Studies on Effect of GA_3 and Growing Media on Seed Germinability, Growth and Survivability of Custard apple (*Annona squamosa* L.)

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

**In partial fulfilment of the requirements for
the Degree of**

MASTER OF SCIENCE

In

AGRICULTURE

Horticulture (Fruit Science)

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Jabalpur, Madhya Pradesh

2015

CERTIFICATE - I

This is to certify that the thesis entitled **“***Studies on effect of* GA_3 *and growing media on seed germinability, growth and survivability of Custard apple (Annona squamosa L.)*” *submitted in partial fulfilment of the requirement for the degree of* ***MASTER OF SCIENCE in Agriculture, Horticulture (Fruit Science)*** *of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by Sumit Jain under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.*

All the assistance and help received during the course of the investigation have been acknowledged by him.

Place: Jabalpur

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CERTIFICATE - II

This is to certify that the thesis entitled "Studies on effect of GA_3 and growing media on seed germinability, growth and survivability of Custard apple (Annona squamosa L.)" submitted by Mr. Sumit Jain to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of Master of Science in Agriculture, Horticulture (Fruit Science) in the Department of Horticulture has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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DECLARATION AND UNDERTAKING BY THE CANDIDATE

I, Sumit Jain S/o Shri Paras Chand Jain certify the work embodied in thesis entitled "Studies on effect of GA_3 and growing media on seed germinability, growth and survivability of Custard apple *(Annona squamosa* L.*)*" is my own first hand bonafide work carried out by me under the guidance of Dr. T. R. Sharma, Sr. scientist, Directorate of Extension Services, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 2014-2015.

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

I, undertake the complete responsibility that any acts of misinterpretation, mistakes, errors of fact are entirely of my own.

I, also abide myself with the decision taken by my advisor for the publication of material extracted from the thesis work and subsequent improvement, on mutually beneficial basis, provided the due credit is given, thereof.

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Date : **(Sumit Jain)**

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ABBREVIATION

cm	:	Centimeter
et al.	:	and other co-worker
C.D	:	Critical difference
Cv	:	Cultivar
DAS	:	Days after sowing
ºC	:	Degree centigrade
Fig.	:	Figure
‘F’ value	:	Fisher value
M	:	Growing Media
G	:	Gibberellic acid (GA_3)
Max.	:	Maximum
Min.	:	Minimum
W	:	Weight
No.	:	Number
g	:	Gram
%	:	Percentage
F	:	Fresh weight
d.f	:	Degree of freedom
FYM	:	Farm yard manure
h	:	Hours
i.e	:	That is
R.S.S	:	Replication sum of square
S.Em ±	:	Standard error of means
S.S	:	Sum of square
Tab.	:	Tabulated
/	:	Per
Cal.	:	Calculated
LAI	:	Leaf area index
LTR	:	Light transmission ratio
LAD	:	Leaf area duration
Ei	:	Energy Interception
mm	:	milimeter
LA	:	Leaf area

INTRODUCTION

Custard apple (*Annona squamosa* L.) belongs to family Annonaceae and is one of the finest fruits gifted to India by tropical America. It is commonly found in India and cultivated an area of 23 thousand ha with production of 176 MT (Anonymous, 2013). Custard apple, popularly known as Sitaphal is grown mainly in the States of Andhra Pradesh, Assam, TamilNadu, Madhya Pradesh and grows wild in Deccan plateau and some parts of central India. Custard apple is generally classified as semi wild fruit by virtue of its spontaneous spread in forests, wastelands and other uncultivated places.

It is hardy, tolerant to drought, salinity and saline irrigation water to certain extent. It grows very well even on a shallow soil. It also sheds off leaves during stress period to minimize the moisture loss from plant tissues through transpiration and thus a most appropriate fruit crop for rainfed region.

Custard apple is known by varied name like Sitaphal, Sugar apple and Shariffa. It is considered as one of the delicious and nutritionally valuable fruits meant for table purpose. Fruits have an edible, soft, granular, juicy and sugary pulp with mild flavour and with slight acidity. Fruits are considered for their medicinal value besides their general use in ice cream, confectionery, certain milk products and in making preserves as jam, jelly and other products. It is considered as beneficial for cardiac disease, diabetes, hyperthyroidism and cancer. It contains about 28-55% of edible portion consisting of 73.30% moisture, 1.60% protein, 0.30% fat, 0.70% mineral matter, 23.90% carbohydrates, 0.20% calcium, 0.40% phosphorus, 1.0% iron, 12.4-18.15% sugar and 0.26-0.65% acidity with caloric value of 105 KCal/100g.

It is generally propagated by seed since there is little variability among seedlings. Maximum germination can be obtained by sowing of freshly extracted seed upto 20-30 days. The seeds of Annonaceae are albuminous ellipsoids and their length varies between 5 and 30 mm. They have a ruminate endosperm (Corner, 1976). The embryo is small, straight, with moderately developed embryonic axis, rudimentary plumule and a flat and thin cotyledon; which develops after the seed is formed (Corner, 1976). Setten and Koek-Noorman (1992) observed that Annonaceae seeds undergoing dispersal have a small embryo that is considered underdeveloped and immature; immaturity requires time to complete embryo growth after seed dispersion. Meanwhile, Hayat (1963) reported that the seeds of *A. squamosa* have a small embryo with two foliaceous, thin cotyledons that take one to three months to germinate.

Seed germination is the resumption of active growth of embryo that results in the emergence of the young plant. Seeds of many fruit crops remain ungerminated even under favourable conditions. Such kind of dormancy in seeds may be due to presence of hard and impermeable seedcoat, germination inhibitors and improper development of embryo. Such seeds may require special treatments like scarification, soaking in water, growth regulators etc. to overcome dormancy. Gibberellins (GA_3) activate the embryonic vegetative growth, weakens the endosperm layer that involves the embryo and restricts its growth, and mobilizes the energetic reserves from the endosperm of cereals (Bewley, 1997; Taiz and Zeiger, 2006). Cereal embryo synthesizes and releases GA during the germination, which leads to the production and/or secretion of several hydrolytic enzymes involved in the solubilization of reserves, including α-amylase and β-amylase (Taiz and Zeiger, 2006).

Growing media is one of the important environmental factors, which plays an important role in growth and survival of seedlings. Several growing media or their combinations are being used for raising the seedling. Different growing media like soil, sand, farm yard manure (FYM) and vermicompost either alone or in different proportion have been found beneficial to influence germination and growth of seedling. A good growing media provides sufficient anchorage or support to the plant, serves as a reservoir for nutrients and water, allows oxygen diffusion to the roots and permits gaseous exchange between roots and the atmosphere outside root substrate.

Bio-fertilizers are also beneficial in seed germination and growth of seedling. Bio-fertilizers are the carrier-based preparations containing mainly effective strains of microorganisms in sufficient number, which are useful for nitrogen fixation. Amongst bio-fertilizers *Azotobacter* strains play a key role in harnessing the atmospheric nitrogen through its fixation in the roots. They have been also reported to improve fertility condition of the soil. The seed coat of most of the fruit crops is very hard. To break the seed dormancy, either some chemical treatment or long incubation period is required but bio-inoculants like *Azotobacter*, PSB etc. also can be helpful in breaking the seed dormancy by producing various plant growth substances in combination with either farmyard manure (FYM) or vermicompost on seed germination and plant growth. Keeping the above point in view, the present study has been proposed with the following objectives;

OBJECTIVES:-

1. To study the effect of GA_3 on germination, growth and survival of seedling.
2. To find out the effect of growing media on germination, growth and survival of seedling.
3. To find out the interaction effect of GA_3 and growing media on seed germination, growth and survival of seedling.

REVIEW OF LITERATURE

The success of any programme mainly depends on the right selection of material and its skilful management. It is only possible when we possess knowledge of previous work done in the concerned field. In the present chapters, efforts have been made to review the work done by other workers in India and abroad on propagation of custard apple and other fruit plants through seed applied growth regulators and growing media. The brief resume of the studies conducted by several workers and their findings related to this study is presented under the following heads;

Influence of GA_3 on growth and survival

Burns and Coggnies (1969) found that the germination of Sweet orange seeds was significantly hastened when seed soaked for 24 hours in GA_3 1000 ppm solution. The growth and uniformity of seedlings were also enhanced by seed treated with GA_3 at 1000 ppm.

Prasannakumar and Majumdar (1972) reported that Kagzi lime seeds sown immediately after extraction gave 58% germination and it declines after wards. The initial germination took 15 days to start and potential germination took place at 29 days to complete when seed sown immediately after extraction.

Choudhary and Chakrawar (1982) studied the effect of soaking the seed of Rangpur lime for 6 or 12 h in solution of GA_3 10, 20 and 40 ppm; NAA 10, 20, 40 ppm and thiourea 2%. The maximum value of seedling height, number of leaves, stem girth and fresh and dry shoot weight were obtained when seed treatment with GA_3 at 40 ppm for 12 h followed by same concentration of NAA.

Ak et al. (1995) investigated the effect of GA_3 (0, 125, 250, 500 and 1000 ppm for 24 or 48 h) on the germination of pistachio (cv. Siirt) seeds in Turkey. The higher germination (73.33%) was observed with concentration of GA_3 at 125 ppm with soaking period of 48 h. Further maximum seedling height and internode length were observed with GA_3 at 1000 ppm. The healthiest plants were obtained under 250 followed by 500 ppm concentration of GA_3.

Hore and Sen (1995) reported the role of pre-sowing seed treatment on germination, seedling growth and longevity of ber (*Zizyphus mauritiana* Lam.) seeds. Seeds of ber cv. Gola were stored for 1 and 17 months in a polyethylene bag and then treated with a range of chemicals for 24 h. The highest germination percentage after 1 and 17 months was obtained from seeds treated with 200 ppm GA_3 (98.76 and 77.82%, respectively). Days to first germination were lowest with 1.0% thiourea treatment, while the shortest span of germination was recorded under concentration of 1000-2000 ppm Cycocel [chlormequat]. Incidence of polyembryony was highest with 400 ppm GA_3 and 1000 ppm Cycocel.

