INFLUENCE OF GROWTH REGULATORS ON PRODUCTIVITY POTENTIAL IN SESAMUM (*Sesamum indicum* L.) GENOTYPES

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By

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CERTIFICATE

This is to certify that the thesis entitled "INFLUENCE OF GROWTH REGULATORS ON PRODUCTIVITY POTENTIAL IN SESAMUM (*Sesamum indicum* L.)GENOTYPES" submitted by Mr. CHOUGALE D.Y., for the degree of MASTER OF SCIENCE (AGRICULTURE) in CROP PHYSIOLOGY, to the UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD, is a record of research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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Affectionately placed in
The Golden feet of my beloved father
Late Shri Yallappa Chougale
and mother
Smt. Sumitra

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(CHOUGALE, D. Y.)

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INTRODUCTION

I INTRODUCTION

We are fortunate to have a wide range of oilseed crops grown during *kharif* and *rabi* seasons in different agroclimatic conditions. India is one of the largest producer of oilseeds in the world, accounting 10 per cent of the global oilseed production but uses 20 per cent of the world land area to produce it. Over years, though, the total production has considerably increased from 9.3 million tonnes in 1980-81 to 21.4 million tonnes in 1994-95, but it has not kept pace with its increasing demand. The edible oil requirement is met from imports and the increase in production has essentially come from an increase in area than an increase in yield per unit area. Now, there is a growing optimism that, if this tempo of progress in production is maintained, the target of 26 million tonnes set for 2000 A.D. could be met and the country could be in a position to phase out the import of edible oils rather completely.

Among nine major oilseeds produced in India, sesamum (*Sesamum indicum* L.) is one of the oldest and the third most important oilseed crop next only to groundnut and rapeseed mustard. Its area and production in India (1994-95) stood at 2.6 million hectares and 0.81 million tonnes as against the global area and production of about 6.68 million hectares and 2.3 million tonnes, respectively (Anon., 1995). In India, Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Andhra Pradesh and Rajastan are the states where sesamum is being cultivated extensively. In Karnataka, sesamum is cultivated over an area of 1.8 lakh hectares with a production of 0.8 lakh tonnes (Vikas Singhal, 1995) covering Bidar, Gulbarga, Bijapur, Dharwad, Raichur and Belgaum which are important districts where it is cultivated extensively.

Sesamum, a short day plant with indeterminate growth habit, belongs to family Pedaliaceae and is commonly known as ellu, gingelly, tal, til, yellu, etc. in different places. Sesamum is considered as the "Queen of oilseed crops" by virtue of its excellent oil quality and its importance in the domestic use. Among oilseed crops, sesamum ranks first for having highest oil content (46-64%) and 6355 kcal kg^{-1} dietary energy in seeds (Sanjaykumar and Goel, 1994). Seed is also a rich source of proteins (20-28%), sugars (14-16%) and 5 to 7 per cent minerals (Kuldip Singh and Gupta, 1973). Its oil is having about 80 per cent unsaturated fatty acids,

mainly oleic and linoleic acids. Indian output comprises different varieties like white, black and brown seeds. The natural white seed with high purity has desirable taste and is used in making sweets and confectionery products.

Though sesamum is rich in oil content, its productivity is very low as compared to other oilseed crops. The main reason for low productivity of this energy rich crop is due to large scale cultivation under the energy starved conditions under rainfed agriculture, which is risk-prone and almost a gamble with the rains. The main physiological reasons for low productivity could be poor source-sink relationship, low translocation efficiency at later stages of crop growth and the shedding of flowers and other reproductive parts.

Plant growth regulators may be considered as a new generation of agrochemicals after fertilizers, pesticides and herbicides. These are the chemical substances, when added in small amounts modify the growth of plants usually by stimulating or inhibiting part of the natural growth regulatory system. About 60 plant growth regulators are now commercially available and several of them have reached considerable importance in crop production. The growth regulators include both growth promoters and growth retardants which have been shown to modify the canopy structure and other yield attributes.

Growth retardants are known to reduce internodal distance, thereby enhancing source-sink relationship and stimulates the translocation of photoassimilates to the seeds (Luib*et al.*, 1987). The growth promoters like NAA and cytokinins enhance harmone modified translocation of photosynthates which will help in better seed filling at the later stages of the crop growth. There is hardly any precise and conclusive information availble in this regard in sesamum. Therefore, studies were initiated to find out the effect of plant growth regulators (both promotors and retardants) on productivity potential in sesamum genotypes with the following objectives.

1. To find out the physiological and biochemical changes due to the application of growth regulators in sesamum genotypes.

2. To find out the influence of growth regulators on partitioning efficiency in sesamum genotypes.

3. To find out the effect of growth regulators in regulating the phenological stages and flowering efficiency in sesamum genotypes.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The role of plant growth regulators (PGRs) in various physiological and biochemical processes in plant is well known, which enables a rapid change in the phenotype of the plant within one season to achieve desirable results. The plant growth regulators are known to affect right from seed germination to senescence either by enhancing the growth (growth promoters) or by reducing the plant height (growth retardants), flowering, fruit and seed development, fruit ripening and yield. Sesamum often produces more vegetative growth than is needed for maximum capsule production and seed yield, especially when climatic conditions favour vegetative growth, thereby directing the nutrients and photoassimilates towards the vegetative growth rather than reproductive growth. This chapter emphasizes the recent work on the synthetic plant growth regulators in sesamum and related oilseed crops and their effects on morphological, physiological, biochemical parameters and yield attributes.

2.1 MORPHOLOGICAL CHARACTERS

Sesamum is an annual herb having erect green angular stem with opposite or alternate leaves and lower leaves tend to be broad, some times lobed. The opposite arrangement of leaves encourages multiple flowering and flowers arise in the axil of the leaves, on the upper portion of the stem and branches. In some Indian varieties, flowers may occur singly in the leaf axil on the lower part of the stem, but at two to three per axil on the higher part of the stem and branches. Basically, sesamum is a short day plant with a ten hour day length enhances the flowering. The fruit is a capsule and the number of capsules per plant is directly related to the number of flowers per plant.

2.1.1 Plant height and number of branches

Plant height and number of branches are influenced by the interaction between the environmental conditions and genetic make-up of the plant. Planofix is a growth promoter which increases plant height, whereas cycocel is a growth retardant which reduces the plant height when applied at bud formation stage in sunflower (Kene *et al.*, 1993). The repeated foliar

application of benzyladenine at 50 ppm was found to result in increased plant height in sunflower (Goswami and Srivastava, 1987).

Bora (1988) worked on the effect of triazoles (Paclobutrazol and XE-1019) on growth and yield attributes of sesamum and reported a decrease in plant height. Treatment of triazole growth retardants such as triapenthenol, flurprimidol and BASH at the beginning of the stem extension reduced stem length and increased lateral bud outgrowths which led to increased branching in rape (Child *et al.*, 1989). Similarly, foliar application of hymexazol gave the highest number of nodes and branches per plant in sesamum (Jung, 1991).

The effect of growth retardants vary with plant species, variety, concentration used, method of application and various other factors which influence the uptake and translocation of chemicals. Ogilvy (1985) reported that the foliar application of Cycocel (chlormequat), Cerone (ethephon) and Terpal (Mepiquat chloride and ethephon) at the start of stem extension resulted in retarded vegetative growth in rape, but none of the growth regulators affected the branching pattern.

2.1.2 Number of flowers per plant

Jain *et al.* (1985) identified high rate of bud, flower and capsule abscission as the cause of low yields in sesame. Abscission of these organs can be prevented with the help of various synthetic plant growth regulators such as benzathiadiazole, morphactin and ethephon (Bora, 1981).

Li *et al.* (1987) reported that the treatment of Pix (mepiquat chloride), CCC (chlormequat) increased the flower number in sesamum. Similarly, Bora (1988) observed reduced abscission of flowers in sesamum with the application of growth retardants.

2.1.3 Number of capsules per plant

The number of capsules per plant is determined by the number of flowers which ultimately form the yield contributing parameter in sesamum. Whatever the flowers produced

will not set into capsule, some of them get lost prematurely thereby reducing the total number of capsules per plant. The number of fruits per plant can be increased by using growth regulators which reduces pre-mature flower and fruit drop. Bora (1988) while studying the effect of triazoles on growth and yield attributes in sesamum noticed increased number of capsules per plant by preventing the abscission of flowers and capsules.

The effect of 0.01 per cent Pix (Mepiquat chloride) and 0.1 ml of 50 per cent CCC on sesamum seed treatment was demonstrated by Li *et al.* (1987) and noticed an increased flower and capsule number per plant. Similarly, Budzynski and Ojczyk (1995) reported reduced lodging of plants with 15 per cent increased siliqua in rape when triapenthenol was applied at the rosette stage. When terpal (chlormequate + ethephon) was treated during vegetative growth with 1.5 litre, increased the total dry weight of the plant in rape along with more number of pods per plant (Megale *et al.,* 1990).

The yield components responded well to applied plant growth regulators such as 1 ppm ABA, 1 ppm GA_3, 0.01 ppm epibrassinolide and 5 ppm kinetin and yield increase was due to increased number of pods per fertile nodes in soybean (Kamal *et al.*, 1995). Similarly, the number of immature pods per plant were decreased when 125 ppm Mepiquat chloride was sprayed at 70 days after sowing in groundnut (Chandrababu *et al.*, 1995). The effect of growth regulators depends on the concentration, application dates and whether the crops were grown in monoculture or intercropped. Lee *et al.* (1986) showed that application of B-9 and GA_3 before flowering and after flowering increased capsule number per plant in sesamum and shortened the maturity period when grown after barley in sesamum.

2.2 PHENOLOGICAL STAGES

Sesamum having indeterminate growth habit, both vegetative and reproductive growth occur simultaneously and after some period, the number of reproductive parts get reduced resulting in reduced/lack of sink. Maintenance of higher level of chlorophyll, protein and RNA in rape for longer duration would delay the senescence of leaf when treated with CCC and SADH at 40 DAS (Kar *et al.,* 1989).

Anderson *et al.* (1965) reported that pre-flowering treatment with TIBA delay the maturity whereas, treatments at flowering or after flowering hasten the maturity in soybean. Delayed flowering was also observed in Helianthus sprayed with MH at 1000 ppm (Sen and Sen, 1968). A spray solution of 10 ppm of cytokinin applied to safflower at the 1st true leaf stage delayed the senescence (Patil *et al.*, 1980) whereas, 3 per cent paraquat + 25 ppm of ethephon accelerated leaf drop, drying of stems and capsules and shortened the maturation time in sesamum (Rojus and Salinas, 1981). Similarly, the application of folcysteine at flower initiation and 15 days later, increased the seed yield from 0.75 to 1.25 t ha^{-1} due to increased flower retension in sesamum (Salinas and Rojus, 1981).

Polowick and Sawnhey (1991) conducted *in vitro* studies on the growth and development of young inflorescence of rape and concluded that cytokinin is required for normal maturation of floral buds, including the completion of microsporogenesis and BA was most effective of the cytokinins tested. More vigorous growth of seedlings and flower bud differentiation was due to higher carbohydrate content and plant dry weight when 400 ppm paclobutrazol was sprayed on to rape (Shyen *et al.*, 1990).

2.3 DRY MATTER PRODUCTION AND ITS PARTITIONING

Total dry matter production and its partitioning is the integral part of the growth over the entire growing period and is related to seed yield. Sesamum often puts on lot of vegetative growth when climatic conditions favour and whatever the dry matter accumulated will not be utilized for reproductive development due to lack of translocation efficiency to different parts. The application of 250 or 500 ppm IAA increased the non-reducing sugars in leaves at flowering stage while 100 or 200 ppm of GA increased it at pod formation stage thereby increasing the seed yield to 0.55 and 0.58 t ha^{-1} as compared with the untreated control (0.35 t ha^{-1}) in sesamum (Sontakey *et al.*, 1992).

Pando and Srivastava (1985) reported that the application of cycocel was found to increase the RuBP carboxylase enzyme activity, photosynthesis and dry matter partitioning in both *rabi* and summer sunflower, while the combination of N-triacontanol with paras or planofix

increased the dry matter accumulation in *Brassica juncea* (Ghosh *et al.*, 1991). However, the spraying of triapenthenol increased the number of leaves per plant, reduced plant height and shoot weight in rape (Bury and Kozak, 1993).

According to Kettlewell *et al.* (1984), 1.36 kg ha^{-1} chlormequat treated rape produced maximum dry matter as compared to untreated control. The dry matter production and seed yield ranged from 1.29 to 2.28 kg m^{-2} and 244 to 538 g m^{-2}, respectively. Photoassimilate distribution is under harmonal control and the maximum seed yield was achieved in sunflower with the application of Benzyladenine (150 or 250 mg $litre^{-1}$) and GA (150 mg $litre^{-1}$) at 40 days after emergence and which was due to an improvement in photoassimilatory distribution (Beltrano *et al.*, 1994). The effect of cycocel and planofix on growth and yield of sunflower was studied by Kene *et al.* (1991b) and reported that the plant height was decreased by cycocel but increased by higher rates of planofix and dry matter yield was increased more by cycocel than planofix.

Lovett and Orchard (1977) reported that CCC not only reduces the plant growth but also there was a reduction in the accumulation of dry matter in stems, leaves and petioles of sunflower, besides reduction in leaf area. Whereas, the application of 125 ppm of mepiquat chloride recorded the maximum leaf weight, haulm weight, total plant dry weight and total pod yield in groundnut (Chandrababu *et al.*, 1995).

2.4 GROWTH AND GROWTH PARAMETERS

The division, expansion and differentiation of plant cells are the functions of the plant growth and are not only affected by environmental factors but are also controlled by plant growth regulators. Study on leaf parameters is very important since they are the major assimilatory organs of the plant. Sahod *et al.* (1989) reported that the foliar application of 20 ppm NAA (planofix), GA or IAA at 25 and 40 days after sowing increased RGR, NAR and plant dry weight in sesamum. However, 0.3 or 1.0 ppm paclobutrazol or Uniconazole applied to the soil at 100 ml pot^{-1} decreased the plant height, RGR, NAR and seed yield, but increased the leaf area ratio (Bora, 1988).

Pando amd Srivastava (1985) studied the effect of CCC on leaf area, photosynthesis and translocation and observed reduced plant size and leaf area when 3000 ppm of cycocel was applied at pre and post flowering stages but the translocation of sucrose from the leaf to the capitulum was increased in sunflower. Similarly, Li *et al.* (1987) noticed increased leaf area index in sesame when treated with 0.01 per cent Pix (Mepiquat chloride) and similar results were also obtained by Child *et al.* (1989) in rape.

Under dry conditions, increased transpiration is the main constraint and that can be avoided by applying 4000 ppm of chlormequat to sunflower, which was mainly due to reduced leaf area (Orchard and Lovett, 1980). According to Kulkarni (1993), LAD and SLA decreased significantly with a significant increase in SLW at all the stages except at 40 and 55 days after sowing. Whereas, AGR, CGR, RGR and NAR decreased at 55 days after sowing and increased at maturity when two sunflower genotypes were treated with 1000 ppm of mepiquat chloride.

2.5 BIOCHEMICAL PARAMETERS

Apart from the morphological and physiological alterations, growth regulators also influence various biochemical parameters thereby bringing alterations in quality characters in various crops.

2.5.1 Chlorophyll content in leaf

Among various functions of growth regulators, they also cause induction of greening in plants. In a study to know the effect of cycocel on growth and metabolism of sunflower, cycocel not only reduced the plant height at 0.4, 0.6 or 0.8 per cent concentrations, but also increased the chlorophyll, protein, amino acids, total soluble sugars and starch content in leaf (Kumari *et al.*, 1990). According to Kumari and Bharti (1992) while working on the effect of cycocel and FAP on photosynthesis in sunflower under stimulated drought conditions, reported that cycocel and 6 Furfuryl amino purine (kinetin) treated plants showed increased relative water content, total soluble protein and chlorophyll content with decreased protease activity.

Goswami and Srivastava (1988) reported that the application of BA with 50 or

100 ppm in sunflower decreased protease enzyme activity in the lower leaves at later stages, while it increased slightly in the younger leaves and delayed the loss of chlorophyll in both older and younger leaves. Similarly, Srivastava and Goswami (1988) opined that repeated application of benzyl adenine (50 ppm) increased leaf chlorophyll contents, chlorophyll a:b ratio and ribulose 1, 5-bisphosphate carboxylase acitivity. Whereas, at early growth stage, BA had no effect in sunflower. Bai and Kastori (1990) reported that cytokinin treatment (50 mg litre^{-1}) over the surface of the yellowing leaves increased the chlorophyll 'a', chlorophyll 'b' and carotenoid contents in the chloroplasts of sunflower. Synthesis of chlorophyll 'a' and 'b' was stimulated by 50 ppm chlorflurecol but not by higher concentrations (Lord *et al.*, 1985).

In a study to know the effect of paclobutrazol on growth and metabolism of soybean, Sankhla *et al.* (1985) noticed retardation of senescence with enhanced concentration of chlorophyll and protein in plant tissues. Similarly, the application of paclobutrazol to *Brassica carinata* had higher total chlorophyll content than those of control plants and had decreased chlorophyll 'a' and 'b' ratio (Setia *et al.*, 1994).

2.5.2 Chlorophyll content in capsule

In sesamum, capsule wall also contain chlorophyll which contributes assimilates for grain development. Biswas and Ghosh (1989) worked on monocarpic senescence in relation to yield of *Sesamum indicum* during source-sink alteration and reported that smearing of kinetin increased the chlorophyll content in capsule wall and seed weight per capsule. The smearing was more effective than injection, whereas, ABA delayed the senescence of leaves and capsule walls and increased the seed weight per capsule when applied to the capsule wall, but not when injected.

2.5.3 Nitrate Reductase Activity (NRA)

Assimilation of nitrate involves a series of enzymatic reactions catalyzed by the enzyme nitrate reductase which is cytoplasmic, containing molybdenum and flavin co-enzyme, FAD. Repeated application of benzyladenine keeps the sunflower leaves functional for a longer

period and thereby maintains high nitrate reductase activity during the reproductive development in order to supply the nitrogen for the synthesis of enzymes and maintenance of higher photosynthetic rate in the leaves (Goswami and Srivastava, 1989).

Bashist (1988) reported that GA reduced the sugar level, chlorophyll and Hill-reaction activity thereby GA treated sesamum seedlings showed reduced nitrate reduction and uptake. Similarly, the foliar application of cycocel with 3000 ppm to sunflower at 33 and 53 days after sowing decreased the nitrate reductase activity during early growth stages, while 5000 ppm chlormequat decreased throughout all the growth stages (Pando *et al.*, 1988). According to Yang *et al.* (1994) treatment of 0.05-1.00 ppm S3307 (uniconazol) to rape increased the activities of SOD (superoxide dismutase), CAT (catalse) and NR (nitrate reductase) by 7.5-10.6, 56-90 and 156.4-69.2 per cent, respectively.

2.5.4 Protein content in seed

Li *et al.* (1987) found increased protein content in sesamum seed when seeds were treated with 0.01 per cent Pix (mepiquat chloride), 0.1 ml of 50 per cent CCC. Uppar and Kulkarni (1989) studied the effect of nitrogen and growth regulators on seed yield and quality of sunflower and found increased 1000 seed weight, protein and oil contents due to the application of 250 ppm TIBA, 15 ppm kinetin and 2500 ppm cycocel and the maximum increase was in TIBA than CCC and kinetin.

Setia *et al.* (1994) reported that paclobutrazol treated *Barssica carinata* plants showed 218.1 mg g^{-1} dry mass increased the seed protein content as compared to control (180.2 mg g^{-1} dry mass) whereas oil content was slightly decreased.

2.5.5 Oil content in seed

Sesamum is a rich source of oil which contains about 80 per cent unsaturated fatty acids, composed mainly of oleic (18:1) and linoleic (18:2) acids. In general, white co+loured seeds contain more oil depending upon the gentoypes and environment. Al-Gharbi and Yousif (1989) recorded increased seed oil content with CCC treatment whereas, GA increased the

seed protein content in sunflower. Effect of some growth regulators on seed yield and oil content of sunflower was studied by Parmilsingh *et al.* (1990) and reported highest seed yield and oil content when 2 µg triacontanol/ml was sprayed.

According to Nagarjun *et al.* (1980), 500 ppm of MH had no effect on seed protein content in groundnut whereas, 500 ppm and above concentrations of MH significantly increased the oil content. However, Gurubakshsingh and Sharma (1982) noticed increased pod protein content with MH while it had little effect on seed oil content in sesamum and groundnut.

Higher (40 ppm) and lower (10 ppm) concentrations of NAA neither affected oil content nor influenced oil yield of sesamum (Garai *et al.*, 1990). Increased oil content in oilseeds due to the application of growth regulators were also noticed by Pando and Srivastava (1987), Uppar and Kulkarni (1989) and Kene *et al.* (1992).

2.6 YIELD AND YIELD ATTRIBUTES

Under good crop management conditions in the rainfed areas, the highest yield levels obtained through improved package of practices, aproached 11.1 q ha^{-1} in sesamum (Rai, 1994). The difference in the yield levels with improved package of practices and farmers practice showed greater potentility of achieving productivity equals to groundnut and sunflower.

