One of the promising fields of research which has benefited agricultural production is that of plant growth substances. The history of research on growth substances is a very fascinating one and the results already achieved are of outstanding importance both to science and practice. It can easily be said that since the discovery of hormone systems in plants and subsequent synthetic production of growth substances (both of promoters and retardants) few subjects have had drawn so much interest among the scientists concerned with the subject of crop productivity in agriculture.

The use of growth hormone in agriculture dates back as early as 1936 when Cholodnay reported that hormonization of grains of wheat and oat resulted in an increase of crop yield up to 55%. Further studies on this subject revealed that the growth substances influence the crop productivity by altering the various plant processes through certain mechanisms without causing any malformation of the plant organs.
It is known that, the growth rate, or for that matter the crop productivity is greatly influenced by the various environmental factors, yet, the integrated system involving the process of growth and development of plants is determined largely by the interaction of internal or physiological factors including endogenous growth substances which control the activity of various meristems. Exogenous application of growth substances rapidly affects these physiological processes within the plant to a great extent that results in alteration of plant parts, vegetative as well as reproductive and leads to enhancement of the production in the long run without even causing any injury to the plant organs of any sort during the process. This complete inadversity of the growth substances to the plants is one of the primary reasons to draw and increase the interest of the plant physiologist all over the world to explore their beneficial effects in the practical field.
Amongst the growth promoting substances, Gibberellic acid is one of the most outstanding discoveries in the present century that explained many phenomena connected with plant growth and development. Gibberellic acid, first isolated by Yabuta et al. (1941), is known to work primarily by cell division and cell elongation in the subapical meristematic region (Sachs, et al., 1959).

Gibberellic acid appeared to affect almost all plant organs that subsequently regulate the reproduction and yield of a plant. However, most dramatic effect of the Gibberellic acid is the transformation of dwarf plants into tall ones through stem elongation (Brian and Hamm ing, 1955). Flowering was delayed in cuprid sweet peas as a result of GA<sub>3</sub> application to the apex. However, GA<sub>3</sub> increased the number of flower buds and number of seeds and improved the mean seed weight (Brian et al., 1959).
Kanwar and Chopra (1961) showed from pot culture experiments that the yield of berseem can be increased markedly by spray application of $GA_3$. The maximum yield of 110.5 gm/pot was obtained with 1.5 mg of $GA_3$ as against 40.8 gm/pot of control. Similar significant results in straw and grain yield were obtained for sorghum plants also following spray applications of $GA_3$ (Pillai and Chandhoke, 1961; Morgan et al., 1977). They found that $GA_3$ stimulated the plant height and production of leaves and finally promoted tillering.

Foliar application of $GA_3$ on cowpea (Vigna unguiculata L.) seedlings also increased the plant height, number of branches and leaves, enhanced dry matter accumulation and finally increased the seed yield by 28.1% in respect of control at the higher concentration of 25 ppm, the lower concentration of 10 ppm being less effective. (Yadava and Sreenath, 1975).

Time of application also influenced the promotive action of $GA_3$ in the productivity of crop plants as reported by Biswas and Choudhury (1977). Post flowering spray of $GA_3$ in rice plants increased the yield by virtue of increasing the most of the yield components whereas pre flowering application remained least
effective. Earlier to that Chatterjee et al. (1976) also found similar decreases in the paddy yield in two rice varieties (one tall and one dwarf) as a result of preflowering foliar spray application of GA$_3$. However, GA$_3$ considerably increased the plant height, dry matter accumulation, leaf area and leaf chlorophyll contents.

Many crop plants are reported to respond positively to seed treatment with GA$_3$ which primarily stimulate the rate of germination, accelerate the rate of growth and maturity thus finally improved the productivity.