Pawshe et al. (1997) conducted an experiment to determine the effect of pre-germination seed treatment on germination and vigour of aonla (*E. officinalis*) seeds. Treatments included gibberellic acid (GA_3) at 50 and 100 ppm, soaking in water for 24 h and hot water soaking at 60^0C for 5 min. They reported that GA_3 at 50 and 100 ppm increased the percentage seed germination. Further the tallest plants were observed when seed treated with 100 ppm GA_3 and soaking for 24 h.

Pillewan et al. (1997) studied to findout the effects of soaking mango (cultivars Local, Neelum and Totapuri) seeds in tap water for 24 h, hot water at 60^0C for 5 min, gibberellic acid (GA_3) at 100 or 150 ppm for 24 h, water for 24 h followed by GA_3 (100 or 150 ppm), or treatment with thiourea at 150 ppm for 24 h, on germination was determined. They reported that the seeds treated with thiourea (1500 ppm) and soaking for 24 h in water followed by soaking for 12 or 24h in 150 ppm GA_3 resulted in the highest germination percentage.

Verma et al. (1998) studied the effect of GA_3 on seed germination of kiwifruit cultivars Abbot, Allison, Bruno, Hayward and Monty. The extracted seeds were soaked in water or in 10, 20, 30 or 40 ppm solution of GA_3 for 24 h and sown in pots of sand. The highest seed germination was recorded under 30 ppm concentration of GA_3 with soaking period of 24 h.

Wagh et al. (1998) conducted an experiment on effect of seed treatment on germination of seed and initial growth of aonla seedling in polybag. Seeds were soaked for 12 h in 100-400 ppm gibberellic acid (GA_3), water and unsoaked (control). They reported that 400 ppm GA_3 resulted higher percentage germination as well as seedling development (plant height, number of leaves/plant and root development).

Ynoue et al. (1999) removed the seeds from ripe Kiwifruits, washed then dried in the shade to study the effect of stratification at 5º C for 2 weeks, or 50, 100 or 150 mg GA_3/litre (the substrate being moistened with GA_3 for 1 week). They observed most effective treatment for increasing percentage of germination and minimized time of germination when seed treated @ 150 mg GA_3/litre.

Rahemi and Baninasab (2000) studied the effect of gibberellic acid (GA_3) at concentrations of 100, 250, 500, 750 and 1000 mg/litre were used during and after stratification to enhance seedling growth of Beneh and Kolkhog, are wild species of pistachio. The results showed that GA_3, applied during and after stratification, significantly increased the length, trunk diameter, internode length, leaf area and fresh and dry weight of seedlings of both species. They observed that the application of GA_3 after stratification was more effective on seedling growth of Beneh further they reported that the GA_3 applied at higher concentrations (500 and 750 mg/litre) increased the growth rate.

Ono (2000) studied the effects of storage time and exogenous gibberellic acid on lychee (*Litchi chinensis*) on seed germination. The seeds were removed from ripe fruit, washed, dried, stored at 8^0C for 0, 15 and 30 days, and soaked for 24 hours in water and 50, 100 and 200 mg GA_3 L^{-1} solutions. They reported that as the storage period increased, resulted decreased germination capacity. Seven percent germination was recorded after 30 days of storage period. Gibberellic acid did not significantly affect germination percentage or time.

Dalal et al. (2002) conducted an experiment to improve seedling growth of Rangpur lime (*Citrus limonia*) to enable it to become buddable rootstocks earlier. The four foliar applications of 25 ppm GA_3 were found most effective for enhancing stem height and girth, number of leaves and increasing the percentage of buddable seedlings (31.59% more than control) followed by foliar applications of 1% urea gave 28.77% more buddable seedlings than control.

Ghosh et al. (2003) conducted an experiment to see the effect of pre-sowing seed treatment on germination, seedling growth and viability of custard apple (*Annona squamosa*) seeds. One, 90, 180 and 270-days old seeds of custard apple (*A. squamosa*), treated with sodium thiosulfate (100 or 200 ppm), potassium dihydrogen phosphate (100 or 200 ppm), potassium metabisulfide (100 or 200 ppm), thiourea (1 or 2%), NAA (10 or 20 ppm), gibberellic acid (10 or 20 ppm) or water, were sown in polybags containing soil mixture. All the seed treatments were ineffective in enhancing the germination of fresh seeds except for seed soaking for 6 h and treatment with 200 ppm sodium thiosulfate which reduced seed germination to 8 days. NAA at 20 ppm was the most effective in retaining seed viability up to and beyond 90 days. Seed longevity and seedling vigour in 180-day-old seeds increased with 200 ppm potassium metabisulfide treatment. Germination was not recorded in 270-day-old seeds.

Kalalbandi et al. (2003) conducted a field experiment to investigate the effect of GA_3 (40, 60 and 80 ppm); NAA (40, 60 and 80 ppm) and KNO_3 (1%) on the germination and growth of kagzi lime. They observed that the seed soaked in GA_3 and NAA for 12 h resulted in high germination and shoot length. Further they observed that GA_3 concentration of 80 ppm was the most effective for improving germination, seedling height and number of leaves.

Meena et al. (2003) reported that pre-sowing seed treatment with four concentration of GA_3 (25, 50,100 and 200 ppm) and control without any treatment. The maximum percentage of germination and percent survival were noted under 100 ppm GA_3. Further they reported that the GA_3 significantly affected the germination percentage, days required for completion of germination and survival percentage in all the cultivars of papaya .

Ratan and Reddy (2003) studied the influence of potassium nitrate on germination and subsequent seedling growth of custard apple (*Annona* *squamosa*). Seeds of *A. squamosa* were soaked in 0.5 or 1% potassium nitrate for 12 or 24 h before sowing in raised beds. Seed germination was highest with seed soaking at 1% potassium nitrate for 24 h. Stem diameter and weight, and root weight increased with increasing seed soaking time and were highest with seed soaking at 0.5 potassium nitrate for 24 h. Seedling vigour index and plant height were highest with seed soaking at 0.5% potassium nitrate for 12 and 24 h, respectively

Ratan and Reddy (2004) reported that when the seeds of custard apple (*Annona squamosa*) cv. Balanagar were soaked in 200, 400, 600 ppm GA_3 for 12 and 24 h to determine their effect on seed germination and seedling growth. Seed soaked with 400 ppm GA_3 gave the highest seed germination percentage (69.00), plant height (25.33 cm), root length (12.23 cm), and dry weight of stems (0.245 g) and roots (0.175 g). Further they observed that seed soaked with 600 ppm GA_3 for 12 h gave the earliest days for initiation of germination (16.00), which was at par with 600 ppm GA_3 for 24 h and leaf dry weight (0.795) whereas The highest stem diameter (2.86 cm) was obtained with 200 ppm GA_3 for 24 h.

Rao and Reddy (2005) reported that soaking of mango stones for 12 h in gibberellic acid (GA_3; 100, 200 and 300 ppm), potassium nitrate (1, 2 and 3%) and water increased the germination percentage and enhanced the rate of germination of mango stones. GA_3 at 200 ppm for 12 h was the best treatment which recorded the maximum germination percentage (85.5%) as compared to other treatments. further GA_3 at 200 ppm recorded the maximum seedling growth compared to other treatments.

Lavania et al. (2006) reported that the seed germination of *Pinus wallichiana* was maximum with the application of 300 ppm GA_3 for 24 h followed by 200 ppm GA_3 for 36 h. These results indicate that increasing the soaking period or concentration of GA_3 leads to maximum germination.

Kumar et al. (2008) studied the effect of water soaking (12 hours), 1% KNO_3 (10 min), 100 ppm GA_3 (10 min), cow dung (12 hours), cow urine (12 hours), Amritpani (3% for 3 hours) and Panchagavya (3% for 12 hours) on seed germination. They observed all the treatments promoted significantly earlier germination when compared with the control. The stones pre-treated with 3% Panchagavya significantly took lesser number of days for the initiation of germination (12.25 days) and completion of germination (46.18 days) as well as maximum germination percentage (75.22%), rootstock diameter (7.35 mm), number of leaves (14.77), graft success (76.15%), graft survival percentage (92.04%), sprout height (5.96 cm) and number of leaves per graft (17.80). GA_3 at 100 ppm showed the highest germination index (4.46) and rootstock height (36.43 cm), which was at par with KNO_3 and water soaking.

Mobli and Baninasab (2008) reported that six-week old seedlings were treated with gibberellic acid (GA_3) (100 $mg.L^{-1}$) alone or with GA_3 followed by ethephon [(100 and 200) $mg.L^{-1}$], or chlormequat chloride (CCC) [(500 and 1000) $mg.L^{-1}$], or paclobutrazol (PBZ) [(500 and 1000) $mg.L^{-1}$] *in Prunus amygdalus* and *P. webbii*. Most levels of plant growth regulators significantly enhanced seedling growth. However, GA_3 alone was most effective on stem height, leaf area, and shoot fresh and dry weights of both almond species. The thickest stems of *P. amygdalus* and *P. webbii* were obtained from the application of 100 mg $GA_3.L^{-1}$ followed by application of (1000 and 500) mg $PBZ.L^{-1}$, respectively.

Ahmad (2010) studied that seeds of two kiwi fruit verities viz., Bruno and Hayward were treated with four concentration of GA_3 500, 1000, 1500 and 2000 ppm for a period of 20 h and stratified at 4.4º C for 6, 8, 10 weeks and sown directly in open field conditions. They reported that the maximum seed germination of 67.25 and 53.00% was observed with the application of 2000 ppm GA_3 in cvs. Bruno and Hayward, respectively.

Munde and Gajbhiye (2010) studied the effect of plant growth regulators on seedling growth of mango stone. They observed that the plant growth regulator GA_3 at 200 ppm applied to mango stone produced maximum height and more number of leaves. Further plant growth regulator IAA at 500 ppm applied to mango stone produced maximum girth and leaf area. GA_3 at 200 ppm and IAA at 500 ppm applied to mango stones induced more growth of mango seedlings.