2.6.1 Seeds per capsule and test weight (1000)

According to Bora (1988), the application of paclobutrazol and uniconazole decreased the plant height along with 1000-seed weight in sesamum. Similarly, the application of triapenthenol reduced the number of seeds per siliqua but 1000-seed weight was not affected (Natt, 1990) in rape. In a study to know the effect of gibberellic acid and benzyladenine upon yield components in sunflower, Beltrano *et al.* (1994) found increased achene weight, 1000-achene weight and achene number in the inner portion of the capitulum.

In a trials with winter rape, Svaton and Palka (1988), reported decreased seed weight per capsule and 1000-seed weight when paclobutrazol and triapenthenol were treated.

However, the application of planofix (60 ppm) and 1500 ppm of cycocel increased the number of filled seeds per capitulum, percentage of filled seeds and 1000-seed weight in sunflower (Kene *et al.*, 1991a). Similar results were obtained by Kulkarni (1993) with 250 ppm maleic hydrazide, 50 ppm TIBA, 1000 ppm cycocel and 100-1000 ppm mepiquat chloride in sunflower.

2.6.2 Seed yield (q ha^{-1})

Sontakey *et al.* (1991) reported that the application of IAA (100 ppm), abscissic acid (250 ppm) and gibberellic acid (500 ppm) increased the seed yield in sesamum from 0.46 to 0.58 t and decreased from 0.47 to 0.36 t and from 0.49 to 0.35 t ha^{-1} with an increase in the rate of these chemicals from 100 to 500 ppm, respectively.

Similarly, Liang *et al.* (1994) found increased seed yield in groundnut when PP333 (Paclobutrazol) was given at flowering stage. Whereas, Tripathy *et al.* (1996) noticed highest seed yield of 1.43 t ha^{-1} and 1.36 t ha^{-1} in sesamum when 25 ppm of IBA and 20 ppm NAA were sprayed, respectively .

Cytozyme (containing cytokinin, auxin, enzymes and chelated micronutrients) recorded the maximum seed yield in safflower (789 kg ha^{-1}) when applied as foliar spray, but same chemical as seed treatment (2.5 ml per kg seed) with recommended doses of fertilizer gave seed yield of 888 kg ha^{-1} in safflower (Ingole and Puranik, 1992). Similarly, Mimbar and Wardhani (1993), recorded 2.3-2.4 t ha^{-1} of yield with 0-900 ml of cytozyme as against 2.1 t ha^{-1} (control) in soybean.

Impact of drought can be offset by treatment with growth regulators. In a field experiment where, the plants were subjected to drought conditions and treated with chlormequat (10-2 g $litre^{-1}$) sunflower seed yield was increased by 12.6 per cent over control (Zafirova *et al.*, 1987). Whereas, Kar *et al.* (1989) reported that when dikegulac sodium (100, 250 or 500 µg ml^{-1}) and CCC (500, 1000 or 2000 µg ml^{-1}) were applied at 40 days after sowing to safflower, increased the seed yield along with number of branches but low concentration of both retardants found effective. Similarly, Deotale *et al.* (1994), found increased seed yield by 25 (100 ppm) to

75% (with 600 ppm) over the untreated control in safflower when crop was sprayed with 100-1100 ppm of TIBA at 40 days after sowing.

While studying the effect of TIBA under different plant population levels in sunflower, it was observed that the foliar application of TIBA in combination with Navaras or planofix at higher plant population gave seed yield similar to that of hand pollination crop (Subbaiah, 1983).

MATERIAL AND METHODS

III MATERIAL AND METHODS

Plant growth regulators play an important role in agricultural and horticultural crop production both by enhancing shoot growth and reducing the unwanted shoot elongation. These chemicals are now used extensively at almost every stage of development of the plant to modify the canopy architecture and other quality and yield attributes. Several possible reasons may be attributed for low productivity in sesamum such as, pre-mature flower and fruit dropping, imperfect relationship between vegetative and reproductive growth and imbalance in photoassimilatory distribution. However, information on the effect of growth regulators in sesame is inadequate. Hence, the present experiment was conducted to study the influence of growth regulators on productivity potential in sesamum genotypes.

A field experiment was conducted during *kharif*, 1995 to study the "influence of growth regulators on productivity potential of sesamum (*Sesamum indicum* L.) genotypes". The details of the materials used and techniques adopted during the course of investigation are described in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was carried out in plot No 126 A of E block on medium black soils of Agriculture College Farm, University of Agricultural Sciences, Dharwad.

3.2 CLIMATE

The College of Agriculture, Dharwad is situated in the transitional tract at 15°26' N latitude, 76°07' E longitude and at an altitude of 667 m from the mean sea level. The total rainfall during the experimental year was 779.0 mm., which was distributed from April to November with a peak in July.

The meteorological data of previous 45 years and the year of investigation recorded at the Meteorological Observatory, Agricultural College Farm, Dharwad are presented in Table 1. The mean maximum temperature during 1995 varied from 37.4°C (May) to 26.2°C

Table 1. Monthly meteorological data for the year 1995-96 and average of 45 years (1950-1995) at Agricultural College Farm, Dharwad

Month	Rainfall (mm)		Maximum Temp. (°C)		Minimum Temp. (°C)		Relative Humidity (%)	
	1995-96	1950-95	1995-96	1950-95	1995-96	1950-95	1995-96	1950-95
July	184.40	164.58	26.20	25.93	20.90	20.29	87.00	89.04
August	50.50	110.72	28.10	26.22	20.70	20.27	85.00	87.04
September	121.60	97.95	28.20	28.56	20.50	19.76	82.00	81.65
October	127.60	129.12	29.30	29.63	19.90	19.08	81.00	77.37
November	81.00	19.13	29.10	28.85	15.80	15.97	81.00	73.64
December	0.00	1.66	28.70	28.55	13.50	13.67	77.00	71.42
January	0.00	0.56	30.10	29.36	14.60	14.76	75.00	60.52
February	0.00	0.19	32.50	32.24	16.30	15.16	71.00	52.61
March	5.00	6.80	34.70	34.82	19.60	18.30	64.00	52.96
April	13.20	49.52	36.70	36.29	20.30	20.52	60.00	58.09
May	65.60	85.16	37.40	34.56	21.10	21.25	63.00	65.09
June	130.10	107.95	30.20	29.23	21.40	20.82	78.00	79.97
Total	**779.00**	**773.34**						

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(July). The mean minimum temperature varied from 21.4°C in June to 13.5°C in December. The relative humidity was highest (87%) during July and lowest (60%) during April 1995.

3.3 SOIL AND ITS CHARACTERISTICS

The experiment was laid out on medium black soils. Composite soil samples were collected from the experimental area and analysed for various physical and chemical properties. The data on soil analysis along with methods employed are furnished in Table 2.

3.4 PREVIOUS CROP

During summer 1994, Chickpea was raised on the experimental site.

3.5 EXPERIMENTAL DETAILS

The experiment was laid out in a factorial randomised block design with three replications and the details of which are discussed under the following sub heads.

3.5.1 Design and Layout

The experiment was laid out in a factorial randomised block design with three replication and the plan of layout of the experiment is given in Fig. 1.

3.5.2 Plot size

Gross : 3.2 m x 1.8 m

Net : 3.0 m x 1.5 m

3.5.3 Treatment details

There were 14 treatment combinations with two genotypes and seven treatments in each replication.

3.5.3.1 *Genotypes*

V_1 = DS-1 (White seeded variety)

V_2 = CO-1 (Black seeded variety)

Table 2. Physical and chemical properties of the soil of experimental site

	Particulars	Values obtained
I	**PHYSICAL PROPERTIES**	
	Coarse sand (%)	5.80
	Fine sand (%)	14.20
	Silt (%)	28.00
	Clay (%)	51.90
	Textural class	Clay loam
	Bulk density (g cc^{-1})	1.20
	Field capacity (%)	32.50
	Wilting co-efficient (%)	16.30
II	**CHEMICAL PROPERTIES**	
	Total Nitrogen (%)	0.051
	Available phosphorus (Kg ha^{-1})	40.00
	Available potassium (Kg ha^{-1})	320.00
	Soil pH (1:2.5 Soil : water)	7.50
	Total iron (ppm)	18.40
	Available iron (ppm)	2.00
	Total zinc (ppm)	36.30
	Available zinc (ppm)	2.00

LEGEND

Genotype :

V_1 - DS-1

V_2 - CO-1

Treatments :

T_1 - Planofix (1000 ppm)

T_2 - TIBA (100 ppm)

T_3 - Mepiquat chloride (1500 ppm)

T_4 - Cycocel (1000 ppm)

T_5 - Cytokinin (25 ppm)

T_6 - Cytozyme (1000 ppm)

T_7 - Control (water spray)

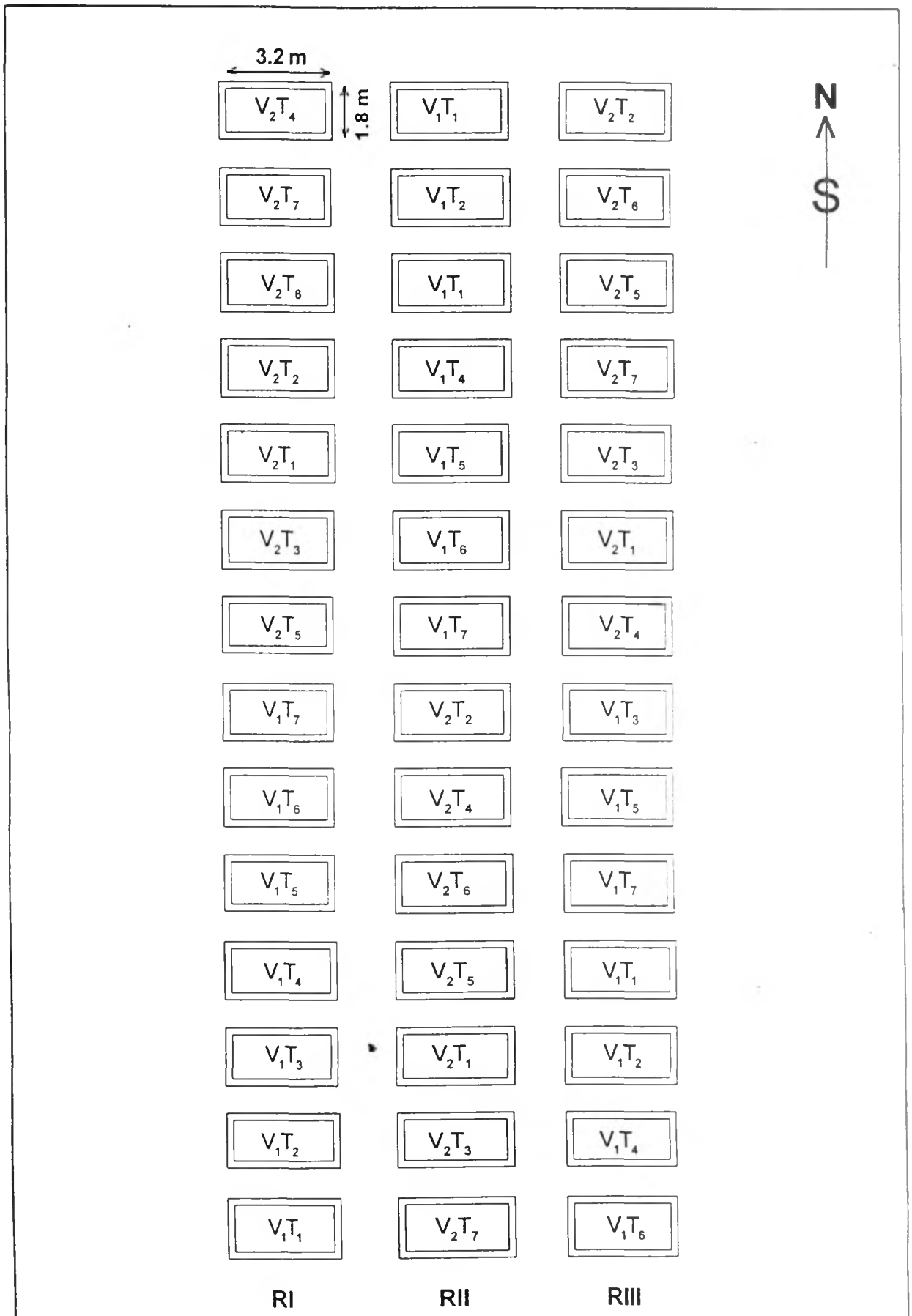

FIGURE 1. PLAN OF LAYOUT OF THE EXPERIMENT

The salient features of these genotypes are given in Table 3.

3.5.3.2 ***Treatments***

T_1 = Planofix (1000 ppm)

T_2 = TIBA (100 ppm)

T_3 = Mepiquent chloride (1500 ppm)

T_4 = Cycocel (1000 ppm)

T_5 = Cytokinin (25 ppm)

T_6 = Cytozyme (1000 ppm)

T_7 = Control (water spray)

The details of each of these growth regulators are given in Table 4.

3.6 CULTURAL OPERATIONS

3.6.1 Land preparation

The land was ploughed and harrowed twice after the harvest of the previous crop, followed by planking to bring the soil to a fine tilth, suitable for sowing. The plots were laid out according to the plan given in Fig. 1.

3.6.2 Seed rate and spacing

Seed rate : 4 kg ha^{-1}

Inter-row spacing : 30 cm

Intra-row spacing : 10 cm

3.6.3 Seed source and sowing

Seeds were obtained from the AICRP on oilseeds, Main Research Station, Dharwad. Healthy and bold seeds were mixed with sand in 1:4 proportion for uniform distribution of seeds. Sowing was taken up by hand dibbling in the furrows opened at 30 cm apart to a depth of 4 cm on 11th July, 1995.

Table 3. Salient features of the genotypes used in the experiment

Sl. No.	Characters	Genotypes	
		DS-1	CO-1
1.	Parentage	Gulbarga local x JT-68-135	(TMV3 x SI 1878) x SI 1878)
2.	Recommended ecology	Northern-transitional zone, North-Eastern-transitional zone and North-Eastern dry zones of Karnataka	Tamil Nadu
3.	Plant height	90-120 cm	100-140 cm
4.	Branching habit	Less	More
5.	Capsules	Multiple capsules per node on main stem (3-4)	Both on main stem and branches
6.	Maturity period	85-90 days	90-95 days
7.	Seed colour	White	Black
8.	Oil content	53.5%	50.0%
9.	Yield	5 - 6 q ha^{-1}	7 - 8 q ha^{-1}

Table 4. Salient features of the growth regulators used in the experiment

Sl. No.	Common / Trade name	Chemical group	Chemical name	Use
1	Planofix	Auxin	1-Naphthalene acetic acid	Growth promoter, prevents pre-mature flower and fruit drop, stimulates root formation in cuttings
2	TIBA/Regim-8	Anti-auxin	2, 3, 5-Tri iodobenzoic acid	Growth retardant, controls vegetative growth
3	Mepiquat chloride/Pix/DPC	Anti-gibberellin	1, 1-dimethyl piperidinium chloride	Growth retardant, controls vegetative growth, boll retention, uniform maturity and yield
4	Cycocel/CCC/Chlormequat chloride	Anti-gibberellin	2-chloroethyl-trimethyl ammonium chloride	Growth retardant, prevents lodging and controls vegetative growth
5	Benzyladenine	Cytokinin	6-benzyladenine	Growth promoter, dormancy breaker and delayed senescence
6	Cytozyme/Biozyme	Biological product containing auxin and cytokinin	--	Growth promoting substance. Biological product (bacterial hydrolysate) containing auxins, cytokinins, chelated micronutrients and enzymes.

3.6.4 Thinning operation

After 20 days of sowing, seedlings were thinned out by maintaining only one plant per hill.

3.6.5 Fertilizer application

The fertilizer dose prescribed for sesamum was applied in the furrows of 5 cm deep opened at 5 cm apart from seed rows immediately after thinning. The recommended doses of nitrogen (37.5 kg N), phosphorus (25 kg P_2O_5) and potassium (25 kg K_2O) per hectare were applied in the form of urea, diammonium phosphate and muriate of potash, respectively.

3.6.6 Treatment imposition

Foliar application of growth regulators at different concentrations as described in 3.5.3 was done at 45 days after sowing in both the genotypes.

3.6.7 Plant protection

To keep the crop free from weeds, two hand weedings were carried out at 20 days interval and the first operation was done on 6/8/1995. There were no disease and insect pest incidence in the early stage of the crop. After 55 days of sowing, Endosulfan (@ 3 ml. per litre of water) was sprayed to the crop for the control of sesamum spinx moth and capsule borer.

3.6.8 Harvesting and Threshing

The genotypes differed in their maturity period and hence harvesting was done at physiological maturity of each genotype as follows.

Harvesting was done when leaves and capsules turned yellowish and defoliation started. The plants in each treatment were cut at the base close to the ground level (five labelled plants in each treatment were separated from the net plot). The bundles were stacked erect on the threshing floor for 5-7 days for drying of capsules. After complete drying, the stacked bundles were inverted upside down and tapped gently with a stick to separate the seeds.

The same operation was repeated three days after the first beat. Similarly, the remaining plants from the net plot were harvested, bundled and threshed. After threshing, the seeds were cleaned and weighed separately and the seed yield of each treatment was calculated on plant basis (g plant^{-1}) and hectare basis (kg ha^{-1}) from five plants and net plot area, respectively.

3.7 COLLECTION OF EXPERIMENTAL DATA

Five plants at random from each plot were selected and tagged at 35 days after sowing for the purpose of recording various morphological, growth and yield parameters at 40, 55, 70, 85 days after sowing and at harvest.

3.7.1 Morphological characters

3.7.1.1 *Plant height (cm)*

The plant height was measured from the ground level to the growing tip of the main shoot. Measurements were taken from five plants in each treatment tagged earlier and the average height was calculated and expressed in cm.

3.7.1.2 *Number of primary and secondary branches per plant*

Total number of primary branches arising from the main stem and secondary branches on primary branches were counted in five tagged plants in each treatment separately and the average was worked out and expressed as number of primary and secondary branches per plant.

3.7.1.3 *Number of flowers per plant*

The number of flowers were counted in five tagged plants in each treatment and the mean was worked out as number of flowers per plant.

3.7.1.4 *Days to first flowering*

The date of first flower initiation in each treatment was recorded and expressed as days to first flowering.

3.7.1.5 *Days to 50 per cent flowering*

One meter row length of crop was selected in each treatment for recording this observation. The number of days required for the flower to appear in 50 per cent of the plants in the selected row length was recorded and expressed as days to 50 per cent flowering.

3.7.1.6 *Days to capsule initiation*

The first capsule formation in each treatment was noted and expressed as days to first capsule initiation.

3.7.1.7 *Days to cessation of flowering*

The number of days required for flowers to wither in 100 per cent of the plants to each treatment was considered as days to cessation of flowering.

3.7.1.8 *Days to physiological maturity*

The indication of physiological maturity in sesamum is the yellowing of leaves and capsules. The number of days required for such a change in at least 50 per cent of the total population in each plot was recorded as days to physiological maturity.

3.7.1.9 *Dry matter production and its distribution in different plant parts*.

Three plants were uprooted at random in each treatment and partitioned into their component parts viz., stem, leaf and reproductive parts. These were air dried and then transfered to hot air oven at 80°C for 72 hrs (until constant weights were obtained) and their dry weights were recorded. The sum of the mean dry weight of all the plant parts was taken separately. The dry weight of different plant parts and total dry weight was recorded at 40, 55, 70, 85 days after sowing and at harvest and expressed on per plant basis.

3.7.1.10 *Measurement of leaf area*

Leaf area per plant was worked out by leaf disc method (Vivekanandan *et al.*, 1972) on dry weight basis at 40, 55, 70, 85 days after sowing and at harvest. Twenty leaf discs

having a known diameter (1.8 cm^2) were collected randomly from fully expanded leaves throughout the plant canopy by avoiding midrib of the leaf. The discs thus collected and rest of the leaves were oven dried separately at 80°C for 72 hrs. The dry weight of the leaf discs and rest of the leaves was noted and leaf area was calculated using the following formulae.

$$\text{Leaf area} = \frac{a \times W}{b} \times \frac{1}{100} \; dm^2 \, plant^{-1}$$

where,

a = leaf area (cm^2) of 20 circular discs

b = dry weight of 20 discs in g

W = dry weight of the rest of the leaves in g

3.7.2 Growth parameters

Various growth parameters were worked out from the data obtained on dry weight of different plant parts and the leaf area as described below.

3.7.2.1 *Leaf Area Index (LAI)*

The LAI was calculated by dividing the leaf area per plant by the land area occupied by that plant (Sestak *et al.*, 1972).

$$LAI = \frac{\text{Leaf area } (dm^2 \, plant^{-1})}{\text{Land area } (dm^2 \, plant^{-1})}$$

3.7.2.2 *Leaf Area Duration (LAD)*

LAD for various growth periods was worked out as per the formulae of Power *et al.* (1967).

$$LAD = \frac{L_1 + L_2}{2} \times (t_2 - t_1)$$

Where,

L_1 = LAI at time t_1

L_2 = LAI at time t_2

$(t_2 - t_1)$ = Time interval between the two consecutive stages

3.7.2.3 *Absolute Growth Rate (AGR)*

The AGR expresses the dry matter accumulation per unit time and was calculated by using formulae suggested by Radford (1967) and expressed in g plant^{-1} day^{-1}.