Seed treatment with GA$_3$ at 30 ppm enhanced the yield and dry matter production in Okra (Singh et al., 1976). Identical experiments performed by Pawar et al. (1977) through seed treatment of Okra with GA$_3$ at 25, 50, 75 and 100 ppm brought about higher yields as a consequence of increased weight and size of the fruits in addition to a promotion in vegetative growth with more number of branches. Only the lower concentrations were found to be effective. Choudhury and Singh (1960) similarly obtained a better germination, quicker growth and subsequently a higher yield of fruits in tomato as a result of seed treatment with GA$_3$ for 24 hours. In contrast to these results in Okra and tomato, Teare et al. (1970)
found seed treatment of *Pisum sativum* L with GA\textsubscript{3} at different doses ineffective as far as yield components were concerned. However, GA\textsubscript{3} caused stem elongation that showed direct co-relation with GA\textsubscript{3} concentrations.

GA\textsubscript{3} was reported to have a marked effect in narcotic yielding plants like Hookah tobacco (*Saxena* and *Tyagi*, 1970). Pretreatment of Hookah tobacco seeds with 10, 50 and 100 ppm GA\textsubscript{3} markedly increased the plant height, stem diameter and number of leaves/plant as well as the fresh and dry weight of the plants.

Fibre yielding plants also reported to be well responsive to GA\textsubscript{3} treatment. Fibre length in different crops was increased mainly due to increased length of stems as a result of foliar sprayings of GA\textsubscript{3}. *Sircar* and *Chakravarty* (1960), *Kar* and *Saha* (1962) found such increase in jute, *Atal* and *Sethi* (1961) in hemp (*Cannabis sativa* L) and in sunhemp (*Crotalaria juncea* L). *Atal* (1961) also showed that in the GA\textsubscript{3} treated plants fibres (of hemp) were larger in diameter, more lignified and upto 10 times larger than those of the untreated plants.
In cotton the increased fibre production is attributed to the prevention of bud and boll shedding as a consequence of GA$_3$ applications (Dransfield, 1961; Subbiah and Mariakulandai, 1972). In both of the experiments GA$_3$ was used as a foliar spray.

Beverage yielding plants like tea also showed an increase in the yield as the leaf area expanded after GA$_3$ was applied as a foliar spray to the plants (Aono et al., 1976).

Many reports have been concerned with the gross changes in the carbohydrate metabolism and synthesis of proteins. Yet, the mechanism of action of GA$_3$ in the production of these compounds remains still clouded. It is commonly believed that GA$_3$ applications activated the synthesis of enzymes like $\alpha$-amylase, ribonuclease, protease etc. and helped maintaining an increased level of enzyme activity which in turn enhanced the synthesis of nucleic acids (DNA & RNA) as well as the proteins and sugars.

Radwan et al. (1976) observed an increase in the tuber nitrogen and carbohydrates in potato due
to GA$_3$ foliar applications. Similarly, Chatterjee et al. (1976) found GA$_3$ spray applications to increase the total nitrogen content in rice. Protein content was increased in tomato (Fattah and Jahan, 1976) in garden pea (Doijode, 1977) in pea (Merkushina, 1978) following GA$_3$ applications to the plants.

Oil content of plants like Ocimum basilicum L was reported to increase by about 21% as a result of GA$_3$ treatment (Eid and Ahmed, 1976).

(2 chloropethyl) trimethylammonium chloride - (CCC)

Chemical structure: $\text{CH}_2\text{Cl} - \text{CH}_2 - \text{N}^+ - \text{CH}_3 - \text{Cl}^-$

Tolbert reported a quarternary ammonium compound to be effective as a growth retardant in 1960. The most active substance of them is (2 chloropethyl) trimethylammonium chloride, widely known as chloro-choline chloride or abbreviated to CCC or cycocel. This growth retardant was found to retard growth in a large number of species (Cathey and Stuart, 1961).
Physiological regulation in plant height as a result of CCC application and subsequent increase in the yield was reported in many crop plants in recent years. CCC primarily works by retarding cell division and elongation of subapical meristems resulting in sturdier and stockier stems with darker green leaves. Treated plants appeared to be more tolerant to various stress conditions such as soil salinity and water stress and also to frost conditions. Promotion of flowering is yet another beneficial effect of CCC which in turn substantially contributes towards a higher yield. Increased fruit set through CCC also have a cumulative effect in greater productivity of crop plants.