Patil and Patel (2010) studied the effect of GA_3 and NAA on growth and yield of Okra. The treatments comprised of three concentrations of GA_3 (15 mg/l, 30 mg/l and 45 mg/l), NAA (10 mg/l, 20 mg/l and 40 mg/l), soaking of seeds in distilled water and control (unsoaked seeds). GA_3 at 15 mg/l recorded the highest percentage of seed germination, stem girth, number of branches and number of leaves per plant.

Pio et al. (2010) studied the effect of seed submerged in different gibberellic acid concentrations: 0, 100, 200 and 300 mg/l, for 24 hours, with an oxygenation system. At the end of each period, the seeds were distributed in polystyrene trays containing 72 cells, with vermiculite as substrate. After 30 and 60 days, the percentage emergence was measured and at the end of 60 days, the mean length of the seedlings and mean dry mass were determined. It was concluded that the seeds of Japanese quince treated with 200 mg/l of GA_3 and stratified in humidified cotton for 60 days.

Gharge et al. (2011) studied the effect of various concentration of GA_3 and soaking period on seed germination of custard apple. The maximum germination percentage was recorded when seed soaked with GA_3 at 400 ppm, with regard to the period of soaking, soaking of seeds for 24 to 48 h gave early and maximum germination percentage of the seedlings. In respect of interaction effect of GA_3 concentration and soaking period, it was observed that soaking of seeds in GA_3 400 ppm for 12 h gave maximum germination percentage and seedling height.

Gurung et al. (2014) conducted an experiment to study the effect of chemicals and growth regulators on germination, vigour and growth of passion fruit. Maximum germination percentage and germination index was observed in seeds treated with thiourea 1% whereas maximum seedling height 16.23 cm, 19.62 cm and 20.91 cm and number of leaves 10.25, 11.35 and 14.25 were observed in seeds treated with GA_3 500 ppm at 30, 60 and 90 days respectively. Vigour index-I (1547.34 cm), Vigour index-II (128.76 g) as well as maximum fresh (3.76 g) and dry weights (0.98 g) of shoot were recorded under GA_3 500 ppm.

Zanotti et al. (2014) studied on Germination of "Solo" papaya seeds at maturity stages 3 and 5 (50% and 75% of the fruit skin showing a yellow colour) treated with plant hormones. The seeds were subjected to treatments involving different combinations of acid 2-chloroethylphosphonic - (CEPA 0, $5x10^{-7}$ and $5x10^{-4}$ M), GA_3 (0, 10 and 50 mg/l) and KNO_3 (0 or 1 M), and germination was assessed at the 14^{th} and 30^{th} days. Seeds from fruits at maturity stage 3 showed increased germination when treated with all growth regulators tested. KNO_3 promoted a decrease in germination and in the germination speed index, especially in the seeds from stage 5.

Dhiman et al. (2015) conducted an experiment to find out the effect of soaking conditions with growth regulators and nutrient solutions on germination behaviour of Ratela: a fuel wood species of shiwalik hills. The seeds were soaked at different periods viz., no soaking, 6 h and 12 h with different growth regulators-IAA, IBA, NAA, GA_3, KIN, and Ethrel and salt solutions ($MgSO_4$ and KNO_3). The results revealed that treatment with GA_3 without soaking gave higher germination percentage (41.67%) though the interaction effect was non-significant. The seeds took minimum days of 4.67 in water soaked seeds for initiation of germination.

Effect of growing media enhancing germination, growth and survival

Bisla et al. (1984) recorded that early and high percentage of seed germination of ber (*Ziziphus mauritiana*) occurred in pots having m_1-media (sand: soil: organic manure in ratio of 1:1:1) whereas growth of the seedling was also more in m_1-media than m_2-media (soil : sand in the ratio of 1:1), Similarly higher percent of buddable seedlings were obtained under m_{1-} media.

Hartman and Kester (1986) reported that sphagnum moss contains large group of water holding cells and small amount of minerals with p^H about 3.5-4. Therefore, these qualities make it one of the most effective rooting media.

Mishra (1990) found that among the four rooting media M_4 (soil + sand + leaf mould) and M_3 (soil + sand + FYM) proved significantly better for rooting of Kagzi lime air layers.

Jain and Parmar (1993) observed that number of roots per cutting, root length and diameter of pomegranate cutting were greater in river silt + FYM than in river silt alone.

Bahunguna and Pyarelal (1993) found that for better germination of *Acacia auriculiformis*, the soil medium (soil and sand) should be in the 2:1 ratio. They also emphasized that farm yard manure could be added for the better growth of the seedlings at the time of transplanting. For exotic pines, such as *Pinus elloti*, *P*. *greggii* and *P. petula*, the use of pure sand as nursery medium was best for achieving good germination.

Biradar et al. (1998) reported that sandal seed sown in soil mixture of 1:2:1 of sand: soil: FYM recorded highest germination.

Chattopadhya and Mohanta (1998) found that the height of tamarind seedlings were best in cow dung manure followed by sand and the number of leaf was highest in cow dung manure.

Mishra and Jaiswal (1998) studied that among the different nursery mixtures tested to raise silver oak seedlings, the mixture with loamy soil : sand : FYM (1:1:1) produced better seedling with a plant height (107.16 cm). The mixture was also found economical.

Shrivastava et al. (1998) revealed that the seedlings of eucalyptus raised in nursery media of soil: compost: sand (2:1:1) produced maximum plant height (36.88 cm) and collar diameter (10.55 cm) after four month sowing among the different nursery media tested.

Chopde et al. (1999) studied the effect of growing media on germination and growth of seedlings of custard apple. The cocopeat and vermiculite were found significantly superior to the standard pot mixture in terms of germination percentage, root number, root length, seedling height and number of leaves per plant.

Shrivastava and Bhel (2002) conducted an experiment using four potting media viz. sand, sand loam, alkaline soil mixed with sand 4:1 and alkaline soil mixed with sand and additional amendment of vermicompost for raising seedling of *Terminalia arjuna*. They observed that the seedlings grown in sand showed poor response. However, there was a significant increased in seedling height, diameter, leaf area and seedling biomass grown in vermicompost amendment media.

Taiwo (2004) reported that the use of *Azotobacter croococcum* inoculum was an effective biological management option in tomato fertilization programme. It positively impact the height, stem girth as well as the number of fruits of the test crop when compared with the control.

Sinish et al. (2005) conducted an experiment on 3 types of potting media (cow dung, poultry manure and coirpith compost); 3 biofertilizers, i.e. Azospirillum, Phosphorus Solubilizing Bacteria (PSB) and Arbuscular Mycorrhizal Fungi (AMF) as single inoculation and in combination of all the 3; and an absolute control with only sand and soil in equal proportion in cashew rootstock production. Earlier germination and higher germination percentage were obtained with cow dung and coirpith compost as compared to poultry manure. The combined inoculation of Azospirillum, PSB and AMF in the potting mixture induced earlier germination with better germination percentage. The values of biometric characters were highest in the potting mixture containing sand:soil:cow dung+Azospirillum+PSB+AMF.

Ambadkar and Jadhav (2007) conducted an experiment to evaluate the effects of different bio-inoculants on the seed germination, seedling emergence and seedling mortality of Rangpur lime. The highest seed germination of 64.66% was obtained using *Acetobacter diazotrophicus*. Further, the highest seedling emergence (93.75%), and the lowest seedling mortality (6.25%) was observed in plots inoculated with Biomix. Mortality reduction was also low in treatments with *T. viride* and *T. harzianum.*

Kumar and Sharma (2007) reported that the efficacy of FYM and vermicompost of *Jatropa curcus* through cutting and comparison were made between two types of soil mix i.e. (soil + FYM) and (soil+ vermicompost) between the different treatments soil + vermicompost was found to be better on vegetative growth (survival, plant height, diameter, number of branches / plant) and generative development (seed yield and oil content) of *J. Curcus*.

Krishna et al. (2008) conducted an experiment under which seeds of Kalmegh [*Andrographis paniculata*], Ashwagandha [*Withania somnifera*] and Tulsi [*Ocimum tenuiflorum*] were treated with *Azospirillum*, phosphorus-solubilizing bacteria (PSB), *Azotobacter*, N_2 fixer, B1+B2+B3+B4 combination and control. Combined application of all biofertilizers recorded the highest values for seed germination and vigour of the medicinal plants.

Sahni et al. (2008) studied that the effect of combined application of vermicompost and coir dust in the treatment (soil : coirdust : sand : vermicompost 1:1:1:1) on germination, seedling growth and plant biomass probably due to the synergistic combination of both the factors in improving the physical conditions of the media and nutritional factors.

Bihari et al. (2009) studied the effect of growing media on seed germination, rate of seed germination, transplanting success and seedling mortality in aonla *(Emblica officinalis* Garten.). There were seven treatment combinations (T_1 to T_7) along with T_8 in which seeds were in sown nursery bed. Different ratios of soil, sand and FYM mixture were filled in polythene bags. The effect of growing media was found to be significant for seed germination, transplanting success and seedling mortality percentage. However, insignificant effect was observed with rate of seed germination. Treatment T_7 (soil, sand and FYM 1:1:1) yielded highest percentage of seed germination while the lowest percentage was recorded in T_6 (sand and FYM 1:3) and the transplanting success was lowest in T_8. The seedling mortality percentage was maximum under T_6 whereas lowest mortality percentage was observed under T_7 treatment.

Game (2009) carried out an experiment to study the effect of arbuscular mycorrhizae (AM) *viz; Glomus epigaeum, Glomus mosseae* and *Gigaspora calospora* and their combinations on growth parameters of custard apple seedlings. All three AM fungi either singly or in combinations significantly increased the growth parameters like height of plant, root length, number of leaves, dry weight of shoot and root and mycorrhizal dependency values. The combined inoculation of all the three mycorrhizae was superior over all the inoculation treatments in recording the growth parameters.