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where,

W_1 and W_2 = Total dry weight of the plant (g) at time t_1 and t_2

t_2 and t_1 = Time interval in days

3.7.2.4 *Relative Growth Rate (RGR)*

It indicates the rate of increase in dry weight per unit of dry weight already present and was calculated by the formulae given by Blackman (1919) and expressed in g g^{-1} day^{-1}.

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

where,

W_1 = Dry weight of plant at time t_1

W_2 = Dry weight of plant at time t_2

3.7.2.5 *Crop Growth Rate (CGR)*

Crop growth rate is the rate of dry matter production per unit of ground area per unit of time (Watson, 1952) and was worked out by formulae,

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A} \quad g\ dm^{-2}\ day^{-1}$$

Where,

W_1 = dry weight of the plant at time t_1

W_2 = dry weight of the plant at time t_2

A = Land area covered by plant in dm^2

3.7.2.6 *Net Assimilation Rate (NAR)*

Net assimilation rate is the rate of dry weight increase per unit leaf area per unit time (Watson, 1952). It was calculated by using the following formulae,

$$NAR = \frac{(W_2 - W_1)(\log_e L_2 - \log_e L_1)}{(t_2 - t_1)(L_2 - L_1)} \text{ g dm}^{-2} \text{ day}^{-1}$$

where,

L_1 and W_1 = Leaf area (dm^2) and dry weight of the plant (g) at time t_1

L_2 and W_2 = Leaf area (dm^2) and dry weight of the plant (g) at time t_2

3.7.2.7 *Leaf Area Ratio (LAR)*

The LAR was worked out by using the formulae suggested by Radford (1967) and expressed interms of $dm^2\ g^{-1}\ day^{-1}$.

$$LAR = \frac{(LAI_2 - LAI_1)(\log_e W_2 - \log_e W_1)}{(W_2 - W_1)(\log_e LAI_2 - \log_e LAI_1)}$$

Where,

LAI_1 and W_1 = LAI and dry weight of plant at time t_1, respectively

LAI_2 and W_2 = LAI and dry weight of plant at time t_2, respectively

3.7.2.8 *Specific Leaf Weight (SLW)*

It indicates the thickness of leaf and was calculated by the method given below,

$$SLW = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area (dm}^2\text{)}} \text{ g dm}^{-2}$$

3.7.2.9 *Specific Leaf Area (SLA)*

It is the inverse of SLW and was calculated by the following relationship,

$$SLA = \frac{\text{Leaf area (dm}^2\text{)}}{\text{Leaf dry weight (g)}} \text{ dm}^2\ \text{g}^{-1}$$

3.7.3 Yield and yield components

Yield and yield components were recorded on five plants tagged earlier at different stages.

3.7.3.1 *Number of capsules per plant*

The number of capsules produced per plant were observed at 55, 70, 85 days after sowing and at harvest on plants which were labelled earlier in each treatment (five plants) and the average was taken as the number of capsules per plant.

3.7.3.2 *Capsule length and width*

Ten capsules were collected from each treatment and length and width each capsules was measured and average was taken as the capsule length and width in cm at harvest.

3.7.3.3 Number of locules per capsule

From the selected ten capsules from each treatment, the number of locules were counted and mean was expressed as number of locules per capsules at harvest.

3.7.3.4 *Number of seeds per capsule*

The seeds from ten representative matured capsules were separated and counted and the mean number of seeds per capsule was calculated.

3.7.3.5 *Thousand seed weight (g)*

From the seed yield of each treatment, 1000-seeds were randomly collected and their weight was taken as thousand seed weight in g.

3.7.3.6 *Seed yield (q ha^{-1})*

The capsules from each net plot were threshed, cleaned and seed yield was recorded. From this, seed yield per hectare was calculated and expressed in q ha^{-1}.

3.7.4 Physiological parameters

The following physiological parameters were estimated at different stages of crop growth.

3.7.4.1 *Estimation of chlorophyll content in leaves*

Total chlorophyll, chlorophyll 'a' and chlorophyll 'b' contents were estimated at 40, 55, 70 and 85 days after sowing and at harvest by following the procedure of Arnon (1949).

Fresh leaf sample (sixth) from the top of the canopy in each of the treatment were brought to laboratory in an ice box from the field. About 200 mg of leaf was weighed from each sample and was cut into small pieces. Weighed sample was homogenised with pure acetone, extract was filtered through Whatman No.1 filter paper and washed twice with 80 per cent acetone. The final volume of the extract was made to 25 ml and the absorbance of the extract was measured at 645 and 663 nm in spectrophotometer (Systronics, UV-VIS Model CL-54). The total chlorophyll, Chl.a and Chl.b contents were calculated using the following formulae and expressed as mg g fresh weight^{-1} of leaf.

$$\text{Total Chlorophyll} = (20.2 \times A_{645}) + (8.02 \times A_{663}) \times \frac{V}{a \times W \times 1000}$$

$$\text{Chlorophyll 'a'} = 12.7 \times A_{663} - 2.69 \times A_{645} \times \frac{V}{a \times W \times 1000}$$

$$\text{Chlorophyll 'b'} = 22.9 \times A_{645} - 4.68 \times A_{663} \times \frac{V}{a \times W \times 1000}$$

Where,

A_{663} = Absorbance of the extract at 663 nm

A_{645} = Absorbance of the extract at 645 nm

a = Path length of the light in the cuvette (1 cm)

V = Volume of the extract (25 ml)

W = Fresh weight of the sample (0.20 g)

3.7.4.2 *Estimation of chlorophyll content in capsule*

30

Uniform sized capsules from each treatment were brought in an ice-box. The capsule wall in sesamum is differentiated into two layers, outer layer was peeled out and about 250 mg was weighed for the estimation of chlorophyll content in capsule wall as per the method of Arnon (1949) at 55 and 70 DAS and as described in 3.7.4.1.

3.7.5 Biochemical parameters

The following biochemical parameters were estimated at different stages of crop growth.

3.7.5.1 *Nitrate Reductase Activity (NRA)*

The nitrate reductase activity determines the nitrogen utilization efficiency in plants. NRA in sesamum leaves was measured by the method of Saradhambal *et al.* (1978) at 40, 55 and 70 days after sowing.

Fresh, fully expanded leaves from the top of the canopy were brought in an ice-box, 25 discs of 0.8 cm diameter were weighed and suspended in 25 ml flasks containing 5 ml of solution having 0.1 m phosphate buffer (pH 7.6), 0.02 M KNO_3, 5 per cent propanil and to that two drops of chloromphenicol (0.5 mg ml^{-1}) was added. The flasks were incubated at 30°C for 30 minutes, after which, the reaction was stopped by adding 0.1 ml of 1.0 M zinc acetate and 1.9 ml of ethanol (70%). The contents were centrifuged at 3000 rpm for 10 minutes and the supernatant was collected. The supernatant was transfered to test tubes and 1 ml of 1 per cent sulphanilamide and 1 ml of 0.02% N-1 napthyl ethylene diamine dihydrochloride were added. The absorbance of the pink colour developed was measured at 540 nm after incubating the contents of the tube at room temperature for 20 minutes. The activity of nitrate reductase was determined from a standard curve of KNO_2 and expressed as µ moles of NO_2 formed g fresh $weight^{-1}$ $hour^{-1}$.

3.7.5.2 *Seed protein content in per cent*

The crude protein content in seed was determined by knowing the amount of

nitrogen present by adopting Micro Kjeldahl technique (Yoshida *et al.*, 1972). Total nitrogen content in seed was multiplied by the factor 6.25 to get crude protein content.

3.7.5.3 *Oil content in per cent*

The oil content in seed was determined with the help of NMR (Nuclear Magnetic Resonance) spectrophotometer installed at Regional Research Station, Raichur. The oil content was expressed in per cent.

3.8 STATISTICAL ANALYSIS

Fisher's method of analysis of variance was applied for the analysis and interpretation of the experimental data as given by Panse and Sukhatme (1967). The level of significance used in the 'F' and 't' tests was of P = 0.05. The results are presented and discussed in the text at this probability level.

Correlation co-efficients between seed yield and other morphological, growth, phenological, physiological and biochemical parameters were worked out as per the procedure outlined by Snedecor and Cochran (1967). The level of significance was tested at P = 0.05 and P = 0.01 for n - 2 degrees of freedom.

3.9 ECONOMICS

Additional cost involved and returns obtained by applying different growth regulators was worked out, taking into consideration, the market rates of all the applied inputs during experimentation on per hectare basis.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

A field experiment was conducted during *kharif*, 1995 to study the influence of growth regulators on various morphological, phenological, physiological, biochemical parameters and productivity potential of two sesamum genotypes at Agriculture College Farm, University of Agricultural Sciences, Dharwad. The crop was sprayed with different growth regulators at 45 days after sowing to evaluate the impact of both growth retardants and promoters on the regulation of phenological stages and flowering efficiency, physiological and biochemical changes and partitioning efficiency in sesamum genotypes. The results obtained in the present investigation are described hereunder.

4.1 MORPHOLOGICAL CHARACTERS

4.1.1 Plant height

It is evident from the Table 5 that the plant height increased continuously from 40 DAS till harvest. Among the treatments, planofix (1000 ppm) recorded significantly higher plant height over other treatments, except cytozyme (1000 ppm) at all the growth stages. The treatments TIBA (100 ppm), mepiquat chloride (1500 ppm) and cycocel (1000 ppm) in CO-1 and TIBA (100 ppm) and mepiquat chloride (1500 ppm) in DS-1 were on par with each other at 70, 85 DAS and at harvest. Significantly lower plant height was recorded with cycocel (1000 ppm) in DS-1 at 70, 85 DAS and harvest, whereas, no significant difference was observed between the growth regulators at 40 and 55 DAS in both the genotypes.

Among the genotypes, CO-1 recorded significantly higher plant height at all the growth stages as compared to DS-1. However, the interaction effect between the genotypes and growth regulators was non-significant at all the growth stages.

4.1.2 Number of primary branches and flowers per plant

The data on the number of primary branches and flowers presented in Table 6 indicated that they increased due to growth regulator treatments at all the growth stages, but the

Table 5. Influence of growth regulators on plant height (cm) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing													
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	55.4	56.7	**56.1**	91.5	96.3	**93.9**	116.3	120.9	**118.6**	120.7	124.7	**122.7**	121.1	126.5	**123.8**
2	TIBA (100 ppm)	56.4	58.3	**57.3**	89.1	95.5	**92.3**	107.3	109.3	**108.3**	108.7	113.0	**110.7**	108.6	113.1	**110.9**
3	Mepiquat chloride (1500 ppm)	55.6	55.8	**55.7**	92.4	95.7	**94.1**	107.8	107.9	**107.9**	110.0	108.9	**109.4**	110.3	111.5	**110.9**
4	Cycocel (1000 ppm)	56.7	58.2	**57.4**	88.9	94.1	**91.5**	99.8	107.9	**103.9**	100.0	109.3	**104.6**	103.7	109.3	**106.5**
5	Cytokinin (25 ppm)	57.3	57.7	**57.5**	92.5	94.9	**93.7**	109.9	113.5	**111.7**	112.1	117.5	**114.8**	113.5	117.4	**115.5**
6	Cytozyme (1000 ppm)	57.4	58.5	**57.9**	95.1	97.3	**96.2**	116.3	119.9	**118.1**	118.4	120.3	**119.4**	118.0	120.9	**119.4**
7	Control (water spray)	59.7	57.2	**58.4**	95.9	95.8	**95.8**	113.0	115.8	**114.4**	115.1	116.5	**115.8**	115.7	118.5	**117.1**
	Mean	**56.9**	**57.5**	**57.2**	**92.2**	**95.7**	**93.9**	**108.0**	**112.4**	**110.2**	**112.2**	**115.7**	**114.0**	**113.0**	**115.7**	**114.9**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	1.0		NS	0.8		2.4	0.8		2.2	1.8		2.5	0.7		2.1
	Growth regulators	1.9		NS	1.5		NS	1.4		4.1	1.4		4.0	1.3		3.9
	Interaction	2.7		NS	2.2		NS	2.0		NS	2.0		NS	1.9		NS

Table 6. Influence of growth regulators on number of primary branches and number of flowers per plant at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing																	
		Number of primary branches plant $^{-1}$												Number of flowers plant $^{-1}$					
		40			55			70			85			40			55		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	2.1	1.7	**1.9**	2.3	2.2	**2.2**	2.4	2.3	**2.4**	2.5	2.6	**2.5**	5.6	4.9	**5.2**	13.4	12.9	**13.2**
2	TIBA (100 ppm)	2.1	2.2	**2.1**	2.3	3.0	**2.6**	2.4	3.1	**2.7**	2.5	3.3	**2.9**	6.1	6.3	**6.2**	11.9	11.7	**11.8**
3	Mepiquat chloride (1500 ppm)	2.1	2.2	**2.1**	2.2	2.8	**2.5**	2.3	3.1	**2.7**	2.4	3.1	**2.8**	6.1	5.8	**5.9**	12.9	11.1	**12.0**
4	Cycocel (1000 ppm)	2.5	2.5	**2.5**	2.7	3.0	**2.9**	2.7	3.1	**2.9**	2.7	3.4	**3.1**	7.1	3.3	**5.2**	13.5	13.4	**13.4**
5	Cytokinin (25 ppm)	2.0	2.0	**2.0**	2.6	2.3	**2.4**	2.7	2.9	**2.8**	2.7	2.8	**2.8**	5.9	5.5	**5.7**	13.4	12.7	**13.1**
6	Cytozyme (1000 ppm)	2.0	2.1	**2.0**	2.3	3.4	**2.8**	2.4	3.5	**2.9**	2.4	3.5	**2.9**	6.2	5.5	**5.8**	12.2	13.7	**12.9**
7	Control (water spray)	1.9	2.3	**2.1**	2.1	3.4	**2.8**	2.3	3.5	**2.9**	2.3	3.5	**2.9**	4.9	3.9	**4.4**	8.6	9.1	**8.9**
	Mean	**2.1**	**2.1**	**2.1**	**2.4**	**2.9**	**2.6**	**2.4**	**3.1**	**2.8**	**2.5**	**3.2**	**2.8**	**6.0**	**5.0**	**5.5**	**12.3**	**12.1**	**12.2**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.1		NS	0.1		0.3	0.1		0.3	0.1		0.3	0.3		0.9	0.4		NS
	Growth regulators	0.2		NS	0.2		NS	0.2		NS	0.2		NS	0.6		NS	0.8		2.4
	Interaction	0.3		NS	0.3		NS	0.3		NS	0.2		NS	0.8		NS	1.2		NS

extent of increase was non-significant with respect number of branches per plant. The number of flowers per plant was increased significantly in all growth regulator treatments over control at 55 DAS. Whereas, among the genotypes, significantly higher number of primary branches were produced in CO-1 at 55, 70 and 85 DAS and at harvest as compared to DS-1. Similarly, the number of flowers were significantly higher in DS-1 at 40 DAS as compared to CO-1. However, at 55 DAS, non-significant differences were observed between the genotypes.

4.1.3 Number of capsules per plant

Spraying of growth regulators significantly increased the number of capsules per plant at all the growth stages except at 55 DAS over the control. However, there was not much variation due to growth regulators at all the growth stages (Table 7). The treatments planofix (1000 ppm), TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel(1000 ppm) and cytokinin (25 ppm) in DS-1 and planofix (1000 ppm), TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel(1000 ppm), cytokinin (25 ppm) and cytozyme (1000 ppm) in CO-1 were on par with each other at 70, 85 DAS and at harvest, but there was no significant difference among the growth regulators at 55 DAS in both the genotypes. However, at harvest, the treatment cycocel(1000 ppm) in both the genotypes had the maximum capsule number.

Among the genotypes, DS-1 showed higher capsule number at all the growth stages, but differed significantly only at 55 and 85 DAS over CO-1. Interaction between the genotypes and growth regulators was non-significant at any of the growth stages.

4.2 PHENOLOGICAL STAGES

The data on phenological stages indicated significant difference due to growth regulators and genotypes for days to 50 per cent flowering, cessation of flowering and physiological maturity (Table 8). Whereas, days to initiation of first flower and first capsule did not differ significantly between the growth regulatrs. In none of the phenological stages studied, interaction effect was significant. It was also observed that the days to initiation of first flower and first capsule were more in CO-1 as compared to DS-1.

Table 7. Influence of growth regulators on number of capsules per plant at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing											
		55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	22.5	18.5	**20.5**	39.5	37.8	**38.6**	47.3	45.5	**46.4**	49.4	47.5	**48.4**
2	TIBA (100 ppm)	20.7	20.7	**20.7**	41.2	38.5	**39.9**	47.2	45.4	**46.3**	49.4	47.1	**48.2**
3	Mepiquat chloride (1500 ppm)	21.2	20.1	**20.6**	40.2	39.3	**39.8**	47.5	43.6	**45.6**	48.0	47.7	**47.9**
4	Cycocel (1000 ppm)	24.9	18.5	**21.7**	41.7	40.2	**41.0**	48.7	46.9	**47.8**	50.1	48.4	**49.2**
5	Cytokinin (25 ppm)	27.8	21.1	**24.4**	41.1	39.3	**40.2**	47.4	45.5	**46.5**	47.6	47.3	**47.4**
6	Cytozyme (1000 ppm)	25.8	21.5	**23.7**	36.3	38.5	**37.7**	47.3	45.6	**46.6**	49.4	48.4	**48.9**
7	Control (water spray)	23.7	14.9	**19.3**	32.6	32.1	**32.4**	38.3	37.8	**38.1**	39.3	39.1	**39.2**
	Mean	**23.5**	**19.3**	**21.4**	**39.3**	**37.3**	**38.4**	**46.3**	**44.4**	**45.3**	**47.3**	**46.4**	**47.4**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.7		2.1	0.4		NS	0.5		1.6	0.6		NS
	Growth regulators	1.3		NS	0.8		2.3	1.0		2.9	1.3		3.4
	Interaction	2.0		NS	1.1		NS	1.4		NS	1.7		NS

Table 8. Influence of growth regulators on phenological stages in sesamum genotypes

Sl. No.	Treatment	Days to initiation of first flower			Days to initiation of first capsule			Days to 50% flowering			Cessation of flowering			Physiological maturity		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	34.0	38.70	**36.3**	40.3	46.3	**43.3**	50.0	54.0	**52.0**	72.0	74.7	**73.3**	93.7	97.3	**95.5**
2	TIBA (100 ppm)	34.0	37.7	**35.8**	42.0	45.3	**43.6**	50.0	54.3	**52.2**	72.7	74.7	**73.7**	92.7	95.3	**94.0**
3	Mepiquat chloride (1500 ppm)	34.0	38.7	**36.3**	40.7	44.7	**42.7**	50.7	53.7	**52.2**	71.7	74.0	**72.8**	92.0	96.3	**94.2**
4	Cycocel (1000 ppm)	33.0	37.3	**35.2**	42.3	45.3	**43.8**	49.3	54.3	**51.8**	72.7	74.7	**73.7**	91.3	97.0	**94.2**
5	Cytokinin (25 ppm)	34.0	36.0	**35.0**	43.0	46.3	**44.7**	49.7	53.3	**51.5**	70.3	73.7	**72.0**	93.7	95.3	**94.5**
6	Cytozyme (1000 ppm)	33.7	38.3	**36.0**	42.0	44.7	**43.3**	49.7	53.7	**51.7**	72.7	74.7	**73.7**	94.3	97.7	**96.0**
7	Control (water spray)	34.0	38.0	**36.0**	43.0	46.0	**44.5**	54.0	56.3	**55.2**	64.3	67.0	**65.7**	88.7	92.3	**90.5**
	Mean	**33.0**	**37.0**	**35.3**	**41.9**	**45.5**	**43.7**	**50.5**	**54.2**	**52.3**	**70.9**	**73.3**	**72.1**	**92.3**	**95.9**	**94.1**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.4		1.0	0.4		1.3	0.3		0.9	0.3		0.9	0.3		0.9
	Growth regulators	0.7		NS	0.8		NS	0.6		1.7	0.6		1.7	0.6		1.8
	Interaction	0.9		NS	1.6		NS	0.8		NS	0.8		NS	0.9		NS

The data with respect to days to 50 per cent flowering indicated that CO-1 took more number of days (54.2) in all the treatments including control as compared to DS-1 (50.5). In all the growth regulator treatments, significantly less number of days required for 50 per cent flowering as compared to control, but these were non significantly differed among themselves. A similar trend was observed with respect to cessation of flowering and physiological maturity wherein, no significant differences were observed between the growth regulator treatments. However, all the growth regulator treatments took comparatively more number of days for both cessation of flowering and physiological maturity as compared to control. Further the genotype, CO-1 took significantly higher number of days for cessation of flowering and physiological maturity. However, none of the phenological stages showed significant interaction effect.

4.3 DRY MATTER PRODUCTION

4.3.1 Leaf dry weight

The leaf dry weight increased from 40 to 70 DAS in all the treatments and in both the genotypes and decreased thereafter until harvest (Table 9). Significant difference in leaf dry weight was observed among the treatments at 70, 85 DAS and at harvest. The treatment cycocel (1000 ppm) maintained higher leaf dry weight at all the growth stages and which was superior over planofix (1000 ppm) at 70 DAS, mepiquat chloride (1500 ppm) and cytokinin (25 ppm) at 85 DAS. However, all the remaining treatments were on par with each other.