Cereals as wheat has received considerable attention because of its striking response to CCC in manipulating growth and yield. Humphries et al (1965) found that CCC treatments as a soil drench increased mean grain yield by 5 percent by increasing the number of ears and the number of grains per ear in addition to an enhancement in dry matter accumulation. Mukula et al (1967) applied CCC as a foliar spray on seedlings of winter and spring wheat at 0,2.5,5.0 and 10.0 kg/ha and noted that stem growth
was reduced and lodging was prevented at 10 kg/ha and thus grain yield was increased. Enhancement in grain yield in wheat through CCC applications was also reported by Pinthua and Halevy (1965), Seitzer (1970); El-Sharkawy et al (1973); Zeidan and Mohamed (1976).

Other economically important cereals like rice, barley, sorghum etc. are also reported to respond to CCC in a very promising way.

Yadava (1971) reported CCC applications to reduce plant height in rice and to increase the accumulation of dry matter and subsequently to increase the grain yield. Ganeshan et al (1975) applied CCC on a tall and a mutant dwarf rice variety and found that plant height was reduced in both and yield was increased due to enhancement of tiller number as well as the spikelet number in the main panicle.

Larter et al (1965) observed soil drench of CCC to be more effective than the foliar application in barley. The soil application of CCC at 10^{-10} and 10^{-4} M significantly increased the tiller number and grain yield in barley plants grown under a moisture
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regime. Padner (1978) found that foliar spray of 8–10 g CCC a.i/ha to malting barley decreased lodging and increased grain yield by 5–6%. The application in higher concentration of 16 g/ha reduced the yield by reducing the number of grains/ear.

Gill et al. (1976) applied cycocel at 0.5–2 g a.i/ha to sorghum 30–60 days after sowing which decreased plant height and gave grain yield of 0.88–1.54 t/ha against 0.61 t/ha in untreated plants. The lowest concentration of 0.5 g a.i/ha was found to be most effective.

CCC also reported to prevent the bud, flower and immature fruit drop in plants and thus increase the yield. In *Vicia faba* control plants showed abscission of 11.05%, 50.5% and 20.9% respectively for flower buds, flowers and immature pods. But 250 mg/l cycocel applied to the soil a week before and again at flowering time reduced the drop to 0.80%, 1.35% and 1.10% respectively (El-Antably, 1976). But Tozani et al. (1976) did not find any significant increase in pod number or seed yield in bean plants (*Phaseolus vulgaris*) after chlormequat was sprayed.
to the seedlings. However, chromequat reduced plant height and leaf area.

Foliar application of CCC at 500 mg/l increased the seed yield by 66.6% in cowpea (Vigna unguiculata L.) as reported by Yadava and Sreenath (1975). The increase in the yield was attributed to the increase in the pod length, number of seeds/pod and also in the thousand grain weight. In addition to that CCC significantly reduced the plant height and increased the number of primary branches and leaves and the fresh weight as well.

Garg and Sing (1976) reported induction of earlier flowering by cycoel spray in cape goose berry. An increase in fruit number due to the cycoel spray subsequently led to 45% higher yield over the controls. Similar increase in the fruit yield was found in grape vine by Forlani et al (1978).

Chromequat applied to one year old strawberry plant at the start of runner development retarded the growth of the runners and increased the number of inflorescence and fruits and increased productivity for the next three years (Agafonov et al, 1978).
CCC was reported to increase the fruit yield by increasing the fruit set. Stahly and Williams (1976) sprayed chlormequat at 1500 ppm to five year old trees (CV Anjou) 4 or 6 weeks after full bloom for 2 consecutive seasons. The fruit yield was increased by 50% as a result of the treatment.