Pathak et al. (2009) studied the impact of bio-inoculants on seed germination and plant growth of guava (*Psidium guajava*). The bio-inoculants tested were *Azotobacter chroococcum*, phosphorus solubilising bacteria (PSB), plant growth promoting bacteria (PGPR) and mycorrhizae in presence of FYM as well as vermicompost. Maximum percent seed germination was observed in treatment having FYM + PGPR or FYM + *A. chroococcum* at 40 DAS, followed by PGPR and VAM treatments. Number of leaves per plant observed at 150 DAS was maximum in the treatment having FYM + VAM. Plant height was maximum in FYM treatment having all the three bio-inoculants at 150 DAS. However, these values were quite comparable to each other in FYM as well as in vermicompost tilled plastic bags

Paroha et al. (2009) studied the effect of inoculation ‘of biofertilizers (AM, *Azotobacter* & PSB) and chemical fertilizer (NPK) on growth and nutrient acquisition of *Tectona grandis* was observed under nursery conditions. In all the combinations, growth and nutrient uptake were found significantly higher in comparison to uninoculated seedlings but showed variation with treatments. AM + *Azotobacter* combination was found to be the most effective (3.91 times higher biomass) than others (effective between 28.18-302.28%). *Azotobacter* alone was found the least effective (28.18%) in *T. grandis*. It was observed that integrated approach of biofertilizers and chemical fertilizers enhanced growth response due to higher uptake of P, N, Cu, Mn and Zn in seedlings treated by both.

Angrej et al. (2010) studied the effect of growing media on seed germination and seedling growth of Peruvian ground cherry (*Physalis peruviana* L.) by using different proportion of sand and FYM including soil in alone as control. Maximum germination, seedling length and total dry weight of seedling were recorded with soil +sand + FYM (1:1:1) treatment. The leaf area and stem diameter of seedlings were maximum with soil + sand + FYM (2:1: 2) but it was statistically at par with soil + sand + FYM (1:1:1) treatment. Treatments having FYM as a component of growing medium showed better growth of the seedlings. Minimum germination, length as well as dry weight of root and shoot, leaf area and diameter were noted in control (soil).

Vasu et al. (2010) studied on two varieties of *Lens culinaris* Medic. cultivated with the treatment of two bio-fertilizers *Azotobacter chroococcum* and phosphate solubilizing bacteria, PSB. In varieties JL-3 and NDL-92, effect of PSB + *Azotobacter* 10 g+10 g inoculation showed 100 and 92% germination with survival of 100 and 88% respectively, In varieties JL-3 and NDL-92 effect of both bio-fertilizers 20 g + 20 g showed 90 and 94% germination with survival of 85 and 77% in two varieties. In varieties of JL-3 and NDL-92 effect of both biofertilizers 30 g +30 g showed 85 and 92% effect on germination with survival of 84 and 70% in both varieties respectively. Control seeds of both varieties showed 100% germination and survival.

Roy and shrivastava (2011) reported that basal application of *Azotobacter chroococcum* was substantially increased growth parameters, biomass, Leaf Area Index (LAI) and yield parameters, followed by inoculation in the form of root dipping of rice seedlings.

Sarhan et al. (2011) revealed that *Azotobacter* alone or in combination with sheep residues had significant effects on vegetative (shoot) parameters, and substantially improved the quantitative and qualitative traits of fruit yield of the two cultivars. The interaction effect of both the bio and organic fertilizers was also significant and resulted in best performance of both the summer squash cultivars in terms of vegetative as well as reproductive characteristic.

Parasana et al. (2012) studied the treatments comprised of four growing media M_1- soil + sand + farm yard manure (1:1:1), M_2- soil + sand + vermicompost (1:1:1), M_3- soil + sand + farm yard manure (2:1:1), and M_4- soil + sand + vermicompost (2:1:1), maximum germination percentage of mango stone were noted in M_3 media. The height of seedling, numbers of leaves per plant, length of shoot, length of root, stem girth, fresh weight of seedling, dry weight of seedling and maximum survival were recorded by M_3 medium.

Madgaonkar et al. (2013) observed that the experimental plant results more number in per cent of root colonization, spore number and P uptake of shoot with triple inoculation compared to control plants. The result suggests that there is a synergistic interaction with different bio-inoculants and the increase of biomass with the application of these bio-inoculants AM fungi (*Glomus macrocarpum*), *Azotobactor* and Phosphate solubilizing bacteria (PSB).

Peng et al. (2013) reported that organic fertilizers in the form of N-fixing *Azotobacter* enhanced biofertilizer increased yield with positive effects on measured plant height, weight and leaf index. Given the significant enhancement in growth and yield of corn taking place mainly with N-fixing Azotobacter fertilizers under organic condition, the mechanism for this beneficial effect could be due to the more balanced nutrition and improved absorption of nitrogen and other mineral nutrients by the corn.

Bhardwaj (2014) reported the effect of growing media on seed germination and seedling growth of papaya (*Carica papaya)*. The treatments were combined between types of media with levels of cocopeat. The results showed that the medium of vermicompost + sand + pond soil (1:1:1) with 2 cm cocopeat in top of the polybags (T_9) gave maximum speed of emergence, highest germination percent, highest seed vigour, maximum germination index, germination value and least time required for imbibitions and minimum germination period. This medium was also found to be the best medium for the growth of papaya seedlings as it gave the highest parameters in term of seedling height, leaf area, numbers of leaves, stem girth, number of roots, root length and production of total biomass. This treatment also significantly reduces the seedling mortality and produce maximum healthy seedling in minimum days with highest net profit and B:C ratio.

Joshi et al. (2015) found that vermicompost is an excellent soil amendment and a bio-control agent which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers. It can increase the production of crops and prevent them from harmful pests without polluting the environment. Application of vermicompost increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits /plant, chlorophyll content, P^H of juice, TSS of juice, micro and macro nutrients, carbohydrate (%) and protein (%) content and improved the quality of the fruit and seeds.

Interaction effect of growing media and GA_3on growth and survival

Panda and Das (1990) reported that semi- hardwood and hardwood cuttings were taken from 12 year old pomegranate tree and treated with 2500, 5000, 7500 and 10000 ppm IBA or IAA. The cutting were planted in sand and kept under intermittent mist condition. They reported that the highest percent of rooting, number of roots and length of roots were obtained with hardwood cutting dipped in 5000 ppm IBA. Better results were obtained with hardwood cuttings and IBA dips over semi-hardwood cuttings and IAA treatment.

Jain and Parmar (1993) studied hardwood cutting of pomegranate were treated with IBA at 500, 1000, 1500 ppm and/or Boron at 50 ppm and planted at river silt alone or mixed with FYM. They reported that cuttings treated with 1000 ppm IBA + 50 ppm Boron produced the most roots sprouts and were likely to survive.

MATERIAL AND METHODS

The present investigation entitled **"Studies on effect of GA_3 and growing media on seed germinability, growth and survivability of Custard apple (*Annona squamosa* L.)"** was conducted at Fruit Research Station, Imalia Farm, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur (M.P.). The details of the experiments and methods followed during the course of investigation are described under following heads.

3.1 Experimental site:

The experiment was carried out at Fruit Research Station, Imalia, JNKVV, Jabalpur during the year 2014-2015. Jabalpur is situated in "Kymore Plateau and Satpura Hills" Agro-climatic zone of Madhya Pradesh at 23.9ºN latitude and 79.58º east longitudes and an altitude of 411.78 meters above the mean sea level. The tropic of cancer passes through the middle of the district.

3.2 Climate and weather condition:

The climate of Jabalpur region is semi-arid and subtropical having warm and dry spring summer and cool winter as main characteristics feature, in general the highest temperature reaches above 45°c and below 5°c respectively. The relative humidity varies from 70-80%. The average annual rainfall of about 1375, mm, which is mainly distributed from mid June to first week of October from south-west monsoon with occasional rain during winter.

The meteorological data were recorded during the experimental period 2014-15 from the Department of Physics and Agro-meteorology, college of Agricultural Engineering, JNKVV, Jabalpur (M.P.) and summarized in Table 3.1 and graphically presented in Fig 3.1

Table 3.1: Meteorological data during the period of investigation (December 2014- April 2015)

Month	No. of week	Temperature (^{0}C)		Sun shine (hrs.)	Rainfall (mm)	Relative humidity		Rainy days
		Max.	Mini.			Max.	Mini.	
Dec	49	28.7	8.0	8.7	0.0	88.0	24.0	0.0
	50	29.0	11.8	6.2	3.2	89.0	52.0	1.0
	51	25.3	5.6	7.6	0.0	86.0	32.0	0.0
	52	23.8	4.8	8.5	0.0	87.0	32.0	0.0
	1	20.5	11.7	6.5	37.7	90	61	3.0
Jan	2	22.1	5.3	8.5	0.0	87	38	0.0
	3	22.2	5.3	8.3	0.0	91	37	0.0
	4	21.6	12.1	3.7	10.2	89	75	2.0
	5	22.5	8.7	9.8	10.8	85	44	2.0
Feb	6	24.2	10.2	7.1	14.4	88	52	1.0
	7	26.8	10.4	9.1	6.2	88	40	1.0
	8	30.6	12.0	9.7	0.0	86	33	0.0
	9	26.7	14.5	6.8	64.8	85	54	3.0
March	10	28.0	12.0	9.5	0.0	85	39	0.0
	11	26.8	15.2	6..0	23.6	87	54	3.0
	12	31.8	13.8	10.3	0.0	80	26	0.0
	13	35.1	17.4	8.5	0.0	78	23	0.0
April	14	30.9	19.4	9.2	0.0	61.3	23.4	0.0
	15	33.1	18.5	7.4	1.6	71.3	36.3	0.0
	16	39.2	21.3	9.7	0.9	54.3	15.4	0.0
	17	38.9	21.7	9.2	0.0	43.1	17.6	0.0

3.3 Experimental details

In this experiment, the response of different soil media and GA concentration was evaluated for germination and vegetative growth of custard apple. The experiment details are given below;

Location: Fruit Research Station, Imalia. Department of Horticulture, JNKVV, Jabalpur (M.P.)