The genotype CO-1 recorded significantly higher leaf dry weight over DS-1 at all the growth stages. Among the treatments, cycocel (1000 ppm) recorded the maximum (9.95 g plant^{-1}) leaf dry weight in DS-1, whereas, the treatment cytokinin (25 ppm) recorded the maximum leaf dry weight (10.46 g plant^{-1}) in CO-1 at 70 DAS. Interaction effect was found to be non-significant at all the growth stages.

4.3.2 Stem dry weight

The data on stem dry weight revealed that it increased from 40 to 70 DAS and reduced slightly thereafter in all the growth regulator treatments in both the genotypes. Treatments

Table 9. Influence of growth regulators on leaf dry weight (g plant^{-1}) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	2.47	2.90	**2.69**	7.69	8.57	**8.13**	9.15	9.35	**9.25**	5.07	6.13	**5.65**	3.09	3.57	**3.33**
2	TIBA (100 ppm)	2.49	3.06	**2.77**	7.84	8.24	**8.04**	9.27	10.19	**9.73**	5.24	6.16	**5.70**	3.05	3.45	**3.25**
3	Mepiquat chloride (1500 ppm)	2.78	2.84	**2.81**	7.86	8.57	**8.21**	9.37	10.34	**9.86**	5.04	6.21	**5.53**	3.28	3.50	**3.39**
4	Cycocel (1000 ppm)	2.60	3.09	**2.85**	8.37	8.35	**8.36**	9.95	10.07	**10.01**	5.66	6.69	**6.18**	3.35	3.45	**3.40**
5	Cytokinin (25 ppm)	2.46	3.10	**2.78**	7.91	8.37	**8.14**	9.27	10.46	**9.87**	5.07	5.84	**5.46**	3.00	3.50	**3.25**
6	Cytozyme (1000 ppm)	2.62	3.31	**2.98**	7.87	8.25	**8.06**	9.35	10.27	**9.81**	5.41	6.14	**5.78**	3.09	3.65	**3.37**
7	Control (water spray)	2.53	3.01	**2.77**	7.48	7.45	**7.47**	9.62	9.88	**9.75**	3.71	4.62	**4.16**	2.35	2.38	**2.36**
	Mean	**2.57**	**3.05**	**2.81**	7.86	8.26	**8.07**	**9.40**	**10.08**	**9.74**	**5.03**	**5.95**	**5.49**	**3.03**	**3.36**	**3.19**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.06		0.19	0.11		0.33	0.13		0.32	0.10		0.28	0.11		0.33
	Growth regulators	0.12		NS	0.21		NS	0.25		0.60	0.18		0.51	0.21		0.61
	Interaction	0.17		NS	0.30		NS	0.36		NS	0.25		NS	0.30		NS

Table 10. Influence of growth regulators on stem dry weight (g plant $^{-1}$) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing													
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	2.80	3.03	**2.91**	7.68	8.43	**8.05**	9.80	11.48	**10.44**	8.35	9.74	**9.04**	7.28	8.81	**8.05**
2	TIBA (100 ppm)	2.66	3.06	**2.86**	7.63	8.11	**7.88**	9.65	10.96	**10.30**	8.11	9.38	**8.75**	7.24	8.71	**8.03**
3	Mepiquat chloride (1500 ppm)	2.85	3.06	**2.95**	7.53	8.48	**8.00**	10.01	10.70	**10.35**	8.25	9.62	**8.94**	7.30	8.93	**8.12**
4	Cycocel (1000 ppm)	2.72	3.07	**2.89**	8.01	8.03	**8.15**	10.36	11.20	**10.78**	8.33	9.44	**8.89**	8.09	8.63	**8.36**
5	Cytokinin (25 ppm)	2.52	3.23	**2.87**	7.28	8.48	**7.88**	9.70	10.80	**10.25**	7.96	8.89	**8.42**	7.02	8.46	**7.74**
6	Cytozyme (1000 ppm)	2.39	3.17	**2.78**	7.75	8.30	**8.03**	10.05	10.80	**10.43**	8.18	9.52	**8.85**	7.21	8.95	**8.08**
7	Control (water spray)	2.42	3.08	**2.75**	6.88	7.25	**7.06**	9.43	9.51	**9.47**	6.48	7.46	**6.97**	6.11	7.46	**6.79**
	Mean	**2.51**	**3.19**	**2.78**	**7.35**	**7.67**	**7.56**	**9.86**	**10.78**	**10.32**	**7.95**	**9.15**	**8.55**	**7.20**	**8.56**	**7.88**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.06		0.16	0.13		0.34	0.18		0.53	0.13		0.39	0.11		0.32
	Growth regulators	0.10		NS	0.22		0.63	0.34		NS	0.25		0.72	0.21		0.61
	Interaction	0.15		NS	0.31		NS	0.48		NS	0.35		NS	0.30		NS

differed significantly at 55, 85 DAS and at harvest and the treatment cycocel(1000 ppm) maintained higher stem dry weight at all the growth stages except at 85 DAS where planofix (1000 ppm) was leading. The interaction effect between the genotypes and growth regulatrs was non-significant at all the growth stages.

Among the genotypes, CO-1 recorded significantly higher stem dry weight at all the growth stages over DS-1. However, the treatments planofix (1000 ppm) and cycocel(1000 ppm) recorded the maximum dry matter accumulation in CO-1 and DS-1, respectively at 70 DAS. The pattern of dry matter accumulation in stem remained same throughout the growth stages in all growth regulator treatments and in both the genotypes.

4.3.3 Dry weight of reproductive parts

The dry weight of reproductive parts increased continuously from 40 DAS till harvest in all growth regulator treatments (Table 11). Significant differneces among the treatments were noticed at all the growth stages, except at 40 DAS. The treatment TIBA (100 ppm) recorded higher dry weight of reproductive parts except at 85 DAS, where cycocel(1000 ppm) recorded the maximum. Similarly, all the growth regulator treatments were on par with each other and found significantly superior over control (water spray) at all the growth stages, except at 40 DAS.

Significant differences between the genotypes were observed at all the growth stages. However, DS-1 recorded significantly higher dry weight of reproductive parts at all the growth stages over CO-1. The treatments TIBA (29.24 g plant^{-1}) in DS-1 and cytozyme (28.73 g plant^{-1}) in CO-1 registered maximum values. Whereas, the least dry weight was obtained in control in both the genotypes. The interaction between the genotypes and growth regulators was not significant at all the growth stages.

4.3.4 Total dry weight

Total dry weight increased from 40 DAS to harvest in all the treatments (Table 12). The maximum total dry weight was noticed at harvest in all growth regulator treatments

Table 11. Influence of growth regulators on dry weight of reproductive parts (g plant $^{-1}$) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing													
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.21	0.12	**0.16**	2.92	2.47	**2.69**	15.07	13.30	**14.19**	25.98	24.88	**24.43**	28.43	28.47	**28.45**
2	TIBA (100 ppm)	0.24	0.15	**0.20**	3.17	2.77	**2.97**	15.56	13.75	**14.65**	26.41	25.21	**25.81**	29.94	28.64	**29.29**
3	Mepiquat chloride (1500 ppm)	0.21	0.16	**0.18**	3.10	2.77	**2.93**	14.16	13.35	**13.75**	26.45	23.80	**25.13**	28.36	27.09	**27.73**
4	Cycocel (1000 ppm)	0.16	0.15	**0.16**	3.03	2.28	**2.66**	15.54	14.46	**15.00**	26.75	26.04	**26.39**	29.83	28.15	**28.99**
5	Cytokinin (25 ppm)	0.22	0.16	**0.19**	3.18	2.43	**2.81**	14.54	12.10	**13.32**	25.54	23.47	**24.50**	28.38	26.23	**27.31**
6	Cytozyme (1000 ppm)	0.22	0.18	**0.20**	2.90	2.65	**2.78**	15.04	12.80	**13.92**	24.81	24.73	**24.77**	29.47	28.73	**29.10**
7	Control (water spray)	0.21	0.14	**0.18**	2.15	1.83	**1.99**	11.37	9.96	**10.67**	18.99	18.42	**18.70**	22.77	21.34	**22.05**
	Mean	**0.21**	**0.15**	**0.18**	**2.92**	**2.46**	**2.69**	**14.47**	**12.82**	**13.64**	**24.99**	**23.79**	**24.39**	**28.17**	**26.95**	**27.56**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.01		0.02	0.08		0.22	0.41		1.18	0.35		1.02	0.39		1.14
	Growth regulators	0.01		NS	0.14		0.41	0.76		2.20	0.66		1.99	0.74		2.14
	Interaction	0.02		NS	0.20		NS	1.07		NS	0.93		NS	1.04		NS

Table 12. Influence of growth regulators on total dry weight (g plant^{-1}) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	5.02	5.86	**5.44**	18.14	18.81	**18.48**	36.63	33.04	**33.34**	37.50	38.14	**37.82**	38.42	39.61	**39.02**
2	TIBA (100 ppm)	4.92	6.07	**5.50**	18.10	18.68	**18.39**	34.58	33.94	**34.26**	38.69	38.16	**38.43**	39.96	39.78	**39.87**
3	Mepiquat chloride (1500 ppm)	5.61	5.89	**5.75**	18.52	18.83	**18.68**	33.82	32.89	**33.35**	36.92	36.50	**36.71**	37.94	39.04	**38.49**
4	Cycocel (1000 ppm)	5.24	6.12	**5.70**	18.64	18.85	**18.74**	35.17	33.97	**34.57**	38.22	38.42	**38.32**	40.77	40.62	**40.69**
5	Cytokinin (25 ppm)	4.89	6.40	**5.64**	16.06	19.14	**18.60**	32.52	32.68	**32.60**	36.47	37.07	**36.77**	37.29	37.68	**37.48**
6	Cytozyme (1000 ppm)	5.32	6.13	**5.72**	18.22	18.66	**18.44**	33.97	33.56	**33.76**	37.66	37.83	**37.75**	39.19	39.46	**39.33**
7	Control (water spray)	4.94	5.90	**5.42**	16.89	17.60	**17.25**	29.24	28.22	**28.73**	31.53	30.50	**31.02**	31.57	31.81	**31.69**
	Mean	**5.14**	**6.05**	**5.60**	**18.08**	**18.65**	**18.37**	**33.28**	**32.61**	**32.94**	**36.72**	**36.37**	**36.54**	**37.88**	**38.28**	**38.08**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.10		0.30	0.14		0.42	0.25		NS	0.25		NS	0.26		NS
	Growth regulators	0.20		NS	0.27		0.78	0.46		1.34	0.46		1.34	0.49		1.42
	Interaction	0.30		NS	0.38		NS	0.65		NS	0.65		NS	0.69		NS

and the increase was very high from 55 to 70 DAS. The treatment cycocel (1000 ppm) recorded significantly higher total dry weight over planofix (1000 ppm), mepiquat chloride (1500 ppm), cytokinin (25 ppm) and control (water spray) at harvest, whereas cycocel(1000 ppm), TIBA (100 ppm) and cytozyme (1000 ppm) were on par with each other. Similarly, the treatment cycocel(1000 ppm) maintained higher total dry weight at all the growth stages except at 85 DAS where TIBA (100 ppm) was leading.

Genotypes, DS-1 registered higher total dry weight as compared to CO-1 at 70 and 85 DAS, but CO-1 was found to be significantly superior over DS-1 at 40 and 55 DAS. At harvest, there was no significant difference between these two genotypes. The treatment cycocel (1000 ppm) recorded higher total dry matter accumulation in both the genotypes at harvest. However, all the growth regulator treatments were significantly superior over control in both the genotypes throughout the crop growth except at 40 DAS. The interactions of genotypes with growth regulators were not found significant at any of the growth stages.

4.3.5 Leaf area

The data on leaf area indicated that it increased from 40 to 70 DAS and declined thereafter till at harvest (Table 13). Significant difference between the treatments was noticed at all the growth stages except at 40 DAS. However, the maximum leaf area was noticed at 70 DAS in all the growth regulator treatments and least at harvest. Among the growth regulator treatments, cytozyme (17.08 dm^2 $plant^{-1}$) recorded the maximum leaf area, which was significantly superior over all the treatments except planofix (1000 ppm) and cytokinin (25 ppm) at 70 DAS. The treatment cycocel (1000 ppm) registered the higher leaf area at 40 and 55 DAS, while cytozyme (1000 ppm) recorded the higher leaf area at 70 and 85 DAS, but at harvest, cytokinin (25 ppm) was leading.

The genotype CO-1 recorded significantly higher leaf area at all the growth stages except at 40 DAS. However, treatment planofix (1000 ppm) recorded higher leaf area in CO-1 at 70, 85 DAS and at harvest, but cycocel(1000 ppm) recorded higher leaf area at 40 and 55 DAS in CO-1. In DS-1, higher leaf area varied among the growth regulator treatments at different

Table 13. Influence of growth regulators on leaf area (dm^2 plant $^{-1}$) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	6.59	7.19	**6.89**	13.83	15.23	**14.53**	16.25	17.72	**16.99**	7.17	9.78	**8.48**	4.26	5.19	**4.73**
2	TIBA (100 ppm)	6.55	6.83	**6.69**	13.36	14.07	**13.76**	14.69	15.87	**15.28**	6.93	8.90	**7.91**	3.92	4.57	**4.25**
3	Mepiquat chloride (1500 ppm)	6.10	7.81	**6.96**	13.77	14.79	**14.28**	15.17	16.28	**15.72**	6.69	**8.70**	**7.70**	3.59	4.33	**3.96**
4	Cycocel (1000 ppm)	7.46	7.45	**7.46**	13.61	15.59	**14.59**	15.18	16.03	**15.61**	6.67	**8.82**	**7.74**	3.69	4.39	**4.04**
5	Cytokinin (25 ppm)	7.36	6.97	**7.17**	14.14	14.73	**14.43**	16.66	17.25	**16.95**	7.04	9.03	**8.03**	3.51	4.44	**4.98**
6	Cytozyme (1000 ppm)	6.83	7.04	**6.94**	14.52	14.06	**14.29**	16.62	17.45	**17.08**	7.64	9.77	**8.71**	4.22	4.95	**4.59**
7	Control (water spray)	6.97	7.02	**6.99**	12.57	13.15	**12.86**	13.57	14.03	**13.80**	5.62	7.23	**6.43**	2.72	3.25	**2.99**
	Mean	**6.84**	**7.18**	**7.01**	**13.69**	**14.52**	**14.10**	**15.45**	**16.39**	**15.92**	**6.82**	**8.89**	**7.86**	**3.70**	**4.45**	**4.07**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.18		NS	0.15		0.45	0.13		0.38	0.11		0.32	0.07		0.21
	Growth regulators	0.34		NS	0.29		0.83	0.25		0.72	0.21		0.60	0.14		0.39
	Interaction	0.49		NS	0.41		NS	0.35		NS	0.29		NS	0.19		NS

growth stages. Interaction effect was non significant with respect to leaf area at any of the growth stages.

4.3.6 Leaf Area Index

It was clear from the Table 14 that leaf area index (LAI) increased from 40 to 70 DAS and reduced drastically thereafter till harvest. Significant differences were noticed among the growth regulator treatments at all the growth stages except at 40 DAS. Maximum LAI was recorded at 70 DAS in all the growth regulator treatments, but the treatments cytokinin (25 ppm) and cytozyme (5.68) were found to be statistically superior over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel (1000 ppm) and control (water spray). Treatment cycocel (1000 ppm) recorded higher LAI at 40 and 55 DAS, while treatment planofix (1000 ppm) recorded higher values at 85 DAS and at harvest and which was significantly superior over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel (1000 ppm), cytokinin (25 ppm) and control (water spray) at 85 DAS and at harvest.

Both the genotypes showed increasing trend from 40 to 70 DAS and decreased thereafter. Genotype CO-1 accounted significantly higher LAI value at all the growth stages over DS-1, except at 40 DAS. Treatment cytokinin (25 ppm) in DS-1 recorded significantly higher value over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel(1000 ppm) and control (water spray) whereas in CO-1, the treatment planofix (5.90) had highest LAI and which was found to be superior over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel (1000 ppm) and control (water spray) at 70 DAS. However, the interaction effect was non-significant at all the growth stages.

4.3.7 Leaf Area Duration

The data pertaining to leaf area duration (LAD) presented in Table 15 indicated that LAD increased from 40-55 to 55-70 DAS and showed decreasing trend with an advancement in growth in both the genotypes and growth regulator treatments. Maximum LAD was noticed at 55-70 DAS and the minimum at 85 DAS-harvest in all the growth regulator treatments.

Table 14. Influence of growth regulators on leaf area index (LAI) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	2.20	2.39	**2.30**	4.61	5.07	**4.84**	5.42	5.90	**5.46**	2.50	3.26	**2.88**	1.42	1.73	**1.57**
2	TIBA (100 ppm)	2.25	2.27	**2.26**	4.45	4.69	**4.57**	5.01	5.28	**5.14**	2.25	2.96	**2.61**	1.25	1.52	**1.38**
3	Mepiquat chloride (1500 ppm)	2.03	2.60	**2.31**	4.59	4.92	**4.76**	5.05	5.54	**5.29**	2.22	2.90	**2.56**	1.19	1.52	**1.36**
4	Cycocel (1000 ppm)	2.48	2.48	**2.48**	4.53	5.15	**4.84**	5.05	5.34	**5.20**	2.22	2.94	**2.58**	1.24	1.46	**1.35**
5	Cytokinin (25 ppm)	2.45	2.32	**2.39**	4.71	4.91	**4.81**	5.55	5.80	**5.68**	2.28	2.67	**2.48**	1.16	1.48	**1.32**
6	Cytozyme (1000 ppm)	2.27	2.34	**2.31**	4.83	4.68	**4.76**	5.51	5.84	**5.68**	2.51	3.17	**2.84**	1.40	1.65	**1.53**
7	Control (water spray)	2.25	2.34	**2.30**	4.19	4.49	**4.34**	4.03	4.67	**4.49**	1.76	2.30	**2.03**	0.80	1.08	**0.94**
	Mean	**2.28**	**2.39**	**2.33**	**4.56**	**4.85**	**4.70**	**5.13**	**5.48**	**5.31**	**2.25**	**2.89**	**2.57**	**1.21**	**1.49**	**1.35**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.06		NS	0.05		0.15	0.04		0.13	0.04		0.13	0.03		0.08
	Growth regulators	0.11		NS	0.10		0.28	0.08		0.26	0.08		0.24	0.05		0.15
	Interaction	0.16		NS	0.14		NS	0.16		NS	0.12		NS	0.07		NS

Table 15. Influence of growth regulators on leaf area duration (LAD, days) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing											
		40-55			55-70			70-85			85-Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	48.8	53.5	**51.2**	75.2	82.3	**78.7**	59.3	68.7	**64.0**	29.3	37.4	**33.4**
2	TIBA (100 ppm)	47.8	48.7	**48.2**	70.9	74.8	**72.8**	54.4	61.8	**58.1**	26.2	33.6	**29.9**
3	Mepiquat chloride (1500 ppm)	47.4	52.4	**49.9**	72.2	78.4	**75.5**	54.5	63.2	**58.9**	25.6	38.1	**29.3**
4	Cycocel (1000 ppm)	50.2	53.4	**51.8**	71.9	78.9	**75.3**	54.5	62.1	**58.3**	25.9	32.9	**29.4**
5	Cytokinin (25 ppm)	51.3	50.6	**51.0**	76.9	79.5	**78.2**	58.7	66.2	**62.5**	25.7	33.7	**29.7**
6	Cytozyme (1000 ppm)	51.2	49.2	**50.2**	77.2	78.9	**78.3**	57.0	67.6	**62.3**	29.3	36.2	**32.7**
7	Control (water spray)	46.2	47.1	**46.7**	65.7	68.0	**66.8**	45.4	52.3	**48.8**	19.2	25.3	**22.2**
	Mean	**49.0**	**50.7**	**49.8**	**72.9**	**77.2**	**75.1**	**54.84**	**63.1**	**59.0**	**25.9**	**33.2**	**29.5**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.6		NS	0.5		1.6	0.6		1.6	0.4		1.0
	Growth regulators	1.2		NS	1.0		2.9	1.0		3.0	0.7		1.9
	Interaction	1.7		NS	1.4		NS	1.4		NS	0.9		NS

Significant differences were registered among the growth regulator treatments, except at 40-55 DAS and the treatment planofix (1000 ppm) recorded significantly higher LAD values over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel(1000 ppm) and control (water spray) at 55-70 DAS and similar trend was maintained at other stages except at 40-55 DAS, where no significant differences were observed.

It was also observed that LAD maintained peak in CO-1 at all the growth stages over DS-1 and it was statistically superior, except at 40-55 DAS. However, the treatments cytozyme (77.7 days) in DS-1 and planofix (82.3) in CO-1 recorded higher LAD among all the growth regulator treatments at 55-70 DAS and least LAD was noticed at 85 DAS-harvest in control (water spray). The interaction between the genotypes and growth regulators was found to be non-significant at all the growth stages.