Studies on the vegetables applying CCC were found very encouraging too as far as the productivity is concerned. Esquivel and Franco (1972, 1973) obtained a 36.2% and 56.2% yield increment respectively at 1 or 2 litres/ha chlormequat application to the tomato plants 20 days after transplantation. Similar increase in the yield in Okra was reported by Chhonkar et al (1977). Cycocecal was applied at 125 - 1000 ppm to the Okra plants as a foliar application 37 days after sowing. The lowest concentration was most effective yielding 118.13 qt/ha against 82.06 qt/ha in the untreated plants. Cycocecal also shortened the height in treated plants in respect of control.

CCC or Cycocecal has already established itself as one of the most effective hormones to promote the yield in cotton - the most important fibre yielding plant in India. Foliar spray of Cycocecal arrested the
vegetative growth temporarily but developed a better root system which improved the uptake of plant nutrients from the soil. A temporary check on vegetative growth saves the plant energy for better flowering and fruiting resulting in higher yield. (Singh, 1971).

Hamawai (1965) first reported to have obtained a significant increase in cotton yield through repeated foliar sprayings of cycocel at 5, 10, 25, 50 and 75 ppm on barbadense cotton. The treatments reduced the plant height with leaves showing increase in the chlorophyll contents. Similar significant increase in the cotton yield proceeded by reduction in shoot growth through foliar applications of cycocel was reported in both hirsutum and arborum cotton (Singh, 1970; Singh et al, 1973) in hirsutum cotton (Singh et al, 1970; Chouhan and Verman, 1976).

CCC has been found to be beneficial in raising the level of chemical constituents and thus improving the quality of fruits and seeds as well.

Mahmoud et al (1967) observed that total sugar content was enhanced in Egyptian grapes
during the storage as a result of CCC applications. Similar results were obtained by Randhawa et al. (1976) in perlette grapes. Total carbohydrate and total N was found to increase after CCC applications in potato (Chowdhuri et al., 1976). Seed protein quality was improved following CCC applications in soybean (Boulinola et al., 1978). RNA and Protein concentrations also were increased in wheat after CCC application (Bokhari et al., 1973). 3000 ppm CCC was found to increase the oil content of Ocimum basilicum L by 40% (Eid and Ahmed, 1976).

A significant enrichment of iron in Vicia faba seeds was reported by El-waziri and Abo-Elliel (1975) following the pretreatment of the roots with 20 ppm chloromequat in addition to the Fe supplement to the nutrient solution applied.

\[
\text{Chemical structure: } \quad \text{H}_2\text{C} - \text{C} - \text{NH} - \text{N} - \text{CH}_3
\]

Substituted maleamic and succinamic acids were reported by Riddel et al. (1962) to retard
the growth of a number of plants. The most active compound of the group is known as Succinic acid 2,2-dimethyl hydrazide (SADH) or Alar.

Many reports have been accumulated since then regarding the effectiveness of B9 or Alar as a retardant of vegetative shoot growth as well as a beneficial chemical in promoting the crop yield to a higher level.

Shoot growth was markedly reduced in poinsettia and Hibiscus saptamukhi (Sen and Sen, 1965) in tomato (Younie and El-Tigani, 1970) and in Tokay grapes (Weaver and pool, 1971) following B9 treatments in those plants.

Yadava and Sreeranath (1975) found that seed yield in cowpea was higher by 110.0% due to foliar applications of B9 which also reduced the plant height significantly, accompanied by increased branch and leaf number. Similarly Godfrey and Nidolch (1978) also reported B9 (Alar) to retard vegetative growth in Okra (Abelmoschus esculentus) causing a higher yield by producing more number of bigger pods. In sorghum presowing treatment of B9 (Alar) was found ineffective in reducing the clum height, yet,
it increased the yield by 41.6% over the control by virtue of increasing all the yield components (Rao et al, 1976).

Nakata and Nakai (1977) reported that foliar application of B9 (daminozide) after the formation of panicles increased the grain yield significantly. Application of the compound before the formation of panicles however, decreased the yield. This differential effect of time of application of the growth retardant did not hold for fruit crops like grapes where prebloom applications of B9 were found more effective in increasing the grape-yield through an increment in bunch length and their compactness. (Martinez et al, 1975).