Crop	Custard apple
Replication	03
Statistical design	Factorial RBD
Growing media	06
Gibberellic acid concentrations	04
No. of treatment combinations	24
No. of polybags/treatment/replication	10
Total number of plot	72
Date of sowing	30^{th} November
Condition	Polyhouse

3.4 Treatment Details- Two Factors

Factor (A) Gibberellic Acid:

G_0 GA_3 0 ppm

G_1 GA_3 200 ppm

G_2 GA_3 400 ppm

G_3 GA_3 600 ppm

Factor (B) Growing Media:

M_0 Soil

M_1 Soil + FYM

M_2 Soil + Vermicompost

M_3 Soil + Azotobacter + PSB

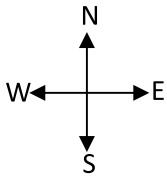
M_4 Soil + FYM + Azotobacter + PSB

M_5 Soil + Vermicompost + Azotobacter + PSB

3.5 Treatment Combinations

Treatments	Treatment combinations	composition
T_1	G_0M_0	0 ppm GA_3 + Soil (Control)
T_2	G_0M_1	0 ppm GA_3 + (Soil + FYM)
T_3	G_0M_2	0 ppm GA_3 + (Soil + Vermicompost)
T_4	G_0M_3	0 ppm GA_3 + (Soil + AZO + PSB)
T_5	G_0M_4	0 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_6	G_0M_5	0 ppm GA_3 + (soil + Vermicompost + AZO + PSB)
T_7	G_1M_0	200 ppm GA_3 + Soil
T_8	G_1M_1	200 ppm GA_3 + (Soil + FYM)
T_9	G_1M_2	200 ppm GA_3 + (Soil + Vermicompost)
T_{10}	G_1M_3	200 ppm GA_3+ (Soil + AZO + PSB)
T_{11}	G_1M_4	200 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_{12}	G_1M_5	200 ppm GA_3 + (soil + Vermicompost + AZO + PSB)
T_{13}	G_2M_0	400 ppm GA_3 + Soil
T_{14}	G_2M_1	400 ppm GA_3 + (soil + FYM)
T_{15}	G_2M_2	400 ppm GA_3 + (Soil + Vermicompost)
T_{16}	G_2M_3	400 ppm GA_3 + (Soil + AZO + PSB)
T_{17}	G_2M_4	400 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_{18}	G_2M_5	400 ppm GA_3 + (soil + Vermicompost + AZO + PSB)
T_{19}	G_3M_0	600 ppm GA_3 + Soil
T_{20}	G_3M_1	600 ppm GA_3 + (Soil + FYM)
T_{21}	G_3M_2	600 ppm GA_3 + (Soil + Vermicompost)
T_{22}	G_3M_3	600 ppm GA_3 + (Soil + AZO + PSB)
T_{23}	G_3M_4	600 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_{24}	G_3M_5	600 ppm GA_3 + (soil + Vermicompost + AZO + PSB)

Plan of Layout: The experiment layout was as under



R-I	R-II	R-III
T_{1}	T_{13}	T_{7}
T_{2}	T_{14}	T_{8}
T_{3}	T_{15}	T_{9}
T_{4}	T_{16}	T_{10}
T_{5}	T_{17}	T_{11}
T_{6}	T_{18}	T_{12}
T_{7}	T_{19}	T_{13}
T_{8}	T_{20}	T_{14}
T_{9}	T_{21}	T_{15}
T_{10}	T_{22}	T_{16}
T_{11}	T_{23}	T_{17}
T_{12}	T_{24}	T_{18}
T_{13}	T_{1}	T_{19}
T_{14}	T_{2}	T_{20}
T_{15}	T_{3}	T_{21}
T_{16}	T_{4}	T_{22}
T_{17}	T_{5}	T_{23}
T_{18}	T_{6}	T_{24}
T_{19}	T_{7}	T_{1}
T_{20}	T_{8}	T_{2}
T_{21}	T_{9}	T_{3}
T_{22}	T_{10}	T_{4}
T_{23}	T_{11}	T_{5}
T_{24}	T_{12}	T_{6}

Fig. 3.2: Layout Plan of Experiment field (Factorial Randomized Block Design)

3.6.1 Preparation of growing media

The media were used to grow seedling in polybags comprising of;

1. **Only soil**
2. **Soil + FYM** – the ratio of 2:1 of soil and fully decomposed FYM.
3. **Soil + Vermicompost** – the ratio of 2:1of soil and vermicompost.
4. **Soil + AZO + PSB** – soil enrich with AZO and PSB (each 5 g/kg soil).
5. **Soil + FYM + AZO + PSB** – the ratio of 2:1 of soil and FYM enrich with AZO and PSB (each 5 g/kg soil).
6. **Soil + Vermicompost + AZO + PSB** – the ratio of 2:1 of soil and vermicompost enrich with AZO and PSB (each 5 g/kg soil).

3.6.2 Preparation of solution of GA_3

200 mg, 400 mg and 600 mg of GA_3 was weighed in a electrical weighing balance and each was dissolved in 10 ml.of 99% absolute ethyl alcohol to which distilled water was added to make up the volume equal to one liter as a stock solution.

Treatment of seed:- seeds soaked in GA_3 solution for 24 h and grown in polybags under the polyhouse.

3.7 Filling of polybags

Polybags having a length of 15 cm and diameter of 10 cm with 200 gauge thickness were used and filled with the media comprising of soil, soil + FYM, soil + vermicompost, soil + AZO + PSB, soil + FYM + AZO + PSB, soil + vermicompost + AZO + PSB, respectively.

3.8 Sowing of seeds

Treated seed of custard apple were sown in polythene bags of 15 X 10 cm size filled in different mixture and its combinations on 30thNovember 2014. One seed per poly bag was sown at 2-2.5 cm depth.

Treatment contained 10 polythene bags. 5 poly bags were arranged in each row and 2 in each column to make 3 replications as described earlier. Manual irrigation was applied daily.

3.9 Observation recorded

The following parameters regarding seed germination and growth were recorded.

A. Germination Parameters:

- Days taken to first germination.
- Days taken to 50% germination.
- Percent of germination in each treatment at 30 DAS.
- Percent of germination in each treatment at 60 DAS.

B. Growth Parameters:

The following observations were recorded at 30, 60, 90, 120 and 150 days after sowing. Five plants were randomly selected for observations and mean value was computed.

- Height of shoots (cm).
- Number of leaves per seedling.
- Girth of stem (mm).

C. Physiological Parameters:

- Leaf Area Index (LAI).
- Leaf Area Duration (LAD).
- Light Transmission Ratio (LTR).
- Energy Interception (Ei).

The following observations were recorded at 150 days after sowing. Five plants were uprooted and the average value was computed at this stage.

- Length of seedling (cm) at 150 DAS.
- Root length (cm) at 150 DAS.
- Number of roots/seedling at 150 DAS.
- Fresh weight of shoots (g) at 150 DAS.
- Dry weight of shoots (g) at 150 DAS.

- Fresh weight of roots (g) at 150 DAS.
- Dry weight of roots (g) at 150 DAS
- Seedling vigour index (cm).
- Seedling vigour index (g).
- Survival percentage of seedling after 150 DAS.

3.10.1 Germination percentage

The germination in each treatment was recorded at 30 and 60 days after sowing. Number of seedlings were counted and expressed as germination percentage.

$$\text{Germination (\%)} = \frac{\text{Total no. of seeds germinated}}{\text{Total no of seeds sown}} \text{ X } 100$$

3.10.2 Height of shoot (cm)

The length from the collar region to the tip of the shoot apex was measured for five randomly selected tagged plants in each treatment at 30, 60, 90, 120 and 150 days after sowing and the average of length was computed.

3.10.3 Girth of stem (mm)

The diameter of shoot above the root collar region was recorded using vernier caliper.

3.10.4 Leaf Area Index:

LAI expresses the ratio of leaf surface considerably to the ground area occupied by the plant or a crop stand worked out as per specification of Gardner et al. (1985),

$$\text{LAI} = \frac{\text{Total Leaf Area}}{\text{Ground area}} = \frac{(LA_1+LA_2)/2}{P}$$

Where, the LA_1 and LA_2 represent the leaf area during the two consecutive intervals and “p” ground area (Watson, 1952).

3.10.5 Leaf Area Duration (LAD)

Leaf Area Duration expresses the magnitude and persistence of leaf area of leafiness during the period of crop growth. It reflects the extent of period of crop growth. It reflects the extent of seasonal integral of light interaction and corrected with yield.LAD was computed as follow (Watson, 1952).

$$LAD = \frac{(LA_1+LA_2)}{2} \times (t_2-t_1)\ (cm^2 x\ days)$$

3.10.6 Light Transmission Ratio (LTR)

It was given by Golingai and Mabbayad in 1969.

$$LTR = \frac{I}{I_0} \times 100$$

Where

I = Light intensity at the base of crop canopy and

I_0 =Total incoming radiation

It was calculated by Lux meter (model LX-105)

3.10.7 Energy interception (Ei)

It can be calculated by lux meter. Its values were converted in terms of energy as per constants.

The values were recorded at 120 and 150 DAS and then the mean value was woked out.

71 K Lux =1 calorie/cm^2/min

Ei = total incident energy – transmitted energy

3.10.8 Length of seedling (cm)

The height of seedling is measured from root tip to the shoot tip and expressed in centimeter at 150 days after sowing.

3.10.9 Root length (cm)

The length from collar region to the tip of the root was measured for five randomly uprooted plants in each treatment. The average value was computed.

3.10.10 Number of roots per seedling

In number of roots per seedling, primary, secondary and tertiary and rootlets were counted.

3.10.11 Fresh weight of seedling

The plants were carefully washed to remove the soil adhering to their roots and shoots. The weight was taken with the help of electronic balance and average value was computed

3.10.12 Dry weight of seedling

For dry weight plant were chopped and oven dried at 60 ± 2^0C temperature till a constant weight. The weight was taken with the help of electronic balance and average value was computed.

