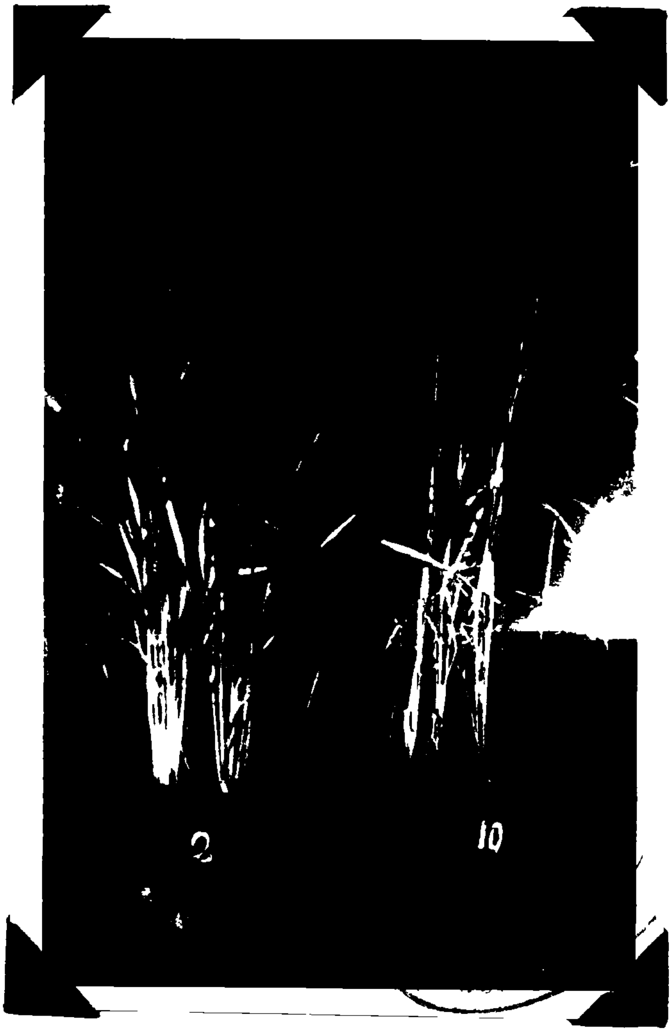


PLATE 5

PLATE 6

PLATE 7

Ilai

Comparison of

tree I

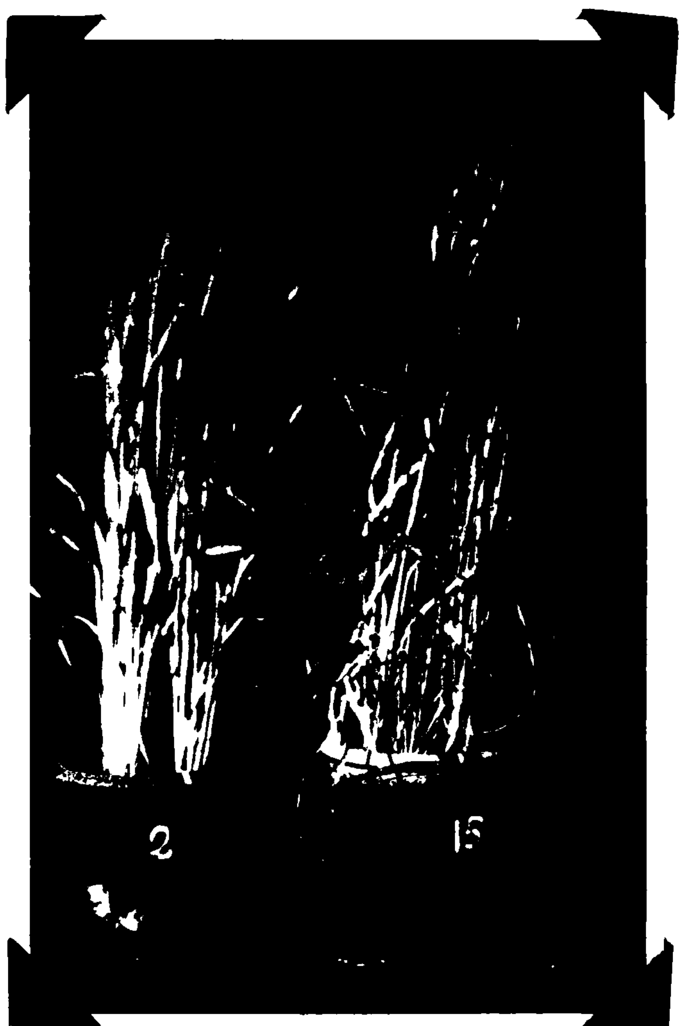


PLATE 8

PLATE 9