4.4 GROWTH PARAMETERS

4.4.1 Absolute Growth Rate

The absolute growth rate (AGR) increased from 40 to 70 DAS and then declined drastically thereafter in all growth regulator treatments (Table 16). The maximum AGR was noticed at 55-70 DAS in all growth regulator treatments, whereas, the least was recorded at 85-harvest. Among the growth regulator treatments, cycocel(1000 ppm) at 40-55 DAS and 85 DAS-harvest, TIBA (100 ppm) at 55-70 DAS and planofix (1000 ppm) at 70-85 DAS recorded higher AGR values. It was also observed that the treatment TIBA (100 ppm) was found to be superior over planofix (1000 ppm), cytokinin (25 ppm) and control (water spray) at 55-70 DAS. At 70-85 DAS, planofix (1000 ppm) was found to be superior over mepiquat chloride (1500 ppm) and control (water spray) and were on par with other treatments. At 85 DAS-harvest, cycocel (1000 ppm) significantly differed over cytokinin (25 ppm), cytozyme (1000 ppm) and control (water spray). The interaction between the genotypes and growth regulators was found non-significant at all the growth stages.

Among the genotypes, DS-1 recorded higher AGR at 40-55 DAS and 55-70 DAS

Table 16. Influence of growth regulators on absolute growth rate (AGR, g day^{-1}) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing											
		40-55			55-70			70-85			85-Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.874	0.863	**0.868**	1.033	0.948	**0.990**	0.324	0.339	**0.332**	0.094	0.108	**0.101**
2	TIBA (100 ppm)	0.879	0.840	**0.860**	1.099	1.017	**1.058**	0.296	0.303	**0.300**	0.118	0.108	**0.113**
3	Mepiquat chloride (1500 ppm)	0.860	0.863	**0.861**	1.019	0.914	**0.967**	0.227	0.263	**0.245**	0.068	0.147	**0.107**
4	Cycocel (1000 ppm)	0.891	0.848	**0.869**	1.102	1.008	**1.056**	0.225	0.341	**0.283**	0.125	0.146	**0.136**
5	Cytokinin (25 ppm)	0.877	0.849	**0.863**	0.964	0.903	**0.933**	0.296	0.292	**0.294**	0.068	0.042	**0.055**
6	Cytozyme (1000 ppm)	0.860	0.835	**0.847**	1.027	0.993	**1.010**	0.302	0.284	**0.293**	0.102	0.093	**0.097**
7	Control (water spray)	0.841	0.802	**0.822**	0.779	0.619	**0.699**	0.135	0.125	**0.130**	0.029	0.039	**0.034**
	Mean	**0.869**	**0.843**	**0.856**	**1.003**	**0.915**	**0.915**	**0.258**	**0.278**	**0.260**	**0.086**	**0.098**	**0.092**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.013		NS	0.019		0.055	0.010		NS	0.009		NS
	Growth regulators	0.024		NS	0.035		0.103	0.019		0.054	0.016		0.048
	Interaction	0.034		NS	0.050		NS	0.026		NS	0.023		NS

and later CO-1 maintained peak, while there was no significant difference between the genotypes at 70-85 DAS and 85 DAS-harvest. In both the genotypes, the treatment TIBA (100 ppm) registered highest values at 55-70 DAS.

4.4.2 Relative Growth Rate

The data on relative growth rate (RGR) indicated that there was a decrease in RGR as the growth stage advanced (Table 17). Significant differences were noticed in all the growth regulator treatments at all the growth stages. However, the maximum RGR was noticed at 40-55 DAS in all the growth regulator treatments and the least at 85 DAS-harvest stages. Among the growth regulators, planofix and TIBA (0.081 $g\,g^{-1}\,day^{-1}$) recorded the maximum RGR at 40-55 DAS and which were on par with all other treatments, except control (water spray) at all the stages. The treatment cytozyme (1000 ppm) registered higher RGR at 55-70 DAS and at 70-85 DAS, while cycocel (1000 ppm) recorded higher RGR values at 85 DAS-harvest stage.

Genotypes differed significantly with respect to RGR at all the growth stages. DS-1 recorded significantly higher RGR at 40-55 DAS and at 55-70 DAS, but the treatment cytokinin (25 ppm) recorded higher RGR in DS-1 at 40-55 DAS and treatment cycocel (1000 ppm) at 55-70 DAS. In genotype CO-1, the treatment planofix (1000 ppm) recorded higher RGR at 40-55 and at 70-85 DAS. However, the interaction effect between the genotypes and growth regulators was non-significant at all the growth stages.

4.4.3 Crop Growth Rate

Table 18 revealed that crop growth rate (CGR) increased from 40 to 70 DAS and showed decreasing trend till harvest in all the growth regulator treatments and the maximum CGR values were obtained at 55-70 DAS. Among the growth regulator treatments, cycocel (1000 ppm) recorded higher CGR at 40-55 and 55-70 DAS. Significant differences in growth regulator treatments were appeared at all the growth stages, except at 40-55 DAS. However, significantly lower CGR was registered in control over all other treatments except at 40-55 DAS. None of the growth stages showed significant interaction effect.

Table 17. Influence of growth regulators on relative growth rate (RGR, g g^{-1} day^{-1}) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing											
		40-55			55-70			70-85			85-Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.085	0.077	**0.081**	0.041	0.037	**0.039**	0.007	0.009	**0.008**	0.001	0.002	**0.002**
2	TIBA (100 ppm)	0.086	0.075	**0.081**	0.043	0.038	**0.040**	0.007	0.007	**0.007**	0.002	0.002	**0.002**
3	Mepiquat chloride (1500 ppm)	0.080	0.007	**0.079**	0.040	0.038	**0.039**	0.005	0.008	**0.006**	0.002	0.002	**0.002**
4.	Cycocel (1000 ppm)	0.084	0.075	**0.079**	0.043	0.037	**0.040**	0.006	0.009	**0.007**	0.003	0.003	**0.003**
5	Cytokinin (25 ppm)	0.087	0.074	**0.080**	0.038	0.037	**0.037**	0.006	0.007	**0.007**	0.002	0.001	**0.002**
6	Cytozyme (1000 ppm)	0.081	0.074	**0.078**	0.041	0.040	**0.041**	0.007	0.008	**0.008**	0.002	0.002	**0.002**
7	Control (water spray)	0.069	0.067	**0.068**	0.030	0.029	**0.030**	0.005	0.004	**0.005**	0.001	0.002	**0.001**
	Mean	**0.082**	**0.074**	**0.078**	**0.039**	**0.036**	**0.038**	**0.006**	**0.008**	**0.007**	**0.002**	**0.002**	**0.002**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.001		0.004	0.001		0.002	0.001		0.001	0.000		NS
	Growth regulators	0.003		0.008	0.001		0.001	0.001		0.001	0.001		0.001
	Interaction	0.004		NS	0.002		NS	0.001		NS	0.001		NS

Table 18. Influence of growth regulators on crop growth rate (CGR, g dm^{-2} day^{-1}) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing											
		40-55			55-70			70-85			85-Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.029	0.028	**0.029**	0.034	0.031	**0.033**	0.011	0.011	**0.011**	0.004	0.004	**0.004**
2	TIBA (100 ppm)	0.029	0.028	**0.028**	0.036	0.034	**0.035**	0.010	0.010	**0.010**	0.004	0.005	**0.004**
3	Mepiquat chloride (1500 ppm)	0.028	0.028	**0.028**	0.034	0.030	**0.032**	0.007	0.009	**0.008**	0.004	0.005	**0.005**
4	Cycocel (1000 ppm)	0.029	0.028	**0.029**	0.036	0.033	**0.035**	0.007	0.011	**0.009**	0.005	0.005	**0.005**
5	Cytokinin (25 ppm)	0.029	0.028	**0.028**	0.032	0.030	**0.031**	0.010	0.010	**0.010**	0.005	0.004	**0.005**
6	Cytozyme (1000 ppm)	0.028	0.028	**0.028**	0.034	0.033	**0.033**	0.010	0.009	**0.010**	0.004	0.004	**0.004**
7	Control (water spray)	0.028	0.026	**0.027**	0.026	0.020	**0.023**	0.004	0.004	**0.004**	0.001	0.001	**0.001**
	Mean	**0.033**	**0.030**	**0.032**	**0.029**	**0.028**	**0.028**	**0.009**	**0.009**	**0.011**	**0.004**	**0.004**	**0.004**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.001		NS	0.001		0.002	0.001		NS	0.001		NS
	Growth regulators	0.001		NS	0.001		0.003	0.001		0.002	0.001		0.001
	Interaction	0.001		NS	0.002		NS	0.001		NS	0.001		NS

At 55-70 DAS, both the genotypes showed higher CGR values, but the treatments cycocel (0.036 g dm^{-2} day^{-1}) in DS-1 and TIBA (0.034 g dm^{-2} day^{-1}) in CO-1 recorded the maximum CGR and these values were significantly superior over cytokinin (25 ppm) at 55-70 DAS in DS-1 and planofix (1000 ppm), TIBA (100 ppm), cytokinin (25 ppm), cytozyme (1000 ppm) and control (water spray) in CO-1, respectively. None of the growth stages showed significant difference, except at 55-70 DAS.

4.4.4 Net Assimilation Rate

It was observed from Table 19 that the net assimilation rate (NAR) decreased from 40 DAS to harvest and the maximum was obtained at 40-55 DAS, while the minimum at harvest. Significant differences were noticed among growth regulator treatments at all the growth stages, except at 40-55 DAS. Among the growth regulator treatments, TIBA (100 ppm) recorded the maximum NAR at 40-55 and 70-85 DAS. Whereas, treatments TIBA (100 ppm) and mepiquat chloride (1500 ppm) registered the maximum NAR at 55-70 DAS and 85 DAS-harvest, respectively. Treatment control (water spray) accounted the least net assimilation rate at all the growth stages and it was statistically inferior over other treatments.

Treatment cycocel (1000 ppm) was found to be significantly superior over planofix (1000 ppm), mepiquat chloride (1500 ppm), cytokinin (25 ppm), cytozyme (1000 ppm) and control (water spray) at 55-70 DAS, while at 70-85 DAS, all the growth regulator treatments were on par with each other except cytozyme (1000 ppm) and control (water spray) and except control (water spray) at 85 DAS-harvest. None of the growth stages recorded significant interaction effect between growth regulators and genotypes.

Among the genotypes, DS-1 registered significantly higher NAR over CO-1 at 40-55 and 55-70 DAS. However, at 70-85 DAS, CO-1 recorded higher value, but was statistically non-significant over DS-1. But at 85 DAS-harvest, these two genotypes showed the same values (0.016 g dm^{-2} day^{-1}). The treatment mepiquat chloride (0.095 g dm^{-2} day^{-1}) recorded the highest value in DS-1, while the treatment TIBA (0.085 g dm^{-2} day^{-1}) accounted higher value in CO-1 at 40-55 DAS.

Table 19. Influence of growth regulators on net assimilation rate (NAR, g dm^{-2} day^{-1}) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing											
		40-55			55-70			70-85			85-Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.087	0.079	**0.083**	0.067	0.056	**0.061**	0.023	0.025	**0.024**	0.018	0.016	**0.017**
2	TIBA (100 ppm)	0.092	0.085	**0.088**	0.076	0.065	**0.070**	0.028	0.025	**0.027**	0.019	0.016	**0.018**
3	Mepiquat chloride (1500 ppm)	0.095	0.078	**0.087**	0.071	0.053	**0.062**	0.024	0.024	**0.024**	0.017	0.021	**0.019**
4	Cycocel (1000 ppm)	0.087	0.082	**0.083**	0.078	0.064	**0.071**	0.022	0.028	**0.024**	0.018	0.016	**0.017**
5	Cytokinin (25 ppm)	0.084	0.082	**0.083**	0.066	0.056	**0.061**	0.023	0.022	**0.023**	0.014	0.017	**0.015**
6	Cytozyme (1000 ppm)	0.085	0.082	**0.084**	0.066	0.058	**0.062**	0.022	0.021	**0.022**	0.020	0.016	**0.018**
7	Control (water spray)	0.087	0.080	**0.083**	0.055	0.047	**0.051**	0.014	0.014	**0.014**	0.007	0.009	**0.008**
	Mean	**0.088**	**0.081**	**0.084**	**0.068**	**0.057**	**0.063**	**0.022**	**0.023**	**0.022**	**0.016**	**0.016**	**0.016**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.002		0.005	0.002		0.004	0.001		NS	0.001		NS
	Growth regulators	0.003		NS	0.003		0.008	0.002		0.005	0.002		0.006
	Interaction	0.004		NS	0.004		NS	0.003		NS	0.003		NS

4.4.5 Leaf Area Ratio

The data on leaf area ratio (LAR) indicated a gradual decline from 40-55 DAS to 85 DAS-harvest (Table 20). Higher LAR was reported at 40-55 DAS and least at harvest. Significantly differed LAR was registered at 70-85 DAS and at 85 DAS-harvest stages in growth regulator treatments. However, the treatment cytokinin (25 ppm) maintained higher LAR at 40-55 DAS and 55-70 DAS, while the treatment cytozyme (1000 ppm) at 70-85 DAS and treatments planofix (1000 ppm) and cytozyme (1000 ppm) at 85 DAS-harvest maintained peak LAR values. Treatment cytozyme (1000 ppm) maintained significantly higher LAR values over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel (1000 ppm) and control (water spray) at 70-85 DAS. Whereas, at 85 DAS-harvest, treatments planofix (1000 ppm) and cytozyme (1000 ppm) were statistically superior over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel(1000 ppm) and control (water spray). None of the growth stages recorded significant interaction effects.

Among the genotypes, CO-1 registered significantly higher LAR values over DS-1 at all the growth stages, except at 40-55 DAS, where DS-1 showed higher value. Maximum LAR value was existed in CO-1 with mepiquat chloride (1500 ppm), but the same treatment recorded the least LAR in DS-1 at 40-55 DAS. Similarly, the treatment cytokinin (25 ppm) had higher LAR in DS-1 while the same treatment recorded the least LAR at 40-55 DAS. Treatment planofix (1000 ppm) in CO-1 and cytozyme (1000 ppm) in DS-1 showed significantly higher values over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel (1000 ppm) and control (water spray) at 70-85 DAS. However, the treatment planofix (1000 ppm) was significantly superior over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel (1000 ppm), cytokinin (25 ppm) and control (water spray) in DS-1 and over treatments TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel(1000 ppm) and control (water spray) in CO-1 at 85 DAS-harvest stage.

4.4.6 Specific Leaf Weight

Specific leaf weight (SLW) as influenced by the application of different growth

Table 20. Influence of growth regulators on leaf area ratio (LAR, $dm^2\ g^{-1}\ day^{-1}$) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing											
		40-55			55-70			70-85			85-Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.318	0.320	**0319**	0.199	0.214	**0.206**	0.103	0.124	**0.113**	0.048	0.060	**0.054**
2	TIBA (100 ppm)	0.302	0.297	**0.300**	0.185	0.194	**0.190**	0.093	0.111	**0.102**	0.042	0.053	**0.047**
3	Mepiquat chloride (1500 ppm)	0.286	0.326	**0.306**	0.187	0.207	**0.197**	0.096	0.116	**0.106**	0.042	0.054	**0.048**
4	Cycocel (1000 ppm)	0.315	0.324	**0.319**	0.180	0.202	**0.191**	0.091	0.111	**0.101**	0.042	0.053	**0.047**
5	Cytokinin (25 ppm)	0.343	0.296	**0.320**	0.208	0.211	**0.209**	0.105	0.122	**0.113**	0.043	0.057	**0.050**
6	Cytozyme (1000 ppm)	0.325	0.300	**0.313**	0.206	0.205	**0.205**	0.107	0.122	**0.114**	0.048	0.059	**0.054**
7	Control (water spray)	0.310	0.310	**0.310**	0.164	0.204	**0.184**	0.094	0.112	**0.103**	0.036	0.049	**0.043**
	Mean	**0.314**	**0.310**	**0.312**	**0.190**	**0.205**	**0.198**	**0.098**	**0.117**	**0.107**	**0.043**	**0.055**	**0.049**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.005		NS	0.004		0.011	0.001		0.003	0.001		0.002
	Growth regulators	0.009		NS	0.007		NS	0.002		0.006	0.001		0.004
	Interaction	0.013		NS	0.010		NS	0.003		NS	0.002		NS

Table 21. Influence of growth regulators on specific leaf weight (SLW, g dm^{-2}) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.384	0.411	**0.398**	0.561	0.560	**0.560**	0.605	0.573	**0.589**	0.698	0.678	**0.688**	0.817	0.708	**0.757**
2	TIBA (100 ppm)	0.361	0.453	**0.407**	0.587	0.586	**0.586**	0.625	0.664	**0.645**	0.658	0.692	**0.675**	0.775	0.795	**0.785**
3	Mepiquat chloride (1500 ppm)	0.456	0.365	**0.411**	0.571	0.579	**0.575**	0.630	0.617	**0.625**	0.756	0.706	**0.731**	0.914	0.795	**0.854**
4	Cycocel (1000 ppm)	0.352	0.416	**0.348**	0.606	0.543	**0.574**	0.697	0.658	**0.677**	0.849	0.758	**0.803**	0.914	0.782	**0.848**
5	Cytokinin (25 ppm)	0.333	0.447	**0.390**	0.570	0.567	**0.569**	0.557	0.591	**0.574**	0.721	0.650	**0.686**	0.844	0.777	**0.810**
6	Cytozyme (1000 ppm)	0.383	0.469	**0.426**	0.530	0.587	**0.563**	0.594	0.601	**0.597**	0.712	0.691	**0.701**	0.789	0.748	**0.769**
7	Control (water spray)	0.364	0.343	**0.399**	0.544	0.589	**0.566**	0.554	0.598	**0.576**	0.661	0.638	**0.649**	0.701	0.667	**0.684**
	Mean	**0.376**	**0.420**	**0.402**	**0.560**	**0.573**	**0.570**	**0.609**	**0.615**	**0.612**	**0.722**	**0.687**	**0.705**	**0.821**	**0.758**	**0.787**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.012		0.036	0.007		NS	0.006		NS	0.021		NS	0.025		NS
	Growth regulators	0.023		NS	0.013		NS	0.012		0.035	0.039		NS	0.047		NS
	Interaction	0.033		NS	0.018		NS	0.017		NS	0.055		NS	0.066		NS

regulators at various growth stages is presented in Table 21. There was an increasing trend in SLW from 40 DAS to harvest in all the growth regulator treatments. Non-significant differences due to growth regulators were noticed at all the growth stages, except at 70 DAS. However at harvest, all the growth regulator treatments registered higher values.

Among the genotypes, DS-1 recorded higher SLW at 85 DAS and at harvest. Whereas, CO-1 maintained peak at 40, 55 and 70 DAS. Significant differences with respect to SLW were noticed at 40 DAS however, the increase in SLW was non-significant at the remaining growth stages between these two genotypes. The interaction effect was non-significant through all the growth stages.

4.4.7 Specific Leaf Area

The specific leaf area (SLA) decreased continuously from 40 DAS until harvest in all the growth regulator treatments (Table 22). Highest and lowest values were noticed at 40 DAS and at harvest, respectively. Significant differences among growth regulator treatments were recorded at 70 DAS, wherein the treatment planofix (1000 ppm) differed significantly over TIBA (100 ppm), mepiquat chloride (1500 ppm), cycocel(1000 ppm) and control (water spray).

It was observed that DS-1 recorded slightly higher SLA at 40, 55 and 70 DAS, while, CO-1 recorded higher values at 85 DAS and at harvest. Significant differences between these two genotypes were noticed at 40 and 85 DAS. The growth regulators and genotypes interaction was found to be non-significant at all the growth stages.