3.10.13 Seedling vigour index I

It was calculated by adding the values of root length and shoot length which was randomly selected and multiplying with their corresponding germination percentage and the values were recorded. (Abdulbaki and Anderson, 1973)

Seedling vigour index I = germination percentage x [root length (cm) + shoot length (cm)]

3.10.14 Seedling vigour index II (g)

It was calculated by multiplying dry weight of seedlings with their corresponding germination percentage.

Seedling vigour index II = dry weight of seedlings (g) x germination percentage

3.10.15 Survival percentage of seedlings

The survival percentage of each treatment was recorded at 150 days after seed sowing. The survival percentage was calculated by using formula as given below:

$$\text{Survival percentage of seedlings} = \frac{\text{No. of survived seedling}}{\text{Total no. of seedlings}} \times 100$$

3.11 Statistical analysis and interpretation of data:

The data collected during the investigation were analyzed statistically by the method of analysis of variance. The significance of various treatments was judged and Suggested by Fisher (1937) applying 'F' test. The skeleton of analysis of variance of design is presented in table-

Table3.2: ANOVA for Factorial Randomized Design

Source of variation	**D.F.**	**Sum of square**	**Mean sum of square**	**F value**	**F_t 5% table value**
Replication	2				
Factor a	3				
Factor b	5				
Interaction	15				
Error	46				
Total	71				

3.11.1 Standard error

S.Em. for growing media = $\pm\sqrt{\frac{MSS}{rG}}$

C.D. = S.Ed. x t at error 5% d.f.

S.Em. for gibberellic acid = $\pm\sqrt{\frac{MSS}{rM}}$

C.D. = S.Ed. x t at error 5% d.f.

S.Em. for interaction = $\pm\sqrt{\frac{MSS}{r}}$

C.D. = S.Ed. x t at error 5% d.f.

EMSS is the error variance and r, M and Grepresent the number of replications, growing media and concentration of gibberellic acid, respectively.

The S.Em.and C.D. at 5% for growing media, gibberellic acid and their interaction has been giving along with each table. The results of various characters were influenced by different treatments have been diagrammatically represented by histograms.

RESULT

This chapter deals with the results of the experiment entitled **"Studies on effect of GA_3 and growing media on seed germinability, growth and survivability of Custard apple (*Annona squamosa* L.)"**. The experiment was carried out during December 2014 to April 2015. The experimental have been summarized and the results are presented with statistical analysis and supported by relevant diagrams wherever necessary.

4.1 Days taken to start germination

The data pertaining to days taken to start germination were recorded and statistically analysed. The results are presented in table 4.1 and fig.4.1.

Table 4.1: Influence of growing media (M) and gibberellic acid (G) on days taken to start germination (days)

Days taken to start germination							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	37.33	35.67	33.67	37.00	34.67	34.33	35.44
G_1 (200 ppm)	36.33	33.67	32.67	35.67	33.33	30.67	33.72
G_2 (400 ppm)	35.67	33.33	32.33	33.67	32.67	31.00	33.11
G_3 (600 ppm)	34.67	33.00	32.00	34.00	32.00	30.00	32.61
Mean	36.00	33.92	32.67	35.08	33.17	31.50	

	M	G	M X G
SEm±	0.644	0.526	1.289
CD at 5%	1.840	1.502	NS

Data revealed that growing media significantly showed earliness to seed germination. The seeds subjected to growing media under M_5 having soil + vermicompost + AZO + PSB were recorded earliest germination (31.50 days) which showed superiority over M_2 (soil + vermicompost), M_4 (soil + FYM + AZO + PSB), M_1 (soil + FYM), M_2 (soil + AZO + PSB) and M_0 (only soil) in which 32.67, 33.17, 33.92, 35.08 and 36.00 days were taken, respectively.

Days taken to start germination were slightly better in the treatments having vermicompost over their respective FYM treatments; however, the difference between them was non-significant.

Gibberellic acid showed significant effect on germination of seed. The minimum days of 32.61 were taken to germinate the seed of custard apple under G_3 (600 ppm) and found statistically at par with other concentration of GA_3 except G_0 (water soaked seed) which taken maximum days (35.44) to start germination.

As regard the interaction effect of growing media and gibberellic acid had shown non significant effect with respect to days taken to start germination.

4.2 Days taken to 50% germination

The data pertaining to days taken to 50% germination were presented in table 4.2 and fig.4.2.

Table 4.2: Influence of soil media and gibberellic acid on days taken to 50% germination.

Days taken to 50% germination							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	53.00	52.67	50.00	51.67	49.00	50.00	51.06
G_1 (200 ppm)	51.67	48.33	48.00	50.33	48.33	47.00	48.94
G_2 (400 ppm)	50.67	47.67	47.00	47.67	48.00	46.00	47.83
G_3 (600 ppm)	50.33	47.00	46.00	49.00	46.33	44.33	47.17
Mean	51.42	48.92	47.75	49.67	47.92	46.83	

	M	G	M X G
SEm±	0.735	0.600	1.471
CD at 5%	2.100	1.714	NS

The result clearly show that growing media and gibberellic acid significantly influenced the days taken to 50% germination. The media M_5 (soil + vermicompost + AZO + PSB) has taken minimum days of 46.83 which showed superiority over M_2 (soil + vermicompost), M_4 (soil + FYM + AZO + PSB), M_1 (soil + FYM), M_2 (soil + AZO + PSB) and M_0 (only soil), respectively. However, the difference between vermicompost and FYM was non significant. The maximum days of 51.42 were taken to reach 50 per cent germination under M_0 (only soil).

Gibberellic acid also had significant effect on days taken for 50 per cent germination. GA_3 concentration of 600 ppm taken minimum days of 47.17 which was statistically at par with rest of the treatments except under control (G_0) i.e. water soaked seed.

As regards the interaction effect, it was found non significant with respect to days taken to 50% germination.

4.3 Percentage of germination at 60 days after sowing

Seed germination percentage was worked out and presented in table 4.3 and fig.4.3.

Table 4.3: Influence of growing media and gibberellic acid on percentage of germination at 60 DAS.

Percentage of germination at 60 DAS.							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	53.33	56.67	60.00	56.67	63.33	66.67	59.44
G_1 (200 ppm)	63.33	66.67	73.33	70.00	66.67	73.33	68.89
G_2 (400 ppm)	60.00	70.00	76.67	70.00	73.33	83.33	72.22
G_3 (600 ppm)	63.33	73.33	80.00	60.00	80.00	86.67	73.89
Mean	60.00	66.67	72.50	64.17	70.83	77.50	

	M	G	M X G
SEm±	3.189	2.604	6.378
CD at 5%	9.107	7.436	NS

Data revealed that the maximum percentage of germination 77.50 was noted at 60 days after sowing under media M_5 (soil + vermicompost + AZO + PSB) and found statistically at par with M_2 (72.50%) and M_4 (70.83%). Whereas, the minimum seed germination of 60.00 percent was under media M_0 having only soil.

As regards the GA_3, the maximum value of 73.89 percent germination was recorded when seed soaked in 600 ppm concentration of GA (G_3) which was statistically at par with rest concentration of GA_3 except G_0 (water soaked seed) and minimum value of 59.44 percent germination was recorded.

The combine effect of growing media and gibberellic acid was found to be non significant with respect to percent of seed germination at 60 days after sowing.

4.4 Height of shoot (cm)

The height of shoots at 60, 90, 120, 150 days after sowing was recorded and presented in Table 4.4 and fig 4.4. Data showed that the growing media and gibberellic acid concentration showed significant effect on height of shoots at 60, 90, 120 and 150 DAS while its combined effect of shoot height was not significant.

The maximum shoot height of 4.09, 8.33, 12.06 and 17.68 cm noted under M_5 (soil + vermicompost + AZO + PSB) at 60, 90, 120 and 150 DAS, respectively and it was significantly superior over rest of the media except M_2 (soil + vermicompost). The minimum shoot height of 2.91, 6.23, 10.32 and 15.63 cm was recorded under M_0 (only soil) at 60, 90, 120 and 150 days after seed sowing, respectively.

Gibberellic acid concentration had shown significant effect on height of shoots and maximum height of 3.97, 7.65, 11.83 and 17.60 cm was noted when seed soaked in 400 ppm concentration of GA_3 at 60, 90, 120 and 150 days after seed sowing, respectively and found significantly superior over rest of the concentrations of GA_3 whereas, the minimum height of shoots (3.09, 6.87, 10.68 and 16.02 cm) was recorded under G_0 at 60, 90, 120 and 150 days after seed sowing, respectively.