Vigorous vegetative growth with more branches and leaves due to B9 (daminozide) application was shown to be beneficial towards higher yield of narcotics as reported by Abou-Zied et al (1978) in Nature metal and by Rehm et al (1978) in coffee plants.

B9 (daminozide) was found to be very effective in increasing the yield of fruit trees as evident from the results of investigations pursued by many
workers in recent years. The fruit yield was increased by B9 by an improvement in the fruit set in mango (Maiti and Sen, 1968) in apples (Cook, 1968) in pears (Stahly and Williams, 1976) in litchi (Khan et al., 1976) and in concord grapes (Funt and Tukey, 1977).

B9 (Alar) was noted to improve the quality of fruits and seeds by increasing level of various chemical constituents. Sharms and Sing (1974) obtained an increase in leaf Mn, Cu and Fe levels in young pear plants after foliar application of Alar. An increase in N and P content of tobacco plants was shown as a result of foliar application of B995 (Yadava, 1975).

B9 (deminoxide) was reported to produce better quality/fruit by changing the colour in cherries (Gil and Mombarg, 1975) and also by enhancing fruit firmness in Jonathan apple (Campbell, 1977).

**Interaction**

CCC is commonly known as antigibberellin as it has been found to counteract or inhibit GA₃.
induced responses like germination, shoot elongation, flowering and senescence. Likewise, inhibitory effect of CCC can be completely overcome by the addition of Gibberellic acid (GA₃).

Tolbert (1960) first observed this mutual antagonism of GA and CCC on vegetative growth of wheat. GA alone produced plants with elongated stem with brighter green leaves than the controls while CCC alone produced stockier plants with thicker stems bearing darker green leaves. When GA and CCC were applied together they reversed the effect of each other (mutual antagonism). Later this antagonism was found in stem growth in bean (Lockhart, 1962; Fallipe, 1969) in cotton (EL-Fouly et al., 1970) in Jute (Fattah and Mallik, 1976) in internodal length in Ipomoea balsamia (Nanda et al., 1968) in dry matter of bean plants (Halavy and Monsalise, 1963) and in flowering of some plants (Baldav and Lang, 1965; Zeevart, 1967; Abdal et al., 1978). If suitable ratios of Gibberellic acid and retardants are used each cancels out the effect of the other resulting in normal growth (Cathey, 1964, Corcoran, 1975). However, their mode of action is still under controversy due to their diversity in action as was
observed from the various investigations in that field.

Combined effects of growth regulators have been tried in practical agriculture also to study their implications upon the final output of crop plants.

Sarin and Uppety (1969) reported that combined action of GA\textsubscript{3} and B9 enhanced flowering, number of pods and consequently the yield of cowpea plants, while single applications had an adverse effect on flowering and yield though the latter increased the stem elongation.

Application of B9 as a foliar spray at 1000 ppm at first bloom followed by 100 ppm GA spray at berry shatter stage (fruit set fell) significantly enhanced the yield in concord grapes through an increase in the berry size, cluster weight in comparison with the plants treated with B9 alone (Funt and Tukey, 1977). In contrast to that Pieri et al (1978) found a reduction of bunch length due to combined action of GA\textsubscript{3} and CCC in Tocai grapes.

An increase in the number of leaves, leaf
area, plant weight, tuber weight / plant and tuber
dry weight was obtained by Popravko (1976) in potato
as a result of combined application of chloromethaquat
and gibberellin.

Similarly, Hifnay and Abdel - All (1977)
found a decrease in berry size in storage conditions
due to alternate spray of GA and CCC before and after
full bloom.

Pulses, vegetables and fibre yielding plants
occupy a position of considerable economic value in
India, because of their importance in agricultural
economy of the country. These plants indeed have
great value to the mankind, as they provide the two
basic needs of human being - the food and the clothing.