4.5 PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS

4.5.1 Chlorophyll 'a' content in leaf

The data on the influence of growth regulators on chlorophyll 'a' content in leaf at different growth stages indicated an increase in chlorophyll 'a' content from 40 to 55 DAS and declined continuously until harvest in all the treatments (Table 23). In all the growth regulator

Table 22. Influence of growth regulators on specific leaf area (SLA, $dm^2\ g^{-1}$) at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing													
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	2.683	2.477	**2.580**	1.777	1.787	**1.782**	1.657	1.740	**1.698**	1.350	1.480	**1.415**	1.263	1.447	**1.355**
2	TIBA (100 ppm)	2.620	2.260	**2.440**	1.700	1.707	**1.703**	1.530	1.510	**1.520**	1.330	1.447	**1.388**	1.293	1.270	**1.282**
3	Mepiquat chloride (1500 ppm)	2.207	2.780	**2.493**	1.753	1.733	**1.743**	1.580	1.690	**1.595**	1.323	1.413	**1.368**	1.100	1.283	**1.192**
4	Cycocel (1000 ppm)	2.870	2.343	**2.607**	1.653	1.787	**1.720**	1.420	1.507	**1.463**	1.173	1.317	**1.245**	1.107	1.277	**1.192**
5	Cytokinin (25 ppm)	3.010	2.247	**2.628**	1.750	1.713	**1.732**	1.793	1.690	**1.742**	1.393	1.553	**1.473**	1.190	1.337	**1.258**
6	Cytozyme (1000 ppm)	2.603	2.243	**2.423**	1.857	1.703	**1.780**	1.677	1.680	**1.678**	1.417	1.447	**1.432**	1.270	1.350	**1.310**
7	Control (water spray)	2.740	2.337	**2.538**	1.840	1.750	**1.795**	1.733	1.603	**1.668**	1.400	1.563	**1.482**	1.343	1.267	**1.305**
	Mean	**2.676**	**2.384**	2.530	**1.761**	**1.740**	1.751	**1.627**	**1.620**	1.624	**1.341**	**1.460**	1.400	**1.224**	**1.317**	1.270
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.075		0.219	0.024		NS	0.014		NS	0.030		0.087	0.046		NS
	Growth regulators	0.141		NS	0.046		NS	0.027		0.079	0.056		NS	0.086		NS
	Interaction	0.200		NS	0.065		NS	0.038		NS	0.079		NS	0.121		NS

Table 23 . Influence of growth regulators on chlorophyll 'a' content (mg g fr. wt. $^{-1}$) in leaf at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.924	0.801	**0.862**	1.774	1.629	**1.701**	1.514	1.629	**1.572**	0.677	0.871	**0.774**	0.547	0.751	**0.649**
2	TIBA (100 ppm)	0.603	0.819	**0.711**	1.770	1.714	**1.742**	1.595	1.669	**1.632**	0.715	0.857	**0.786**	0.615	0.656	**0.635**
3	Mepiquat chloride (1500 ppm)	1.016	0.777	**0.896**	1.715	1.713	**1.714**	1.554	1.580	**1.567**	0.691	0.839	**0.765**	0.591	0.639	**0.615**
4	Cycocel (1000 ppm)	0.961	0.822	**0.891**	1.744	1.702	**1.723**	1.574	1.474	**1.524**	0.716	0.783	**0.750**	0.616	0.683	**0.649**
5	Cytokinin (25 ppm)	0.571	0.796	**0.684**	1.778	1.677	**1.727**	1.639	1.655	**1.647**	0.705	0.843	**0.774**	0.605	0.636	**0.621**
6	Cytozyme (1000 ppm)	0.914	0.813	**0.864**	1.760	1.725	**1.742**	1.531	1.637	**1.584**	0.676	0.850	**0.763**	0.576	0.650	**0.613**
7	Control (water spray)	0.877	0.794	**0.836**	1.426	1.492	**1.459**	1.330	1.390	**1.360**	0.514	0.552	**0.533**	0.314	0.386	**0.350**
	Mean	**0.838**	**0.803**	**0.821**	**1.710**	**1.665**	**1.687**	**1.534**	**1.576**	**1.555**	**0.671**	**0.799**	**0.735**	**0.552**	**0.628**	**0.590**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.043		NS	0.015		0.045	0.020		NS	0.017		0.048	0.013		0.041
	Growth regulators	0.080		NS	0.029		0.084	0.037		0.107	0.031		0.091	0.024		0.074
	Interaction	0.112		NS	0.041		NS	0.052		NS	0.044		NS	0.036		NS

treatments, significant differences were noticed at all the growth stages, except at 40 DAS. Maximum chlorophyll 'a' content was recorded at 55 DAS whereas, the minimum at harvest in all the growth regulator treatments.

Among the growth regulator treatments, TIBA (100 ppm) and cytozyme (1.742 mg g fr. wt.$^{-1}$) registered higher chlorophyll 'a' content, which were on par with all other treatments except control (water spray) at 55 DAS. The treatment TIBA (100 ppm) recorded higher chlorophyll 'a' content at 55, 85 DAS and at harvest but the treatments mepiquat chloride (1500 ppm) and cytokinin (25 ppm) maintained higher chlorophyll 'a' content at 40 and 70 DAS, respectively.

Genotypes differed significantly with respect to chlorophyll 'a' content at all the growth stages except at 40 and 70 DAS. DS-1 recorded higher chlorophyll 'a' content at 40 and 55 DAS whereas, CO-1 recorded at 70, 85 DAS and at harvest. Treatment TIBA (100 ppm) registered higher chlorophyll 'a' content in CO-1 at 40 and 55 DAS, similarly, mepiquat chloride (1500 ppm) in DS-1. Here also the interaction effect between the genotypes and growth regulators was non-significant at all the growth stages.

4.5.2 Chlorophyll 'b' content in leaf

It was observed that chlorophyll 'b' content in leaf increased from 40 to 55 DAS and declined further until harvest in all the growth regulator treatments (Table 24). Significant differences were observed in growth regulator treatments with respect to chlorophyll 'b' content at all the growth stages except at 40 and 55 DAS. However, the maximum values were obtained at 55 DAS and least at harvest in all the growth regulator treatments. Among the growth regulator treatments, cytokinin (0.701 mg g fr. wt.$^{-1}$) recorded higher chlorophyll 'b' content at 55 DAS. At 70, 85 DAS and at harvest, treatment planofix (1000 ppm) recorded higher values and which was statistically superior over control (water spray) at 70, 80 DAS and at harvest.

Significant differences with respect to chlorophyll 'b' content were noticed between the genotypes at all the growth stages. The genotype DS-1 was found to be significantly superior

Table 24. Influence of growth regulators on chlorophyll 'b' content (mg g fr. wt.$^{-1}$) in leaf at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.470	0.421	**0.446**	0.705	0.646	**0.675**	0.532	0.690	**0.611**	0.271	0.381	**0.326**	0.171	0.281	**0.226**
2	TIBA (100 ppm)	0.447	0.401	**0.424**	0.673	0.664	**0.669**	0.539	0.626	**0.583**	0.289	0.296	**0.292**	0.189	0.196	**0.192**
3	Mepiquat chloride (1500 ppm)	0.498	0.402	**0.402**	0.699	0.686	**0.692**	0.534	0.589	**0.561**	0.307	0.307	**0.307**	0.207	0.207	**0.207**
4	Cycocel (1000 ppm)	0.455	0.373	**0.414**	0.703	0.648	**0.675**	0.531	0.591	**0.571**	0.287	0.288	**0.288**	0.187	0.188	**0.188**
5	Cytokinin (25 ppm)	0.423	0.382	**0.403**	0.722	0.679	**0.701**	0.551	0.545	**0.548**	0.269	0.325	**0.297**	0.176	0.225	**0.201**
6	Cytozyme (1000 ppm)	0.455	0.393	**0.424**	0.705	0.662	**0.684**	0.484	0.620	**0.552**	0.317	0.316	**0.317**	0.217	0.216	**0.217**
7	Control (water spray)	0.438	0.367	**0.403**	0.635	0.593	**0.614**	0.361	0.330	**0.349**	0.223	0.205	**0.214**	0.096	0.092	**0.094**
	Mean	**0.455**	**0.391**	**0.423**	**0.692**	**0.654**	**0.673**	**0.507**	**0.571**	**0.539**	**0.280**	**0.305**	**0.392**	**0.178**	**0.201**	**0.189**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.010		0.028	0.010		0.029	0.016		0.046	0.007		0.021	0.005		0.016
	Growth regulators	0.018		NS	0.019		NS	0.030		0.087	0.014		0.040	0.011		0.032
	Interaction	0.026		NS	0.027		NS	0.042		NS	0.019		0.056	0.017		0.041

at 40 and 55 DAS, while CO-1 was statistically superior over DS-1 at 70, 85 DAS and at harvest with respect to chlorophyll 'b' content.

Treatment planofix (1000 ppm) registered higher chlorophyll 'b' content at all the growth stages except at 55 DAS in CO-1, whereas in DS-1, cytokinin (25 ppm) and cytozyme (1000 ppm) recorded higher chlorophyll 'b' content at 55, 70 DAS and at 85 DAS and at harvest, respectively. The interaction effect between the genotypes and growth regulators was found to be significant with respect to chlorophyll 'b' content at 85 DAS and at harvest.

4.5.3 Total chlorophyll content in leaf

The data pertaining to total chlorophyll content in leaf revealed that it increased upto 55 DAS and declined progressively thereafter in all the growth regulator treatments (Table 25). Similarly growth regulator treatments differed significantly at all the growth stages except at 40 DAS and the highest total chlorophyll content was observed at 55 DAS and the least at harvest. All the growth regulator treatments were on par with each other at all the growth stages except at 40 DAS. However, differed significantly over control.

Among the growth regulator treatments, the maximum total chlorophyll content was recorded by cytokinin (2.426 mg g fr. wt.$^{-1}$) at 55 DAS. The growth stage 70 DAS alone registered significant interaction effect between genotypes and growth regulators.

Genotypes differed significantly with respect to total chlorophyll content in leaf at all the growth stages. However, DS-1 differed significantly over CO-1 at 40 and 55 DAS and at remaining growth stages CO-1 maintained significant difference with DS-1. At 55 DAS, both the genotypes recorded highest total chlorophyll content with variation among growth regulator treatments. Treatment mepiquat chloride (2.395 mg g fr. wt.$^{-1}$) in CO-1 and cytokinin (2.496 mg g fr. wt.$^{-1}$) in DS-1 registered higher values at 55 DAS.

4.5.4 Chlorophyll 'a', 'b' and total chlorophyll contents in capsule

Table 26 revealed that chlorophyll 'a' and total chlorophyll increased from 55 to

Table 25. Influence of growth regulators on total chlorophyll content (mg g fr. wt.$^{-1}$) in leaf at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing														
		40			55			70			85			Harvest		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	1.362	1.202	**1.282**	2.473	2.273	**2.373**	2.041	2.362	**2.202**	0.945	1.248	**1.097**	0.718	1.032	**0.875**
2	TIBA (100 ppm)	1.381	1.217	**1.299**	2.440	2.376	**2.408**	2.133	2.294	**2.213**	1.000	1.105	**1.075**	0.804	0.852	**0.828**
3	Mepiquat chloride (1500 ppm)	1.500	1.174	**1.337**	2.410	2.395	**2.402**	2.087	2.164	**2.126**	0.999	1.145	**1.072**	0.798	0.846	**0.822**
4	Cycocel (1000 ppm)	1.410	1.191	**1.300**	2.445	2.347	**2.396**	2.124	2.196	**2.160**	1.000	1.067	**1.034**	0.803	0.871	**0.837**
5	Cytokinin (25 ppm)	1.328	1.174	**1.251**	2.496	2.355	**2.826**	2.196	2.199	**2.197**	0.971	1.157	**1.064**	0.781	0.861	**0.821**
6	Cytozyme (1000 ppm)	1.354	1.209	**1.282**	2.462	2.384	**2.423**	2.042	2.256	**2.149**	0.990	1.163	**1.007**	0.793	0.866	**0.829**
7	Control (water spray)	1.343	1.159	**1.251**	2.073	2.148	**2.110**	1.698	1.660	**1.683**	0.730	0.753	**0.741**	0.410	0.478	**0.444**
	Mean	**1.383**	**1.189**	**1.286**	**2.400**	**2.235**	**2.363**	**2.046**	**2.163**	**2.104**	**0.940**	**1.079**	**1.023**	0.738	0.829	**0.779**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.014		0.041	0.018		0.053	0.019		0.054	0.015		0.045	0.011		0.031
	Growth regulators	0.027		NS	0.034		0.100	0.035		0.101	0.029		0.084	0.022		0.065
	Interaction	0.038		NS	0.049		NS	0.049		0.143	0.041		NS	0.030		NS

Table 26. Influence of growth regulators on chlorophyll 'a', 'b' and total chlorophyll contents (mg g fr. wt.$^{-1}$) in capsule at different growth stages in sesamum genotypes

Sl. No.	Treatment	Days After Sowing															
		Chlorophyll 'a'						Chlorophyll 'b'						Total Chlorophyll			
		55			70			55			70			55			70		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.441	0.377	**0.409**	0.543	0.484	**0.514**	0.171	0.155	**0.163**	0.186	0.139	**0.163**	0.578	0.528	**0.553**	0.727	0.621	**0.674**
2	IBA (100 ppm)	0.451	0.409	**0.430**	0.506	0.499	**0.503**	0.171	0.144	**0.158**	0.176	0.146	**0.161**	0.618	0.551	**0.584**	0.676	0.640	**0.658**
3	Mepiquat chloride (1500 ppm)	0.452	0.412	**0.432**	0.530	0.473	**0.501**	0.169	0.140	**0.155**	0.176	0.146	**0.161**	0.618	0.548	**0.583**	0.701	0.615	**0.658**
4	Cycocel (1000 ppm)	0.445	0419	**0.432**	0.512	0.523	**0.518**	0.176	0.144	**0.160**	0.179	0.147	**0.163**	0.617	0.560	**0.589**	0.686	0.665	**0.676**
5	Cytokinin (25 ppm)	0.455	0.387	**0.421**	0.582	0.538	**0.560**	0.170	0.141	**0.156**	0.176	0.147	**0.161**	0.622	0.522	**0.572**	0.719	0.680	**0.699**
6	Cytozyme (1000 ppm)	0.427	0.433	**0.430**	0.488	0.498	**0.493**	0.170	0.147	**0.159**	0.171	0.143	**0.157**	0.594	0.576	**0.585**	0.658	0.639	**0.648**
7	Control (water spray)	0.408	0.397	**0.403**	0.411	0.428	**0.419**	0.161	0.144	**0.153**	0.162	0.136	**0.149**	0.534	0.538	**0.536**	0.568	0.555	**0.562**
	Mean	**0.440**	**0.405**	**0.422**	**0.510**	**0.492**	**0.501**	**0.170**	**0.145**	**0.157**	**0.175**	**0.143**	**0.159**	**0.597**	**0.546**	**0.572**	**0.676**	**0.631**	**0.653**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.008		0.023	0.010		NS	0.002		0.005	0.002		0.005	0.008		0.025	0.010		0.028
	Growth regulators	0.015		NS	0.018		0.052	0.002		NS	0.003		0.009	0.016		NS	0.018		0.053
	Interaction	0.021		NS	0.025		NS	0.004		NS	0.004		NS	0.022		NS	0026		NS

70 DAS and chlorophyll 'b' maintained similar values at 55 and 70 DAS. Significant differences were noticed with respect to Chlorophyll 'a', 'b' and total at 70 DAS. Maximum chlorophyll 'a' content in capsule was observed in treatments mepiquat chloride and cycocel (0.432 mg g fr. wt.$^{-1}$) and in cytokinin (0.560 mg g fr. wt.$^{-1}$) at 55 and 70 DAS, respectively. But, treatments planofix (0.163 mg g fr. wt.$^{-1}$) and planofix and cycocel (0.613 mg g fr. wt.$^{-1}$) maintained higher chlorophyll 'b' content at 55 and 70 DAS, respectively. Similarly, the highest total chlorophyll content was recorded in the treatments cycocel (0.589 mg g fr. wt.$^{-1}$) and cytokinin (0.699 mg g fr. wt.$^{-1}$) at 55 and 70 DAS, respectively.

At 55 DAS, genotype DS-1 was found to be statistically superior over CO-1 with respect to chlorophyll 'a' content in capsule. Similar trend was maintained with respect to chlorophyll 'b' and total chlorophyll contents at 55 and 70 DAS. The treatment cytokinin (25 ppm) recorded higher chlorophyll 'a' content at 70 DAS in both the genotypes, but chlorophyll 'b' content varied among growth regulator treatments in both genotypes. Treatments cytokinin (25 ppm) and cytozyme (1000 ppm) registered higher total chlorophyll content in DS-1 and CO-1, respectively.

The interaction effect between the genotypes and growth regulators was not found significant with respect to chlorophyll 'a', 'b' and total chlorophyll contents in capsule at 55 and 70 DAS.

4.5.5 Nitrate Reductase Activity in leaf

The nitrate reductase activity (NRA) increased from 40 to 55 DAS and declined drastically thereafter in all the growth regulator treatments (Table 27). Maximum NR activity was found at 55 DAS and the least at 70 DAS. Significant differences among the treatments existed at 55 and 70 DAS, the treatment cycocel (1000 ppm) recorded the maximum NR activity which was statistically superior over cytokinin (25 ppm) and control (water spray) at 55 DAS and over control (water spray) at 70 DAS.

Genotypes differed significantly with respect to NR activity at 40 and 55 DAS

Table 27. Influence of growth regulators on biochemical parameters in sesamum genotypes

Sl. No.	Treatment	Days After Sowing									Oil content in seed (%)			Protein content in seed (%)		
		Nitrate Reductase Activity in leaf (NRA, μ moles NO_2 g fr wt.$^{-1}$ hr^{-1})														
		40			55			70								
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	0.583	0.502	**0.543**	0.940	0.891	**0.916**	0.338	0.343	**0.340**	55.68	55.32	**55.52**	25.05	22.55	**23.80**
2	TIBA (100 ppm)	0.587	0.479	**0.533**	0.973	0.867	**0.920**	0.342	0.373	**0.358**	57.02	56.31	**56.67**	23.62	23.41	**23.51**
3	Mepiquat chloride (1500 ppm)	0.583	0.463	**0.524**	0.919	0.864	**0.892**	0.347	0.365	**0.356**	56.69	56.06	**56.37**	23.08	22.95	**23.01**
4	Cycocel (1000 ppm)	0.632	0.454	**0.543**	0.985	0.921	**0.953**	0.378	0.385	**0.381**	56.16	56.06	**56.11**	23.42	24.08	**23.76**
5	Cytokinin (25 ppm)	0.615	0.449	**0.532**	0.865	0.855	**0.860**	0.334	0.330	**0.332**	57.08	56.18	**56.63**	22.97	23.22	**23.10**
6	Cytozyme (1000 ppm)	0.581	0.461	**0.521**	0.908	0.866	**0.887**	0.365	0.377	**0.371**	56.41	56.70	**56.55**	23.47	23.31	**23.39**
7	Control (water spray)	0.605	0.430	**0.517**	0.599	0.571	**0.585**	0.201	0.183	**0.192**	54.49	54.81	**54.65**	21.14	20.80	**20.97**
	Mean	**0.598**	**0.463**	**0.530**	**0.884**	**0.834**	**0.859**	**0.329**	**0.337**	**0.333**	**56.22**	**55.92**	**56.07**	**22.97**	**22.90**	**22.93**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.020		0.058	0.014		0.041	0.009		NS	0.203		NS	0.188		NS
	Growth regulators	0.038		NS	0.026		0.077	0.018		0.051	0.381		1.106	0.352		1.023
	Interaction	0.053		NS	0.037		NS	0.025		NS	0.538		NS	0.498		NS

and the treatment cycocel (1000 ppm) recorded higher nitrate reductase activity at all the growth stages in both the genotypes. The interaction effect was not found significant at all the growth stages.

4.5.6 Protein and Oil contents in seed

The data pertaining to protein and oil content presented in Table 27, showed significant differences due to growth regulator treatments. All growth regulator treatments were on par with each other except control in both the cases. The maximum protein and oil contents were noticed in treatments TIBA (100 ppm) and planofix (1000 ppm), respectively.

4.6 YIELD AND YIELD ATTRIBUTES

The data on the influence of growth regulators on yield and yield attributes is presented in Table 28.

4.6.1 Number of seeds per capsule

It is evident from Table 28 that significant differences were noticed both in growth regulator treatments and genotypes with respect to number of seeds per capsule. However, the treatment TIBA (100 ppm) recorded the maximum seed number per capsule, which was significantly superior over mepiquat chloride (1500 ppm) and control (water spray) treatments and similar trend was maintained in both the genotypes. Genotype DS-1 found to be significantly higher over CO-1 with respect to number of seeds per capsules. The interaction of growth regulators and genotypes was not significant.

4.6.2 Test weight (1000-seed weight)

The data on the test weight indicated significant differences between the genotypes and growth regulator treatments (Table 28). Genotype DS-1 was found to be significantly superior over CO-1, whereas, the treatments cycocel(1000 ppm) and TIBA (100 ppm) maintained higher 1000 seed weight in DS-1 and Co-1, respectively. However, the treatment cycocel(1000 ppm) recorded statistically superior test weight over planofix (1000 ppm), mepiquat chloride

Table 28. Influence of growth regulators on seed yield and yield parameters in sesamum genotypes

Sl. No.	Treatment	Seed yield per plant (g)			Seed yield (q ha^{-1})			Test weight (g)			No. of seeds / capsule			Capsule length (cm)			Capsule width (cm)		
		DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean	DS-1	CO-1	Mean
1	Planofix (1000 ppm)	6.32	6.41	**6.37**	11.67	10.92	**11.29**	3.55	3.38	**3.46**	65.80	61.96	**63.88**	2.83	2.83	**2.83**	1.05	0.93	**0.99**
2	TIBA (100 ppm)	6.61	6.48	**6.55**	11.26	10.76	**11.01**	3.57	3.61	**3.59**	65.90	62.43	**64.16**	2.83	2.86	**2.85**	1.00	0.92	**0.95**
3	Mepiquat chloride (1500 ppm)	6.53	6.46	**6.50**	10.92	11.44	**11.18**	3.40	3.46	**3.43**	63.86	60.53	**62.20**	2.91	2.82	**2.86**	1.00	0.92	**0.95**
4	Cycocel (1000 ppm)	7.15	6.97	**7.06**	12.08	11.63	**11.85**	3.65	3.58	**3.61**	65.73	62.16	**63.95**	2.87	2.89	**2.88**	1.00	0.95	**0.97**
5	Cytokinin (25 ppm)	6.19	6.28	**6.24**	10.37	10.79	**10.58**	3.62	3.52	**3.57**	64.06	62.16	**63.11**	2.80	2.83	**2.82**	1.00	0.93	**0.97**
6	Cytozyme (1000 ppm)	6.90	7.09	**6.99**	10.98	11.24	**11.11**	3.48	3.38	**3.43**	64.50	61.96	**63.23**	2.77	2.82	**2.79**	1.00	0.94	**0.97**
7	Control (water spray)	4.56	5.18	**4.87**	9.37	8.84	**9.10**	3.48	3.27	3.38	63.56	61.03	**62.30**	2.78	2.76	**2.77**	1.02	0.93	0.97
	Mean	**6.32**	**6.41**	**6.37**	**10.95**	**10.80**	**10.88**	**3.54**	**3.46**	**3.50**	**64.77**	**61.75**	**63.26**	**2.83**	**2.83**	**2.83**	**1.00**	**0.93**	**0.97**
		SEm±		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**	**SEm±**		**CD at 5%**
	Genotypes	0.10		NS	0.06		NS	0.03		0.08	0.22		0.64	0.02		NS	0.01		0.02
	Growth regulators	0.19		0.56	0.11		0.33	0.05		0.14	0.41		1.20	0.03		NS	0.01		NS
	Interaction	0.27		NS	0.16		0.46	0.07		NS	0.58		NS	0.05		NS	0.02		NS

(1500 ppm), cytozyme (1000 ppm) and control (water spray) and here also interaction was non-significant.