Table 4.4: Influence of growing media and gibberellic acid on height of shoots (cm)

Treatment	Height of shoot (cm)			
Gibberellic acid	**60 DAS**	**90 DAS**	**120 DAS**	**150 DAS**
G_0 (0 ppm)	3.09	6.87	10.68	16.02
G_1 (200 ppm)	3.44	7.22	11.16	16.45
G_2 (400 ppm)	3.97	7.65	11.83	17.60
G_3 (600 ppm)	3.75	7.34	11.47	17.05
SEm	0.056	0.104	0.078	0.180
CD at 5% level	0.160	0.298	0.222	0.515
Media				
M_0 (Soil)	2.91	6.23	10.32	15.63
M_1 (Soil+FYM)	3.56	7.13	11.20	16.86
M_2 (Soil+VC)	3.96	8.01	11.82	17.54
M_3 (Soil+BF)	3.10	6.55	10.77	15.96
M_4 (Soil+FYM+BF)	3.76	7.39	11.56	17.03
M_5 (Soil+VC+BF)	4.09	8.33	12.06	17.68
SEm	0.069	0.128	0.095	0.221
CD at 5% level	0.196	0.365	0.272	0.630
Interaction				
G_0M_0	2.47	5.81	9.48	14.33
G_0M_1	3.32	7.17	10.76	16.49
G_0M_2	3.37	7.34	11.19	16.85
G_0M_3	2.57	6.03	10.19	14.69
G_0M_4	3.17	6.97	10.90	16.87
G_0M_5	3.63	7.91	11.56	16.91
G_1M_0	2.56	5.99	10.00	14.52
G_1M_1	3.49	7.07	11.13	16.70
G_1M_2	3.80	8.03	11.71	17.37
G_1M_3	3.19	6.56	10.74	16.03
G_1M_4	3.83	7.49	11.83	16.87
G_1M_5	3.79	8.19	11.56	17.22
G_2M_0	3.42	7.13	10.92	17.20
G_2M_1	3.72	6.92	11.43	17.24
G_2M_2	4.37	8.27	12.43	18.21
G_2M_3	3.53	7.09	11.24	16.91
G_2M_4	4.17	7.61	11.99	17.43
G_2M_5	4.61	8.89	12.97	18.63
G_3M_0	3.20	5.98	10.86	16.44
G_3M_1	3.71	7.36	11.49	17.00
G_3M_2	4.29	8.39	11.93	17.72
G_3M_3	3.12	6.51	10.91	16.22
G_3M_4	3.87	7.48	11.51	16.94
G_3M_5	4.32	8.35	12.13	17.97
SEm	0.137	0.256	0.191	0.441
CD at 5% level	NS	NS	NS	NS

4.5 Number of leaves per seedling

The data pertaining to number of leaves per seedling at 60, 90, 120, 150 days after sowing was recorded and presented in table 4.5 and fig. 4.5. Data revealed that the maximum number of leaves (4.78, 9.05, 16.10 and 21.32 leaves per seedling) was recorded respectively when seed sown in growing media comprising soil + vermicompost + AZO + PSB (M_5) and showed significant superiority over rest of the treatment at 120 and 150 days after seed sowing. But at 60 and 90 DAS, it showed significant effect except M_2 (soil + vermicompost). However, minimum number of leaves (3.17, 7.38, 14.47 and 19.25) per seedling was recorded under M_0 i.e. only soil.

Gibberellic acid had significant effect on number of leaves per seedling and higher number of leaves 4.71, 9.00, 16.10 and 21.06 per seedling were recorded in G_2 (400 ppm) and showed significant superiority over rest of the treatments at 60, 90, 120 and 150 days after seed sowing. Whereas, it was lower in 3.37, 7.58, 14.51 and 19.60 leaves per seedlings in G_0 (control).

Interaction of growing media and gibberellic acid showed non significant effect on number of leaves per seedling. However, the maximum number of leaves per seedling was noted under seed treated with 400 ppm GA_3 and sown in soil + vermicompost + AZO + PSB whereas minimum number of leaves per seedling was recorded under G_0M_0 (control).

4.6 Girth of stem (mm)

Data pertaining to girth of stem presented in table 4.6 and fig. 4.6 that growing media and gibberellic acid had showed significant effect on stem girth at different stages. The maximum stem girth of 2.71, 3.13, 3.53 and 4.16 (mm) was recorded under M_4 (soil + FYM + AZO + PSB) at 60, 90, 120 and 150 days after sowing, respectively and statistically at par with M_1 (soil + FYM) and M_5 (soil + vermicompost + AZO + PSB). Minimum stem girth of 1.78, 2.33, 2.72 and 3.27 was recorded under M_0 (only soil) at 60, 90, 120 and 150 days after sowing.

It is apparent from analyzed data that gibberellic acid concentrations significantly affect the stem girth. Maximum stem girth of 2.57, 2.98, 3.29 and 3.89 mm was recorded at 60, 90, 120 and 150 days after seed sowing,

respectively when seed soaked in 200 ppm concentration of GA_3 (G_1) while minimum girth of stem (1.94, 2.62, 2.92 and 3.51) was recorded under G_0 at 60, 90, 120 and 150 days after sowing, respectively.

As regards the interaction effect of the growing media and gibberellic acid showed non significant at all the stages.

Table 4.5: Influence of growing media and gibberellic acid on number of leaves per seedling

Treatment	No. of leaves per seedling			
Gibberellic acid	**60 DAS**	**90 DAS**	**120 DAS**	**150 DAS**
G_0 (0 ppm)	3.37	7.58	14.51	19.60
G_1 (200 ppm)	3.80	8.00	14.96	20.02
G_2 (400 ppm)	4.71	9.00	16.10	21.06
G_3 (600 ppm)	4.31	8.53	15.34	20.53
SEm	0.118	0.117	0.129	0.156
CD at 5% level	0.338	0.335	0.369	0.444
Media				
M_0 (Soil)	3.17	7.38	14.47	19.25
M_1 (Soil+FYM)	4.02	8.22	15.00	20.20
M_2 (Soil+VC)	4.45	8.72	15.58	20.78
M_3 (Soil+BF)	3.68	7.87	14.85	19.87
M_4 (Soil+FYM+BF)	4.18	8.43	15.37	20.40
M_5 (Soil+VC+BF)	4.78	9.05	16.10	21.32
SEm	0.145	0.144	0.158	0.191
CD at 5% level	0.414	0.410	0.452	0.544
Interaction				
G_0M_0	2.53	6.73	13.60	18.53
G_0M_1	3.47	7.67	14.47	19.53
G_0M_2	3.73	7.93	14.87	20.07
G_0M_3	2.60	6.80	13.93	19.00
G_0M_4	3.60	7.80	14.80	19.87
G_0M_5	4.27	8.53	15.40	20.60
G_1M_0	2.87	7.07	14.20	19.07
G_1M_1	4.07	8.27	15.27	20.40
G_1M_2	4.07	8.27	15.07	20.13
G_1M_3	3.27	7.47	14.40	19.40
G_1M_4	4.27	8.47	15.47	20.53
G_1M_5	4.27	8.47	15.33	20.60
G_2M_0	3.33	7.60	15.20	19.80
G_2M_1	4.53	8.73	15.87	20.80
G_2M_2	5.00	9.47	16.13	21.27
G_2M_3	4.93	9.07	16.20	21.20
G_2M_4	5.13	9.40	16.27	21.20
G_2M_5	5.33	9.73	16.93	22.07
G_3M_0	3.93	8.13	14.87	19.60
G_3M_1	4.00	8.20	14.40	20.07
G_3M_2	5.00	9.20	16.27	21.67
G_3M_3	3.93	8.13	14.87	19.87
G_3M_4	3.73	8.07	14.93	20.00
G_3M_5	5.27	9.47	16.73	22.00
SEm	0.290	0.287	0.317	0.381
CD at 5% level	NS	NS	NS	NS

Table 4.6: Influence of growing media and gibberellic acid on girth of stem (mm)

Treatment	Girth of stem (mm)			
Gibberellic acid	**60 DAS**	**90 DAS**	**120 DAS**	**150 DAS**
G_0 (0 ppm)	1.94	2.62	2.92	3.51
G_1 (200 ppm)	2.57	2.98	3.29	3.89
G_2 (400 ppm)	2.34	2.92	3.25	3.80
G_3 (600 ppm)	2.27	2.80	3.14	3.62
SEm	0.095	0.093	0.095	0.101
CD at 5% level	0.272	0.264	0.272	0.289
Media				
M_0 (Soil)	1.78	2.33	2.72	3.27
M_1 (Soil+FYM)	2.65	3.09	3.37	3.82
M_2 (Soil+VC)	2.16	2.88	3.08	3.65
M_3 (Soil+BF)	2.00	2.64	2.99	3.54
M_4 (Soil+FYM+BF)	2.71	3.13	3.53	4.16
M_5 (Soil+VC+BF)	2.40	2.92	3.22	3.80
SEm	0.117	0.113	0.117	0.124
CD at 5% level	0.334	0.324	0.333	0.354
Interaction				
G_0M_0	1.12	2.06	2.48	2.79
G_0M_1	2.03	3.00	3.16	4.02
G_0M_2	1.96	2.66	2.77	3.34
G_0M_3	2.00	2.34	2.82	3.76
G_0M_4	2.41	2.88	3.21	3.48
G_0M_5	2.15	2.77	3.09	3.46
G_1M_0	2.00	2.28	2.83	3.67
G_1M_1	3.08	3.40	3.46	3.81
G_1M_2	2.55	2.95	3.05	3.55
G_1M_3	2.10	2.85	3.09	3.53
G_1M_4	3.18	3.51	4.13	4.71
G_1M_5	2.52	2.92	3.18	3.93
G_2M_0	1.92	2.64	2.77	3.12
G_2M_1	3.05	2.91	3.51	3.57
G_2M_2	2.13	2.88	3.22	4.11
G_2M_3	1.80	2.70	3.05	3.49
G_2M_4	3.00	3.40	3.76	4.54
G_2M_5	2.15	3.01	3.21	3.97
G_3M_0	2.06	2.32	2.81	3.25
G_3M_1	2.45	3.03	3.36	3.86
G_3M_2	2.01	3.01	3.28	3.58
G_3M_3	2.12	2.65	3.01	3.39
G_3M_4	2.25	2.74	2.99	3.92
G_3M_5	2.76	3.01	3.38	3.60
SEm	0.234	0.227	0.233	0.248
CD at 5% level	NS	NS	NS	NS

4.7 Length of seedling at 150 days after sowing (cm)

It is clear from table 4.7 and fig.4.7 that growing media and gibberellic acid significantly influenced the height of seedling at 150 days after sowing. The maximum seedling height of 43.81 cm recorded at 150 days after sowing under M_5 comprising soil + vermicompost + AZO + PSB, which showed significant superiority over rest of treatments except M_2 (42.85 cm) and minimum height of 34.46 cm was recorded under M_0.

As regards the gibberellic acid concentrations, showed significant effect on height of seedling at 150 days after sowing and maximum seedling height of 42.13 cm was recorded when seed soaked in 400 ppm concentration of GA_3 (G_2) which was significantly superior to rest of the treatments whereas minimum height of seedlings 37.47 cm was recorded under control (G_0) means water soaking done.