Two important crops among the many varieties
of pulses that are in common use, both as pulses and
vegetables are 'cowpeas' and 'Peas'. Here we will be
concerned with these two pulses crops only. Likewise
fibre yielding plants include a number of different
varieties such as jute, hemp, cotton etc. and we will
be concerned only with the last crop mentioned
i.e. cotton.

Cowpea (Vigna unguiculata L)

Cowpea is a sub erect, trailing or climbing,
bushy annual plant that belongs to the genus Vigna under the family leguminosae (sub-family papilionaceae).

Cultivation

Cowpea is one of the principal pulses in India where it is also grown as a vegetable garden plant in its most parts. As a field crop it is grown on a limited scale in the high monsoon tracts of south west India. Generally cowpea is cultivated as a follow up crop with other cereals mainly kharif millets and the cultivation as a pure crop is very much occasional. However, cowpea has drawn much attention in recent years as a fodder crop as well as a green manuring crop in the country.

Data relating to the acreage and production of cowpea in different states in India are not available except in Madhya Pradesh where the crop is grown both as Kharif and Rabi pulse. Nearly 10,000 hectares are reported to be under the cultivation of this crop yielding about 3000 tonnes of the pulse per annum. In Assam it is grown as a green manure crop in the tea and sugarcane estates and as a vegetable garden plant in some parts of the state.

Climate

Cowpea is a warm season crop and cannot stand cold weather but capable of resisting the draught very well. The crop is very →
much susceptible to frost and heavy rains as well. It prefers arid and semi arid regions and can grow well in all types of soils with a good drainage system. Required temperature varies between 15° - 45°C, but 30° - 75°C temperature is optimum for maximum growth.

Uses

Cowpea is said to be a multipurpose legume crop, because of its manifold usefulness to man as well as to animals (livestocks). Cowpea is primarily valued for its pods and seeds used as foods. The plants either before or after harvesting furnish excellent forage for all kinds of livestocks. They are highly palatable and rich in protein and may be used also for stall feeding and as silage or hay. Cowpea has importance as a cover or green manure crop for soil improvement. The green seeds at just before maturity make an excellent nutritious vegetable, while the ripe seeds are used only after they are boiled. Sometimes these seeds are used as dal which is however considered less wholesome than other pulses like urad or mung. Ripe seeds are used to make flour from which one can make sweets, cakes or even porridge. The tender pods are consumed as vegetables.
Seeds are high sources of proteins as they contain proteins 19 - 30% and 54.5% Carbohydrate in addition to a good amount of vitamins and minerals. Even the tender pods supply 3.5% protein and 8.1% carbohydrates.

**Pea (Pisum sativum)**

Pea is a sub-erect trailing or climbing annual herb as like as cowpea and belongs to the genus *Pisum* under the family Leguminosae (Sub-family papilionacaeae). It had its origin in Europe and Western Asia (Thompson, 1949).

**Cultivation**

Pea is grown as a garden or field crop throughout the temperate regions or as a cool season crop or hilly country crop in the tropics. Some of the countries where pea is grown in large scales are China, U.S.S.R., India, U.S.A., Ethiopia and Congo. The first three countries account for more than three fourths of world production.
In India, pea is grown on an area of 1.2 million hectares in Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Assam and Maharashtra. Uttar Pradesh becomes the highest grower of pea in field scale as it includes 83% of the total area of the country under the cultivation of this crop.

**Climate**

Pea is adapted to a temperature range of 7° - 24° C with an optimum range of about 21°C. Dry weather does not suit pea cultivation, as it interferes in seed setting and lowered the quality of pods. Peas grow best in regions where there is a slow transition from cold to warm weather.

**Soil**

The field pea is generally grown on loams and clay loams. It does not thrive on a highly acid soil. The suitable pH range for the plant is 5.5 to 7.5.

**Uses**

Pea is known primarily for the nutritional value
of its seeds. Seeds are used both as vegetables and pulses in human diet. The dried seeds of the field pea constitute the chief commodity of commerce. In India, it is often split, like other pulses, into dal or in some places used for making roasted or parched pea. Canning and freezing practices have been adopted using pea in a large scale. The green plant as well as the pods and grains, and the hay make nutritious fodder for the livestock.