4.6.3 Capsule length and width

The capsule length and width remained non-significant due to growth regulator treatments but the genotypes differed significantly with respect to capsule width where DS-1 was found to be superior. Similarly, the interaction affect was non-significant in both the cases (Table 28).

4.6.4 Number of locules per capsule

Since the number of locules per capsule remained as four per capsule in both genotypes, data related to locule number was ignored.

4.6.5 Seed yield per plant

The seed yield per plant showed significant differences due to growth regulator treatments. However, the treatment cycocel (1000 ppm) maintained significantly higher values over treatments planofix (1000 ppm), cytokinin (25 ppm) and control (water spray). Genotypic differences and the interaction of genotypes with growth regulators were not significant.

4.6.6 Seed yield (q ha^{-1})

The data related to seed yield indicated significant differences among growth regulator treatments (Table 28). However, the treatment cycocel (1000 ppm) maintained statistically higher value over all the growth regulator treatments. Among the genotypes, DS-1 recorded the maximum seed yield over CO-1 without significant difference. Similarly, the treatment cycocel(1000 ppm) registered higher seed yield in both the genotypes. The interaction effect between the growth regulator treatments and genotypes was found to be significant.

4.7 ECONOMICS

The data on economics of growth regulators use in sesamum is presented in

Table 30. Effects of Growth Regulators on Economics of sesamum (*Sesamum indicum* L.) genotypes

Sl. No.	Treatments	Gross yield (q ha^{-1})	Gross returns (Rs. ha^{-1}) (A)	Additional cost due to plant growth regulators (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1}) (B)	Net returns (Rs. ha^{-1}) (A-B)	Net returns due to plant growth regulators (Rs. ha^{-1})
1	Planofix (1000 ppm)	11.29	20322	77.50	4483.20	15838.80	3864.50
2	TIBA (100 ppm)	11.01	19818	4500.00	8905.70	10912.30	-1062.00
3	Mepiquat chloride (1500 ppm)	11.18	20124	142.50	4548.20	15575.80	3601.50
4	Cycocel (1000 ppm)	11.85	21330	5800.00	10205.70	11124.30	-850.00
5	Cytokimin (25 ppm)	10.58	19044	1000.00	5405.70	13638.30	1664.00
6	Cytozyme (1000 ppm)	11.11	19998	200.00	4605.70	15392.30	3418.00
7	Control (water spray)	9.10	16380	--	4405.70	11974.30	--

1.	Basic cost of cultivation (Rs. ha^{-1})		=	4405.70
2.	Price of sesamum (Rs. q^{-1})		=	1800.00
3.	Cost of chemicals	a) Planofix	=	155 Rs./lit.
		b) TIBA	=	900 Rs./10 g
		c) Mepiquat chloride	=	190 Rs./lit.
		d) Cycocel	=	290 Rs./25 g
		e) Cytokinin	=	400 Rs./5 g
		f) Cytozyme	=	400 Rs./lit.

Table 30. Among all the growth regulators, planofix (1000 ppm) followed by cytozyme (1000 ppm) and mepiquat chloride (1500 ppm) gave the maximum net returns. However, TIBA (1000 ppm) and cycocel (1000 ppm) being costly, showed negative values with respect to net returns (-1062.0 and -850.0 Rs. ha^{-1}, respectively). The treatment, cytokinin (25 ppm) was also found beneficial in terms of net returns.

DISCUSSION

Kuchenbuch and Jung, 1988). Similarly, Pando and Srivastava (1985) while studying the effect of CCC on sunflower observed an increase in seed yield by reducing the plant height and leaf area with increased photosynthesis and translocation of photoassimilates towards the capitulum.

With this background, the present investigation was designed with two sesamum genotypes to evaluate the influence of different growth regulators on morphological, phenological growth, biochemical parameters and yield and yield components. The results obtained on these aspects are discussed hereunder in light of the work done by others on sesamum and other oilseed crops.

5.1 MARPHOLOGICAL CHARACTERS

The influence of growth regulators on various morphological characters such as plant height, number of branches, number of flowers per plant, number of capsules per plant, dry matter production and its distribution into different plant parts and leaf area indicated that the growth regulator treatments differed significantly with respect to all the above parameters. Among the growth regulator treatments, cycocel responded better than any other chemical in both the genotypes. Both the genotypes differed significantly with respect to all the morphological characters in all the growth regulator treatments, but none of the morphological characters showed significant interaction between growth regulators and genotypes at all the growth stages.

Basically, plant height is a genetically controlled character. But, several studies indicated that plant height is either increased or decreased by the application of synthetic plant growth regulators. Initially (40 DAS), none of the growth regulator treatments in both the genotypes showed significant difference with respect to plant height because, at this stage, treatments were not imposed. Similarly, at 55 DAS, treatments did not show significant differences in plant height, which could be due to slow action of applied growth regulators. However, both the genotypes differed significantly at this stage and this difference is due to tall growing character of CO-1 variety.

Significant difference in plant height was noticed among growth regulator

treatments from 70 DAS to harvest. The plant growth regulator treatments planofix (1000 ppm) and cytozyme (1000 ppm) increased plant height over control and other growth regulator treatments. Since these two growth regulators are auxin and cytokinin derivatives, are involved in cell division, cell differentiation and cell expansion, thereby leading to enhanced growth and development. Increased plant height may probably be due to stimulating action of auxin which softens the cell wall by increasing its plasticity (Tagawa and Bonner, 1957). Another probable reason may be the oxidative decarboxylation of synthetic auxins which could not be catalyzed by the enzyme peroxidase (Reinecke and Bandurski, 1987). Similarly in sunflower, Kene *et al.* (1991) observed increased plant height with planofix. Though cytokinin is a growth promoter, it had no effect on plant height.

Significant reduction in plant height was noticed in treatments TIBA (100 ppm), mepiquat chloride (1500 ppm) and cycocel (1000 ppm) and cycocel was more effective in reducing the plant height than the other two growth retardants in both the genotypes. Similarly, almost equal reduction in plant height was recorded by these three growth retardants in both DS-1 and CO-1 and these two significantly differed with respect to plant height from 55 DAS until harvest. The mechanism of redution in plant height appears to be due to slowing down of cell division and reduction in cell expansion. It has been suggested that cycocel and mepiquat chloride are antigibberellin dwarfing agents, leading to a deficiency of gibberellin in the plant and reduced growth, that is, blocking the conversion of geranylgeranyl pyrophosphate to copalyl pyrophosphate which is the first step of gibberellin synthesis (Moore, 1980). Thus, the reduced plant height is due to retardation of transverse cell division particularly in steelar cambium, which is the zone of meristematic activity at the base of the internode (Grossman, 1990).

However, TIBA is also a growth retardant, but its mode of action is different from the other two, which inhibits polar transport of auxins from apex to the base of the plant (basipetal) leading to decreased plant height (Hopkins, 1995).

The data on the number of primary branches revealed that none of the growth regulator treatments showed significant differences, which is probably due to ineffectiveness of

these growth regulating chemicals in the induction of lateral bud initiation. However, the genotype, CO-1 recorded significantly higher branching over DS-1 due to branching habit of the genotype. Similarly, Ogilvy (1985) reported ineffectiveness of cycocel, ethephon and mepiquat chloride + ethephon in increasing the number of branches per plant in rapeseed.

The number of flowers per plant depends on the environmental conditions and genotypes and it is also influenced by synthetic plant growth regulators. It is clear from our data that the number of flowers significantly increased due to growth regulator treatments as compared to control at 55 DAS, but increase was non-significant at 40 DAS. Maximum flower number was recorded with planofix (13.2) at 55 DAS. Similarly, Li *et al.* (1987) noticed increased flower number per plant in sesamum with mepiquat chloride and cycocel.

Shedding of pre-mature reproductive organs is a major constraint in sesamum, which is due to the formation of special layer of cells, called the abscission layer near the base of the petiole. Increased flower number per plant with planofix (1000 ppm) was due to reduced ethylene concentration which is being the major abscission zone promoting chemical, leading to cell wall breakdown by increasing hydrolytic enzyme activity (Huff and Dybing, 1980). The growth retardants like TIBA, cycocel and mepiquat chloride may also be involved in balancing of endogenous growth substances and reducing the concentration of abscission inducing chemicals, thereby more number of flowers are retained per plant as compared to control (Clifford *et al.*, 1992).

The number of capsules per plant increased significantly due to the application of growth regulators at 70 DAS and continued until harvest. However, at 55 DAS, none of the growth regulator treatments significantly enhanced the capsule number which is due to slow action of applied growth regulators. Since, the number of capsules depends on the number of flowers retained and it is clear from data that increased capsule number per plant could be due to higher flower retention with the following increased assimilate availability for flower bud initiation due to application of growth regulators. Another probable reason for higher capsule number with applied chemicals may be because of reduced abscission of pre-mature capsules by balancing

endogenous growth regulators in the plant. These results are in accordance with those of Bora (1988) whose work provide ample evidence that triazol treated sesamum plants exhibited higher capsule number per plant by preventing the abscission of flowers and capsules. Both the genotypes, DS-1 and CO-1 responded very well to applied growth regulators and retained higher capsule number without any significant difference.

5.2 PHENOLOGICAL STAGES

The influence of growth regulators on various phenological stages indicated that treatments differed significantly with respect to days to 50 per cent flowering, cessation of flowering and physiological maturity. Similarly, CO-1 recorded significantly higher values with respect to all the phenological stages as compared to DS-1.

Due to early striking of flowers, none of the growth regulators were found to have influence on days to initiation of first flower. Similaly, days to initiation of first capsule had shown non-significant difference in all the growth regulator treatments because at the time of capsule initiation, no growth regulators were applied.

The number of days taken for 50 per cent flowering, indicated statistically superior values with growth regulator treatments over control, which could be due to availability of more assimilates for flower bud intiation. Since CO-1 being a long duration genotype, it took 4 days more for 50 per cent flowering as compared to DS-1.

Cessation of flowering was delayed significantly in all the growth regulator treatments over control, which could be due to longer duration of flowering by maintaining optimum rate of both promoters and retardants endogenously, thereby, enchancing flower bud differentiation and continuous supply of photoassimilates during flowering period (Shyen *et al.*, 1990). Similarly, both the genotypes differed significantly with CO-1 having longer duration as compared to DS-1.

The influence of growth regulators on physiological maturity indicated significant difference over control with all growth regulator treatments maturing late in both the genotypes.

This delay in physiological maturity could be attributed to increased period for flower cessation and delayed leaf senescence due to the application of growth regulators.

5.3 DRY MATTER PRODUCTION AND ITS PARTITIONING

Indeterminate growth habit of sesamum that sets in competition for photoassimilates among simultaneously growing leaf, stem and reproductive leads to insufficient availability of assimilates. This constraint can be overcome by applying synthetic plant growth regulators to improve canopy structure, synchronous flowering and fruit set. The application of different growth regulators enhanced the accumulation of dry matter in different plant parts over control at different growth stages.

During early stage (40 DAS) of crop growth, no significant differences were noticed among the treatments with respect to leaf and stem dry weight. This is because, at 40 DAS, no growth regulators were sprayed to the crop. However, even at 55 and 70 DAS, no significant differences in dry matter accumulation in leaf and stem were obtained between the treatments which may be due to slow to moderate action of applied chemicals. Upto 70 DAS, dry maater accumulation in leaf and stem maintained increasing trend, thereafter, declined till harvest in all the growth regulator treatments. The declined leaf and stem dry weight could be due to translocation of stored photoassimilates towards the development of reproductive organs. These results are in accordance with Kulkarni (1993), who demonstrated decreased stem and leaf dry weight from 65 DAS to harvest in sunflower with growth retardants due to rapid mobilization of photoassimilates from source to sink by shortening the distance between them. Similarly Morandi *et al.* (1984) reported a decrease in stem dry weight of soybean in response to mepiquat chloride treatment.

Among the growth regulators, cycocel (1000 ppm) exerted more positive influence on the accumulation of dry matter in leaf and stems as compared to other growth regulators. This could be attributed to enhanced functional capabilities of leaf for longer duration by maintaining optimum leaf area and increase in chlorophyll and photosynthetic enzymes activity. Similarly, Pando and Srivastava (1985) reported decreased leaf area along with increased activity of Ribulose

bisphosphate carboxylase enzyme in the leaves under the influence of cycocel at 3000 ppm in sunflower. Increased leaf dry weight with mepiquat chloride in groundnut was also noticed by Chandrababu *et al.* (1995). Since, the genotype CO-1 produces more branches and leaves, differed significantly over DS-1 with respect to leaf and stem dry weight at all the growth stages.

The dry weight of reproductive parts exhibited increasing trend throughout the growing period due to growth regulators. The enhanced dry weight of reproductive parts by both growth promoters and retardants is due to increased capsule number per plant and efficient translocation of assimilates from leaf and stem to reproductive parts. Similar inferences were made in sunflower by Kulkarni (1993). Improvement in dry weight of reproductive parts due to growth regulators application was also recorded by Goswami and Srivastava (1987). Among the growth regulators, cytozyme and cycocel maintained higher dry weight of reproductive parts due to increased capsule number per plant. Similarly, genotype DS-1 recorded significantly higher dry weight of reproductive parts throughout the growing period due to increased number of flowers and capsules per plant.

The data pertaining to total dry weight per plant indicated that, it increased from 40 DAS to till harvest in all the growth regulator treatments. Upto 70 DAS, the increase in TDM was at increasing rate which may be due to higher rate of CO_2 fixation and Ribulose bisphosphate carboxylase activity in the early stage of the crop growth as has been observed by Pando and Srivastava (1985) in sunflower. Similarly, Setia *et al.* (1994), while testing the effect of paclobutrazol on *Brassica* carianata noticed considerable dry matter accumulation during post anthesis period till harvest in both vegetative and reproductive structures.

At later stages of crop growth (70 DAS to harvest), the dry matter accumulated at decreasing rate, which could be attributed to decreased dry matter accumulation in leaf and stems. Several workers revealed that after the initial contribution by leaves towards early plant growth, the stem, which is the major storage organ, becomes the major organ of assimilates supply. Dry weight of the above ground parts of the plant during different stages of crop growth and development was significantly increased with the application of benzyladenine in sunflower

(Goswami and Srivastava, 1987) due to longer functioning period of the leaves. In contrast to the above observations, Child *et al.* (1993) reported that the growth retardant, triapenthenol resulted in larger reduction of stem dry weight in oilseed rape. However, Kene *et al.* (1991) demonstrated increased dry matter yield in sunflower under the influence of cycocel than planofix. Among the genotypes, CO-1 was found statistically superior over DS-1 which may be due to quicker response to applied growth regulators and tall growing as well as branching habit of CO-1. Similarly, cycocel was found more effective in increasing the total dry matter accumulation in both the genotypes, because of increased number of reproductive structures than other chemicals.

In general, leaf area increased upto 70 days after sowing and decreased thereafter till physiological maturity, which was due to ageing of leaves. Significant differences were noticed with regard to leaf area among the selected growth regulators at all growth stages except at 40 DAS, since at this stage, treatments were not imposed. However, growth retardants, cycocel (1000 ppm), TIBA (100 ppm) and mepiquat chloride significantly reduced the leaf area as compared to cytozyme (1000 ppm), planofix (1000 ppm) and cytokinin (25 ppm). This variation in leaf area could be attributed to differential mode of action of the growth regulators used in the study. The growth retardants cycocel, TIBA and mepiquat chlroides inhibit cell elongation resulting in reduced leaf expansion without any anatomical changes in leaf thereby increasing the leaf thickness (Lovette and Campwell, 1973). Reduction of leaf area due to application of cycocel in sunflower was noticed by Pando and Srivastava (1985). Similarly in cotton, the application of mepiquat chloride resulted in the reduction of leaf area by 28.6 to 35.7 per cent (Jiang and Deng, 1986). Decreased leaf area in sunflower was also demonstrated by Starman *et al.* (1990) with ancymidol (growth retardant) which inhibited cell elongation.

Growth promoting substances such as planofix, cytokinin and cytozyme are having positive effect on cell division and cell elongation leading to enhanced leaf expansion. This is in accordance with Goswami and Srivastava (1987) who obtained significantly higher leaf area due to benzyladenine treatment in sunflower.

Since leaf senescence is one of the most obvious constraints during peak grain filling period. The application of growth regulators arrested the chlorophyll degradation and protease activity and promoted the synthesis of soluble protein content and photosynthatic enzymes (Goswami and Srivastava, 1987) resulting in more assimilatory surface area for longer period. That is why, significantly higher values were obtained with respect to leaf area in all growth regulator treatments over control. Due to differential growth habit, CO-1 recorded significantly higher leaf area over DS-1. Leaf area index followed the same trend as that of leaf area in all the growth regulator treatments in both the genotypes.

Another parameter which is determined by the leaf area index of two consecutive growth stages is leaf area duration (LAD). As CO-1 was having maximum leaf area than DS-1 during all the growth stages, and it showed significantly higher LAD values over DS-1 except at 40 DAS due to its initial slow growth. The LAD in all the treatments was significantly superior over control which could be attributed to the retention of green leaves for a longer duration. However, among the treatments planofix, cytozyme and cytokinin (growth promoters) have been found superior over growth retardants which could be ascribed to increased leaf area index. Similarly, Kar *et al.* (1989) recorded higher chlorophyll, protein and RNA contents for longer period in safflower when crop was treated with CCC and SADH due to delay in leaf senescence.

It was observed that leaf area ratio (LAR) decreased from 40 DAS to till harvest with higher values under the influence of growth regulators. Similarly, Bora (1988) recorded increased LAR with troazoles in sesamum. Similarly, specific leaf weight (SLW) increased with a decrease in specific leaf area (SLA) in treated plants of both the genotypes. This variation could be attributed to increased leaf thickness due to growth regulator treatments. Among the growth regulators, cycocel, TIBA and mepiquat chloride were more effective in increasing the leaf weight. Whereas, planofix, cytokinin and cytozyme were efficient in increasing specific leaf area because of increased leaf area than leaf thickness. Gausman*et al.* (1978) reported that the application of mepiquat chloride at different concentrations increased leaf thickness by 29 per cent due to longer palisade and strong spongy paranchyma cells within the leaf mesophyll and had more chlorophyll per unit area in cotton. Results pertaining to SLA are in comfirmity with Reddy *et al.* (1990).

5.4 GROWTH PARAMETERS

The computation of various growth parameters indicated differential response of genotypes and treatments at different growth stages because of their differential crop duration and growth habit. Growth regulator treatments were found to have significant effect throughout the crop growth period except at early stage (40-55 DAS) over untreated control. This was mainly because of higher total dry matter and assimilatory surface area due to growth regulators. Net assimilation rate (NAR) as well as relative growth rate (RGR) differed significantly between the genotypes throughout life cycle except at physiological maturity. During the early growth stage, DS-1 maintained higher values because of early vigorus growth habit. Since these growth indices are the measure of the extent to which the rate of dry matter accumulated from stage to stage, applied growth regulators showed higher values by accumulating more dry matter with the enhancement of photosynthetic efficiency and translocation of photoassimilates. Similarly Sahod *et al.* (1989) reported that the foliar application of 20 ppm NAA (planofix) increased RGR and NAR with plant dry weight in sesamum.

5.5 PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS

The effect of growth regulators on cholrophyll 'a', 'b' and total chlorophyll contents in leaf exhibited significant differences due to growth regulators at all the growth stages except at 40 DAS. The chlorophyll content increased upto 70 DAS and declined later in all the growth regulator treatments.

The variation due to growth regulators may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis. These results are in accordance with Starman *et al.* (1990) who explained that the application of ancymidol (growth retardant) to sunflower resulted in higher chlorophyll content without the modification of leaf anatomy and decresed chlorophyll degradation. The delay in leaf senescence could also be attributed to higher chlorophyll content. Similarly, Goswami and Srivastava (1988) also found that the application of benzyladenine to sunflower plants maintained higher chlorophyll content in both lower and upper leaves till 80 days after sowing. They also concluded that BA stimulated the soluble protein content,

amino nitrogen content and chlorophyll and decreased the protease level in the older leaves of sunflower which senescence early.

Among the genotypes, DS-1 maintained higher chlorophyll 'a','b' and total chlorophyll contents at 40 and 55 DAS and at later stages C0-1 dominated. This is because of early and late growth habit of DS-1 and CO-1, respectively. It has been suggested that the application of growth regulators increases the availability of assimilates which inturn may cause prolonged chlorophyll synthesis (Stoddart, 1965). The results of our investigation are in confirmity with the results of other workers (Gausman *et al.* 1978; Stein *et al.*, 1983 and Abdel-Al *et al.*, 1986).

Influence of growth regulators on chlorophyll 'a','b' and total chlorophyll contents in capsule wall indicated non-significant differences at 55 DAS, whereas at 70 DAS, the differences were significant among the treatments. This increase at 70 DAS could be because of increased translocation of photossimilates to capsules under the influence of growth regulators. Similarly, Biswas and Ghosh (1989) reported that the application of BA on capsule wall both as smearing and injection increased the chlorophyll content in capsule wall. Among the genotypes DS-1 had dark green foliage and capsules and also maintained significantly higher values.

It has been observed that, nitrate reductase activity in leaf was significantly increased in growth regulator treatments both at 55 and 70 DAS. Similarly, all the growth regulator treatments registered higher values over control without showing any statistical superiority in relation to each other. Among the genotypes, nitrate reductase activity was significantly higher in DS-1 at 40 and 55 DAS and later declined slightly over CO-1, which was because of early nitrogen utilization capacity of DS-1. Since, nitrate reductase is the key enzyme in nitrogen metabolism, its activity should always be higher, to have higher nitrogenous compounds in plant. It is generally believed that NR activity depends on the availability of the substrate (nitrate) and proteinaceous compounds, therefore, it has been suggested that the application of growth regulators may be attributed to enhanced nitrate uptake by plant (Kuchenbuch and Jung, 1988). Similarly, uniconazole treated rape crop showed higher NR activity along with increased root activity

(Yang *et al.*, 1994). As there is no information available on direct effects of growth regulators on enzyme, their involvement in NR enzyme synthesis may not be ignored.

The effects of foliar application of growth regulators indicated significant differences over control with respect to seed protein content. However, in many cases, this protein content is inversely related to seed yield. Various approaches may help to improve the protein percentage in seed, i.e., by supplying nitrogenous fertilizers, breeding of high protein containing cultivars and applying growth regulators to crops. Thus, by these three means, we can change the inverse relationship between the grain yield and seed protein content. Our results indicated that the application of growth regulators can increase the grain protein content without altering the grain yield. This may be due to delayed leaf senescence which allowed more energy to be available for processes related to nitrogen uptake, reduction and protein synthesis (Daniel O. Caldiz *et al.*, 1991). Similarly, Setia *et al.* (1994) demonstrated increased seed protein content from 180.2 mg g^{-1} dry mass in control to 218.1 mg g^{-1} dry mass in paclobutrazol (20 $\mu g\ ml^{-1}$) treated rape seed. This could be due to rapid assimilate distribution towards seed development.

Oil content in seed differed significantly due to the application of growth regulator over control, without exhibiting statistical superiority with each other. Increased seed oil per cent appears to be due to increased accumulation of hexose sugars at the time of triacylglycerol synthesis resulting in more oil in oleosome (Purohit, 1993). It has been demonstrated by Santprasad and Shukla (1991) that the application of CCC along with nitrogen increased the oil yield and protein content in rape seed. Similarly, Abdel, *et al.* (1986) reported an increased oil and protein contents with the application of mepiquat chloride in cotton. Increased oil content in oilseeds due to the application of growth regulators was also reported by Pando and Srivastava (1987), Uppar and Kulkarni (1989), Kene, *et al.* (1992) and Kulkarni (1993).

5.6 YIELD AND YIELD PARAMETERS

In general, crop yield depends on the accumulation of photoassimilates during the growing period and the way these are partitioned between the desired storage organs of the plants. Seed yield in sesamum was strongly influenced by the application of different growth

regulators in both the genotypes indicating the role of these chemicals in the allocation of assimilates between the vegetative and reproductive organs. Addo-Quaye*et al.* (1985) have demonstrated that paclobutrazol changed the pattern of assimilate distribution towards reproductive parts, especially to the terminal and upper branches of *Brassica* plant, thus, increasing the sink capacity (more siliqua) leading to 16.9 per cent increase in seed yield as compared to control.

In the present study, the application of different growth regulators significantly increased the number of capsules per plant, number of seeds per capsule, seed yield per plant and test weight, which are the important yield determining components of sesamum. Among the selected growth regulators, cycocel (1000 ppm) was found to have significant effect in increasing the seed yield as compared to other chemicals. This could be attributed to maximum increase in capsule number, seed number per capsule, test weight, capsule length and width, which inturn might be due to efficient translocation of assimilates from leaf and stem to reproductive parts by shortening the source to sink distance.

Pando and Srivastava (1985) reported that the application of CCC enhanced the fixation of carbon dioxide, RuBP carboxylase activity and translocation of carbon from leaf and stem to capitulum thereby increasing the seed yield in sunflower. Similarly, Kar*et al.* (1989) recorded increased seed yield in safflower due to CCC and SADH spray. Other growth regulators like planofix (1000 ppm), TIBA (100 ppm), mepiquat chloride (1500 ppm) and cytozyme (1000 ppm) also exerted statistical superiority over cytokinin (25 ppm) and control with respect to seed yield. This could also be due to enhanced chlorophyll contents in leaf and capsule wall, increased total dry matter and leaf area duration along with proportionate increase in yield contributing characters. These results are in line with Tripathy *et al.* (1996) who reported that foliar application of 20 ppm NAA, 5 ppm tricontanol and 25 ppm IBA in sesamum increased the seed yield by 16.7, 15.1 and 21.6 per cent, respectively over control, mainly due to increase in number of siliqua per plant.

Similarly, Setia *et al.* (1994) investigated the increased seed yield in paclobutrazol treated *Brassica carianata* plants along with increase in the number of siliqua per plant because of

enhanced ability of plant to allocate more assimilates to the development of fruits. Although, cytokinin (25 ppm) had numerically higher values over control for almost all the yield attributing characters, but seed yield was less as compared to other growth regulators. This may be due to lower concentration of cytokinin that was used in the experiment, which failed to induce desired effects.

It is further confirmed from the present experiment that chlorophyll content of capsule wall enhanced under the influence of different growth regulators. Thereby, capsule wall became photosynthetically more active resulting in better seed development by supplying more current photosynthates. This may be the another reason for increased seed number per capsule and test weight in growth regulator treatments. Among the genotypes, DS-1 maintained statistically superior values for test weight and number of seeds per capsule over CO-1, which may be due to more assimilates availablity during peak grain filling period and having bigger size capsules.

5.7 CORRELATION STUDIES

The data on correlation coefficients between various morphological, phenological, growth, biochemical, yield and yield components presented in Table 26 indicated that seed yield showed strong and positive correlation with number of capsules per plant, test weight, days to 50 per cent flowering, cessation of flowering, physiological maturity, dry weight of leaf, stem and reproductive parts, total dry weight, leaf area index, leaf area duration, AGR, CGR, RGR, SLW, chlorophyll contents in leaf and capsule, NRA and protein. But it was negatively correlated with plant height. Similarly, plant height maintained negative association with all the parameters except, leaf area, leaf area index, leaf area duration and leaf area ratio.

If we examine the correlation values among growth parameters, it is clear that, AGR had strong and positive association with RGR and CGR whereas, NAR was negatively correlated with leaf area, LAI and LAD. Good correlation existed between chlorophyll content both in leaf and capsules wall with NRA, protein and oil contents. Similarly, NRA with protein had significant positive correlation.

Table 29. Correlation coefficients between morphological, phenological, physiological, biochemical parameters and yield and yield attributes in sesamum

Characters	Seed yield (q ha^{-1})	Seed yield plant^{-1}	Test weight	No. of seeds per cap.	Plant height (cm)	No. of flowers plant^{-1}	No. of Cap. plant^{-1}	Days to 50% fl.	Cessation of flowering	Physiol. maturity	Dry wt. of leaf (g)	Dry wt. of stem (g)	Dry wt. of rep. parts (g)	Total dry wt. (g)
Seed yield (q ha^{-1})	-	0.885**	0.754*	0.547	-0.274	0.705	0.942**	0.779*	0.907**	0.822*	0.843*	0.923**	0.882**	0.903**
Seed yield per plant (g)		-	0.536	0.563	-0.297	0.679	0.960**	0.931**	0.954**	0.855*	0.901**	0.912**	0.954**	0.965**
Test weight (1000 seed)			-	0.574	-0.518	0.295	0.548	0.389	0.500	0.321	0.567	0.605	0.502	0.569**
No. of seeds per capsule				-	-0.071	0.253	0.595	0.264	0.629	0.487	0.272	0.649	0.682	0.687
Plant height (cm)					-	-0.045	-0.184	-0.386	-0.185	0.201	-0.412	-0.167	-0.190	-0.294
No. of flowers per plant						-	0.705	0.730	0.665	0.707	0.504	0.848*	0.613	0.664
No. of capsules per plant							-	0.862*	0.994**	0.916**	0.847*	0.939**	0.982**	0.978**
Days to 50% flowering								-	0.850	0.743	0.885**	0.818*	0.829*	0.859*
Cessation of flowering									-	0.903**	0.816*	0.922**	0.995**	0.985**
Physiological maturity										-	0.742	0.842*	0.889**	0.837*
Leaf dry weight (g)											-	0.721	0.803*	0.804*
Stem dry weight (g)												-	0.906**	0.941**
Dry weight of rep. parts (g)													-	0.990**
Total dry weight (g)														-
Leaf area (dm^2 plant^{-1})														
Leaf area index														
Leaf area duration (days)														
AGR														
RGR														
CGR														
NAR														
LAR														
SLW														
Chl.a (leaf)														
Chl.b (leaf)														
Total chlorophyll (leaf)														
Chl. a (capsule)														
Chl. b (capsule)														
Total chlorophyll (capsule)														
Nitrate Reductase Activity														
Protein (%)														
Oil (%)														

Contd...

Contd. Table 29.

	leaf area (dm^2 $plant^{-1}$)	LAI	LAD (days)	AGR	RGR	CGR	NAR	LAR	SLW	Chl.a (leaf)	Chl. b (leaf)	Total Chl.(leaf)	Chl. a (cap.)	Chl b (cap.)	Total Chl.(cap)	NRA	Protein (%)	Oil (%)
Seed yield (q ha^{-1})	0.741	0.787*	0.846*	0.875**	0.906**	0.886**	0.061	0.375	0.835*	0.922**	0.894**	0.930**	0.914**	0.934**	0.958**	0.940**	0.920**	0.751
Seed yield per plant (g)	0.653	0.693	0.748	0.949**	0.811*	0.939**	0.219	0.135	0.746	0.923**	0.770	0.903**	0.663	0.780*	0.741	0.936**	0.963**	0.777*
Test weight (1000 seed)	0.320	0.353	0.413	0.555	0.549	0.574	-0.202	0.485	0.639	0.545	0.511	0.550	0.762*	0.670	0.746	0.590	0.659	0.479
No. of seeds per capsule	0.341	0.358	0.364	0.713	0.627	0.727	0.021	0.151	0.168	0.552	0.233	0.486	0.458	0.608	0.525	0.649	0.632	0.329
Plant height (cm)	0.395	0.322	0.241	-0.305	-0.115	-0.305	-0.412	0.301	-0.646	-0.205	-0.123	-0.194	-0.145	-0.250	-0.171	-0.259	-0.396	-0.366
No. of flowers per plant	0.617	0.620	0.732	0.592	0.581	0.602	-0.167	0.482	0.583	0.566	0.581	0.567	0.476	0.699	0.586	0.699	0.543	0.214
No. of capsules per plant	0.756*	0.804*	0.846*	0.964**	0.939**	0.964**	0.248	0.163	0.754	0.978**	0.863*	0.965**	0.794*	0.898**	0.868*	0.987**	0.958**	0.796*
Days to 50% flowering	0.518	0.564	0.645	0.828*	0.671	0.814*	0.310	0.027	0.818*	0.814*	0.703	0.805*	0.508	0.676	0.599	0.836*	0.850*	0.702
Cessation of flowering	0.717	0.769*	0.804*	0.980**	0.941**	0.980**	0.323	0.073	0.719	0.975**	0.824*	0.953**	0.749	0.884**	0.832*	0.987**	0.957**	0.796*
Physiological maturity	0.927**	0.943**	0.949**	0.817*	0.849*	0.812*	0.066	0.290	0.511	0.894**	0.836*	0.892**	0.721	0.741	0.772*	0.855*	0.801*	0.686
Leaf dry weight (g)	0.625	0.670	0.708	0.786*	0.626	0.771	0.210	0.139	0.828*	0.872*	0.856*	0.889**	0.714	0.647	0.727	0.793*	0.897**	0.889**
Stem dry weight (g)	0.686	0.717	0.797*	0.907**	0.853*	0.915**	0.029	0.355	0.709	0.853*	0.727	0.831*	0.720	0.905**	0.820*	0.950**	0.875**	0.561
Dry weight of rep. parts (g)	0.690	0.740	0.768*	0.993**	0.925**	0.992**	0.332	0.043	0.675	0.967**	0.782*	0.938**	0.721	0.856*	0.803*	0.976**	0.963**	0.798*
Total dry weight (g)	0.621	0.674	0.726	0.995**	0.905**	0.995**	0.306	0.074	0.738	0.942**	0.753	0.911**	0.709	0.885**	0.803*	0.988**	0.970**	0.754*
Leaf area (dm^2 $plant^{-1}$)	-	0.994**	0.978**	0.509	0.737	0.590	-0.183	0.511	0.376	0.757*	0.825*	0.784*	0.766*	0.627	0.762*	0.673	0.615	0.574
Leaf area index		-	0.986**	0.647	0.797*	0.649	-0.092	0.450	0.451	0.814*	0.874**	0.840*	0.810*	0.687	0.820*	0.730	0.672	0.643
Leaf area duration (days)			-	0.687	0.813*	0.691	-0.120	0.501	0.542	0.829**	0.890**	0.854*	0.824*	0.750	0.843*	0.781*	0.711	0.621
AGR				-	0.905**	0.998**	0.364	0.041	0.706	0.941**	0.728	0.905**	0.692	0.866*	0.783*	0.977**	0.970**	0.774*
RGR					-	0.918**	0.324	0.106	0.694	0.950**	0.859**	0.940**	0.867*	0.947**	0.927**	0.950**	0.880**	0.774*
CGR						-	0.356	0.021	0.715	0.940**	0.733	0.905**	0.711	0.888**	0.803*	0.983**	0.966**	0.763*
NAR							-	-0.892	0.322	0.336	0.188	0.306	0.001	0.206	0.064	0.490	0.305	0.488
LAR								-	0.079	0.078	0.247	0.116	0.422	0.235	0.380	0.126	0.076	-0.114
SLW									-	0.754	0.794*	0.774*	0.713	0.785	0.761*	0.775*	0.789*	0.721
Chl.a (leaf)										-	0.906**	0.995**	0.835*	0.866*	0.883**	0.957**	0.961**	0.896**
Chl.b (leaf)											-	0.943**	0.902**	0.799*	0.905**	0.817*	0.806*	0.848*
Total chlorophyll (leaf)												-	0.865*	0.858*	0.901**	0.936**	0.942**	0.907**
Chl. a (capsule)													-	0.857*	0.983**	0.785*	0.770*	0.740
Chl. b (capsule)														-	0.935**	0.941**	0.841*	0.633
Total chlorophyll (capsule)															-	0.873*	0.828*	0.732
Nitrate Reductase Activity																-	0.955**	0.756*
Protein (%)																	-	0.865*
Oil (%)																		-

* **Significant at 5 per cent level (Table "t" = 0.754)**

** **Significant at 1 per cent level (Table "t" = 0.874)**

5.8 FUTURE LINE OF WORK

Based on the results obtained in the present investigation, suggestions for further studies in the field of plant hormones in the regulation of growth and development and its subsequent influence on quantity and quality aspects of seed are outlined as under.

1. Indeterminate growth habit of sesamum plant, sets in competition for assimilates among simultaneously growing stem, newly formed flowers and developing fruits leading to insufficient availability of assimlates to the developing seeds causing reduction in quantity and quality of seeds especially in the late formed capsules. Hence, it is needed to develop a genotype having determinate growth habit.

2. Induction of synchronous flowering and fruit set by restricting flowering period to 10-12 days will help not only in the full development of capsule but their uniform maturity.

3. Several studies indicated that, photoassimilates distribution within the plant is under hormonal control and hence there is scope for detailed anatomical and histochemical studies regarding the effect of plant harmones on vascular connections between the vegetative and reproductive structures.

4. Little is known about the influence of different growth regulators on nitrate reductase activity and oil synthesizing enzymes, still there is a scope on such studies.

5. It is also important to study the interaction between the externally applied growth regulators and endogenous hormones.

6. From the results of net returns it is clear that planofix (1000 ppm), cytozyme (1000 ppm) and mepiquat chloride (1500 ppm) are more beneficial as compared to cycocel (1000 ppm) and cytokinin (25 ppm) and hence it is necessary to screen large number of commercial plant growth retulators than the pure chemicals.

SUMMARY

VI SUMMARY

A field study was conducted to find out the effect of different growth regulators on sesamum genotypes during *kharif* 1995 at Agricultural College Farm, U.A.S., Dharwad. The experiment was laid out in a factorial randomised block design with two genotypes and seven treatments in three replications. The results obtained are summarised in this chapter.

1. The plant height increased significantly due to planofix but decreased with cycocel, TIBA and mepiquat chloride in both the genotypes.

2. Growth regulators did not have much effect on the number of branches per plant. However, number of flowers increased significantly over control in all the growth regulators in both the genotypes.

3. Number of capsules increased significantly under the influence of growth regulators throughout the growing period in both the genotypes, but maximum number was obtained with cycocel at harvest.

4. It was found that phenological characters responded very well to all the applied growth regulators. Days to 50 per cent of flowering was found less due to plant growth retulators in both the genotypes. However, the cessation of flowering and physiological maturity were delayed due to growth regulators in both the genotypes.

5. The dry matter accumulation in leaf and stem increased up to 70 DAS and declined thereafter in both the genotypes. Maximum dry weight of leaf and stem was noticed with 1000 ppm cycocel at 70 DAS, followed by cytozyme and mepiquat chloride.

6. The production of reproductive parts was significantly higher in all the growth regulator treatments and TIBA followed by cytozyme and cycocel were very much effective in the translocation of assimilates from leaf and stem to reproductive parts resulting in higher dry weight.

7. All the growth regulators were found to have significant effect on the accumulation of total dry weight in both the genotypes and the maximum dry weight was noticed at harvest. Again cycocel maintained significantly higher total dry weight over control and other treatments.

8. The data on a AGR, RGR, CGR and NAR indicated that, they increased significantly due to growth regulators as compared to control. Maximum AGR and CGR values were recorded at 50-70 DAS whereas, the highest RGR and NAR were noticed at 40-55 DAS in both the genotypes.

9. Leaf area and leaf area index increased upto 70 DAS and declined thereafter. Planofix and cytozyme were very effective in increasing leaf area and LAI in both the genotypes. Whereas, cycocel, TIBA and mepiquat chloride significantly reduced leaf area and LAI in both the genotypes as compared to growth promoter treatments.

10. It is clear from the data on LAD that it increased significantly in all the growth regulators and planofix (1000 ppm) maintained higher values in both the genotypes.

11. Specific leaf weight increased significantly with all growth regulators, whereas, specific leaf area maintained non-significant values except at 70 DAS. Cycocel, TIBA and mepiquat chloride resulted in higher SLW, whereas, SLA was maximum with planofix, cytozyme and cytokinin. Similarly, significant differences were noticed with respect to leaf area ratio due to growth regulators.

12. Chlorophyll 'a', 'b' and total chlorophyll contents in leaf increased significantly due to growth regulators over control and the maximum values were recorded at 55 DAS in both the genotypes. However, none of the growth regulators showed significant differences among themselves. Similarly, chlorophyll content in capsule revealed that chlorophyll 'a', 'b' and total chlorophyll increased significantly at 70 DAS in all the growth regulator treatments.

13. Nitrate reductase activity increased upto 55 DAS and reduced later in both the genotypes. Significant differences were registered due to growth regulators. It was also noticed that oil and protein contents in seed enhanced with growth regulators.

14. The results of various yield and yield attributes indicated that all the yield contributing characters viz., seed yield per plant, 1000 seed weight and number of seeds per capsule increased significantly due to growth regulator treatments. Among them, cycocel (1000 ppm) was found to be very effective in increasing the seed yield in both the genotypes. However, capsule length and width did not differ significantly due to growth regulators in both the genotypes.

It is thus clear from our results that the growth retardant, cycocel was found to be more effective in increasing the seed yield in both the genotypes. This could be due to enhanced translocation of assimilates from source to sink by shortening the vascular connection between leaf and stem (source) to reproductive organs (sink). Similarly, among the growth promoters, planofix (1000 ppm) in DS-1 and cytozyme (1000 ppm) in CO-1 were not only economically adoptable but also resulted in remarkable improvement of seed yield. This was mainly attributed to increased number of reproductive parts per plant by reducing pre-mature shedding and maintaining dark green leaf for longer period.

From the point of Economics, though, maximum seed yield was recorded in cycocel (1000 ppm) but was not economical due to high cost of the chemical. On the contrary, planofix (1000 ppm) followed by cytozyme (1000 ppm) and mepiquat chloride (1500 ppm) were found more profitable interms of net returns mainly due to low cost of these chemicals.

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*Original not seen