The pea plants are sometimes used as a winter green manuring crop, the average amount of green matter and nitrogen turned out as 18,500 kg and 67 kg respectively per hectare.

Peas are highly nutritious as it contains a high percentage of proteins (19.7% - 30.0%). The green peas are considered as an excellent food supplying adequate quantities of vitamins and minerals along with carbohydrates.

Peas also have some medicinal value. Dried
peas yield 1.2% of a pale golden yellow fatty oil that prevents pregnancy.

India earns a considerable amount of foreign exchange by exporting dried peas. The chief importing countries being Sri Lanka, Malaysia, Singapore and Saudi Arabia.

Cotton (Gossypium hirsutum)

It is a small genus under the family Malvaceae, with annual or perennial shrubs or small trees, distributed in the tropical and sub tropical regions of Asia, Africa, America and Australia. The plant yields cotton fibres, the most important natural staple fibre used for cloth making industry all over the world.

Cultivation

India has had a long history of cotton cultivation. She enjoys the distinction of being the earliest country to domesticate cotton and utilize the fibre for manufacturing fabrics. Eviden-
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-ncs of antiquity has been traced to Mohenjodaro, the date of which is estimated to be 2,750-3000 BC. Some of the main cotton producing countries in the world are India, Pakistan and China in Asia; Egypt, Sudan, Uganda and Congo in Africa; U.S.S.R. and Turkey in Europe and U.S.A., Mexico, Brazil and Argentina in America.

In India, the area of cultivation which was around 4.2 million hectares in 1947 has progressively increased and has now stabilised itself around 7.8 million hectares. Prior to the partition of India in 1947, India occupied the second rank, first being U.S.A. among cotton producing countries in the world. At present she ranks fourth, the production in India being now surpassed by that in U.S.S.R. and China.

Climate

The crop grows successfully in locations with a mean annual temperature of over 20°C, annual rainfall of at least 500 mm with abundant sunshine during the period of boll maturation and harvesting of the
produce and a frostless season of 180 to 240 days under north Indian conditions. The optimum temperature range during the vegetative growth phase is $25^\circ C - 30^\circ C$.

**Soil**

For good plant growth, cotton generally requires a soil with good moisture holding capacity. The soil should also have good drainage and aeration as the crop cannot stand excessive moisture and water logging. The required pH value ranges from 5.5 - 8.5.

**Uses**

No agricultural commodity in the world has exercised such a profound influence on day to day life as cotton has done from time immemorial. In India it has had the pride of place among the cash crops from the earliest times.

Cotton is primarily required for producing a wide range of fabrics both of pure cotton as well as
of blends of cotton and various synthetic fibres. It is also used in rubber tire fabrics and as it is almost a pure cellulose, its use in cellulose industry as a basic raw material is essential. Unspun cotton is used in stuffing pillows, cushions etc. Even the stalks and the roots have some importance as they are used in paper making and drugs respectively. Oil is extracted from the seeds and this cotton oil is a good substitute for olive oil. and can be used for cooking purposes as well as for making soaps. The oil cake is used as a manure and as a food for the domesticated animals.

Consumption of cotton in India

Cotton consumption in India increases year after year in the context of growing demand to feed the various industries in the country to meet proportionately the increasing requirement of cotton products with the increased population. This fact has also been supported by the data published by the Indian Cotton mills federation (1980) that in 1960-61 the requirement of cotton as a raw material, for the various industries in India was only 56.89 bales including 11.93 bales of imported cotton. But
in 1978-79 this level of consumption rose up to 69.81 lakh bales including 1.46 lakh bales of imported cotton. The sharp fall in the quantum of imported cotton is quite impressive as it reflected a rosy picture of progressive increase in the cotton production in the country. This is further supported by the data shown by Srinivasan* (1979) that the cotton production reached 75-77 lakh bales during 1978-79 from 47.63 lakh bales in 1970-71.

Self sufficiency has been attained in the production of long and extra long staple cottons that largely accounted for the sharp fall in the amount of imported cotton. On the other hand, the country has a serious shortfall in the order of 15-20 lakh bales per year in medium staples which constitute 50 percent

*K.V. Srinivasan, Retired Director, CICR Nagpur and Scientist Emeritus, CICR Regional Station, Coimbatore, India.
of the consumption in the industry, because bulk of the cloth produced by the mills in the country and used by the common man is made out of medium staple cotton. Besides, the Government of India has also accepted a firm policy in producing control varieties of clothes for the benefit of the common man, for which also medium staple cotton is needed. At the moment, the country has no option other than to depend on the imported cotton of that category. This, indeed, means an erosion of foreign exchange reserve of the country in view of the high spurt in cotton prices all over the world. Thus there is an urgent need for increasing the production of medium staple cottons.

Another aspect of agricultural economy which cannot be ignored is the earning of foreign exchange by exporting surplus raw materials of cotton or its end products. Relating to the export of cotton and its products, it has been reported that India earned foreign exchange to the extent of 6,477.20 million rupees exporting cotton yarn as well as other cotton products in the year of 1979 (ICMF, 1980). This itself is a clear indicative
of the fact that cotton provides a very good ground in export earning of the country and thus it could be of immense value in boosting up the dwindling economy of our country in a speedier way.

The literature review in the earlier pages aptly revealed the benefit of using growth regulators like $GA_3$, CCC and $B_9$ in boosting up the yield of various crop plants of economic importance. Even they are found to produce better quality fruits by raising the level of constituent minerals and vitamins, carbohydrates and proteins, fats and oils.

The review further revealed that growth regulators have been very sparingly used on some of the pulse crops like pea and cowpeas and the scope of full manifestation of the action of growth regulators upon the growth and especially on the yield of these two crop plants still remains unsealed to a great extent. Production of pulses remains stagnant at the same level for several years in India (Ramanujan*, 1979). This contention if and when viewed against the spurt in population in the country

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calls for an immediate break-through in the production of pulses in the country. In that case, growth regulators, with their manifold beneficial effects may come to rescue.

For cotton also, lesser attention has been paid to the use of Gibberellic acid (GA) as far as the crop growth and crop productivity is concerned. However, things are found to be different with CCC or cycocal. Cycocal has been in extensive use in recent years in India as evident from the review; yet, it is also clear that in all these experiments the cotton plants were subjected only to foliar applications of the compound (cycocal). Seed treatment which is a very effective method of application of growth substances augmenting better crop growth and subsequently the yield, has found little or no attention in respect of higher productivity of the cotton crop. The seed treatment has another advantage that it is quite less expensive owing to a requirement of lesser quantity solutions in the process. Thus the prospect of upgrading the cost-benefit ratio also becomes brighter than ever.
The review again left an impression that there are virtually no reports on the antagonistic behaviour of \( \text{GA}_3 \) and CCC on the growth and its effect on yield of these crops, though some beneficial effects of their joint actions were noticed for wheat, potato and some other fruit crops like grapes. Antagonism or synergism between the growth regulators on vegetative as well as reproductive growth of the crop might lead to a change in the crop yield subsequently.

In view of these assessments a series of field investigations was conducted at the experimental farm in the Department of Agricultural Botany, Gauhati University, during 1977-1980 with the following research objectives:

1) To study the effect of \( \text{GA}_3 \) and CCC, applied both singly and in combinations, on growth, yield and quality of cowpea.

2) To study the effect of \( \text{GA}_3 \) and CCC applied both singly and in combinations, on growth, yield and quality of pea.

3) To study the effect of seed treatment of \( \text{GA}_3 \) and CCC, applied both singly and in
combinations on growth and yield of a medium staple hirsutum cultivar of cotton.

4) To study the effect of CCC applications alone on growth, yield and quality of pea.

5) To study the effect of B₉ applications alone on growth, yield and quality of pea.

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