The Interaction of growing media and gibberellic acid did not show any significant effect on seedling height.

Table 4.7: Influence of growing media and gibberellic acid on height of seedling (cm) at 150 days after sowing

Length of seedling at 150 DAS (cm)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	31.68	38.06	41.28	33.30	39.31	41.18	37.47
G_1 (200 ppm)	32.90	39.35	41.77	36.55	42.00	42.54	39.18
G_2 (400 ppm)	37.82	41.76	44.87	38.29	43.12	46.90	42.13
G_3 (600 ppm)	35.43	40.67	43.47	36.51	41.91	44.61	40.43
Mean	34.46	39.96	42.85	36.16	41.58	43.81	

	M	G	M X G
SEm±	0.576	0.471	1.153
CD at 5%	1.646	1.344	NS

4.8 Root length at 150 days after sowing (cm)

A perusal of data presented in table 4.8 and fig. 4.8 that growing media significantly increased the root length and maximum root length of 26.13 cm at 150 days after sowing was recorded under M_5 which showed significant superiority over rest of treatments except M_2 (25.22 cm). The minimum root length was recorded under M_0 (18.76 cm).

Gibberellic acid concentrations showed significant effect on root length after 150 days. Maximum root length of 24.52 cm was recorded under G_2 which was significantly superior over rest of the treatments while minimum root length of 21.44 cm was recorded under G_0 (control).

The interaction of growing media and gibberellic acid concentrations did not showed significant effect on root length at 150 DAS.

Table 4.8: Influence of growing media and gibberellic acid on root length at 150 days after sowing

Root length at 150 DAS (cm)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	17.35	21.56	24.43	18.61	22.44	24.27	21.44
G_1 (200 ppm)	18.37	22.65	24.40	20.52	24.20	25.32	22.58
G_2 (400 ppm)	20.62	24.52	26.66	21.38	25.69	28.27	24.52
G_3 (600 ppm)	18.72	23.66	25.37	20.60	24.64	26.64	23.27
Mean	18.76	23.10	25.22	20.28	24.24	26.13	

	M	G	M X G
SEm±	0.530	0.433	1.061
CD at 5%	1.514	1.237	NS

4.9 Number of roots/seedling at 150 days after sowing.

The data pertaining to number of roots/seedling at 150 days after sowing is given in table 4.9 and fig 4.9 indicates that M_5 recorded significantly maximum number of roots per seedling (50.37) at 150 days after sowing followed by M_2 (49.70) whereas, minimum number of roots per seedling was recorded under M_0 (41.45).

Gibberellic acid showed significant effect on number of roots after 150 days. Maximum number of 48.90 roots per seedling was recorded under G_2 which was at par with G_3 (48.36) while minimum number of root was recorded under G_0 (45.13).

The interaction of growing media and gibberellic acid did not show significant effect on maximum number of roots.

Table 4.9: Influence of growing media and gibberellic acid on number of roots per seedling at 150 days after sowing

Number of roots/seedling at 150 DAS							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	39.47	46.20	47.27	43.67	46.53	47.67	45.13
G_1 (200 ppm)	41.33	46.67	48.47	43.60	47.80	48.87	46.12
G_2 (400 ppm)	42.80	47.60	52.40	45.60	51.40	53.60	48.90
G_3 (600 ppm)	42.20	49.60	50.67	46.67	49.67	51.33	48.36
Mean	41.45	47.52	49.70	44.88	48.85	50.37	

	M	G	M X G
SEm±	0.866	0.707	1.733
CD at 5%	2.474	2.020	NS

4.10 Leaf Area Index (LAI)

The data pertaining to Leaf Area Index (LAI) at interval of 120 and 150 days after sowing is presented in table 4.10 and in fig.4.10. The growing media and gibberellic acid significantly influenced the Leaf Area Index (LAI) at interval of 120 and 150 days after sowing. Maximum Leaf Area Index of 1.08 recorded at interval of 120 and 150 days after sowing under M_5 comprising soil + vermicompost + AZO + PSB showed superiority over rest of treatments whereas, minimum Leaf Area Index 0.88 was recorded under $M_{0.}$

As regards the concentration of Gibberellic acid showed significant effect on Leaf Area Index (LAI) at interval of 120 and 150 days after sowing and maximum Leaf Area Index (LAI) 1.11 was recorded under G_2 which was significantly superior to rest of the treatments. The minimum Leaf Area Index (LAI) 0.84 was recorded under $G_{0.}$

The interaction of soil media and gibberellic acid was also showed significant effect on Leaf Area Index (LAI). The maximum Leaf Area Index (LAI) 1.32 was noted under treatment combination G_2M_5 and found significantly superior over rest of the treatment combinations while minimum Leaf Area Index (LAI) 0.78 was noted under $G_0M_{0.}$

Table 4.10: Influence of growing media and gibberellic acid on Leaf Area Index (LAI) at interval of 120 and 150 days after sowing.

Leaf Area Index (LAI)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	0.78	0.84	0.83	0.84	0.88	0.89	0.84
G_1 (200 ppm)	0.83	0.88	0.89	0.93	1.07	0.92	0.92
G_2 (400 ppm)	0.97	1.19	1.20	1.01	0.98	1.32	1.11
G_3 (600 ppm)	0.92	1.00	1.14	0.99	1.10	1.19	1.06
Mean	0.88	0.98	1.02	0.94	1.01	1.08	

	M	G	M X G
SEm±	0.024	0.020	0.049
CD at 5%	0.070	0.057	0.139

4.11 Leaf Area Duration (LAD)

Growing media significantly influenced the Leaf Area Duration (table 4.11 and fig. 4.11) and maximum Leaf Area Duration (LAD) 9434.29 cm^2×day was recorded under M_5 and found significantly superior over rest of growing media and minimum Leaf Area Duration (LAD) 7643.52 cm^2.day was noted under $M_{0.}$

Concentrations of gibberellic acid significantly influenced the Leaf Area Duration (LAD) at an interval of 120 and 150 days after sowing and maximum Leaf Area Duration (LAD) 9715.76 cm^2×day was recorded under G_2 which was significantly superior over rest of the treatments. The minimum Leaf Area Duration (LAD) 7376.60 cm^2×day was recorded under $G_{0.}$

The interaction of soil media and gibberellic acid also showed significant effect on Leaf Area Duration (LAD). The maximum Leaf Area Duration (LAD) 11559.91 cm^2×day was noted under treatment combination G_2M_5 which was found significantly superior over rest of the treatment combinations while minimum Leaf Area Duration (LAD) 6842.77 cm^2.day was noted under $G_0M_{0.}$

Table 4.11: Influence of growing media and gibberellic acid on Leaf Area Duration (LAD) at interval of 120 and 150 days after sowing.

Leaf Area Duration (LAD)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	6842.77	7308.66	7279.54	7308.66	7716.31	7803.67	7376.60
G_1 (200ppm)	7221.31	7716.31	7774.55	8153.09	9317.81	8007.50	8031.76
G_2 (400 ppm)	8473.39	10366.07	10482.54	8822.80	8589.86	11559.91	9715.76
G_3 (600 ppm)	8036.61	8735.45	9958.41	8648.10	9638.11	10366.07	9230.46
Mean	7643.52	8531.62	8873.76	8233.16	8815.52	9434.29	

	M	G	M X G
SEm±	213.277	174.140	426.555
CD at 5%	609.087	497.317	1218.174

4.12 Light Transmission Ratio (LTR)

The data pertaining to Light Transmission Ratio (LTR) was computed and statistically analyzed. The results are presented in table 4.12 and fig. 4.12.

The data revealed that growing media and GA_3 significantly reduced the Light Transmission Ratio (LTR) and minimum Light Transmission Ratio

(LTR) 36.65 was recorded under M_5 whereas maximum Light Transmission Ratio (LTR) 55.19 was recorded under $M_{0.}$

As regards the $GA_{3,}$ minimum LTR 37.32 under G_2 was recorded while maximum Light Transmission Ratio (LTR) 57.52 was recorded under $G_{0.}$

The interaction of growing media and gibberellic acid period showed significant effect on Light Transmission Ratio and minimum LTR 31.63 was recorded under G_2M_5 while the maximum Light Transmission Ratio (LTR) 67.71 was recorded under G_0M_0

Table 4.12: Influence of growing media and gibberellic acid on Light transmission ratio (LTR) at interval of 120 and 150 DAS.

Light Transmission Ratio (LTR)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	67.71	63.95	46.15	64.45	62.63	42.65	57.52
G_1 (200ppm)	58.07	48.21	45.29	59.08	46.70	39.63	49.50
G_2 (400 ppm)	43.80	41.39	32.63	40.60	33.28	31.63	37.22
G_3 (600 ppm)	51.18	47.22	40.51	44.28	43.77	32.70	43.28
Mean	55.19	50.19	41.14	52.10	46.59	36.65	

	M	G	M X G
SEm±	1.293	1.056	2.586
CD at 5%	3.692	3.015	7.385

4.13 Energy Interception (Ei)

Energy Interception (Ei) at interval of 120 and 150 days after sowing was computed and presented in table 4.13 and fig.4.13

The data revealed that growing media and GA_3 significantly increased the Energy Interception (Ei). Maximum Energy Interception 0.52 was recorded under M_5 soil + vermicompost + AZO + PSB and minimum Energy Interception 0.34 was recorded under M_0.

As regards the $GA_{3,}$ maximum Energy Interception 0.49 was recorded under G_2 while it was minimum 0.33 under $G_{0.}$

The interaction of growing media and gibberellic acid showed significant effect on Energy Interception. The maximum Energy Interception 0.56 was recorded under G_2M_5 and minimum Energy Interception 0.26 was recorded under G_0M_0

Table 4.13: Influence of growing media and gibberellic acid on Energy Interception (Ei) at interval of 120 and 150 days after sowing

Energy Interception (Ei)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	0.26	0.30	0.42	0.28	0.29	0.46	0.33
G_1 (200ppm)	0.29	0.42	0.43	0.30	0.42	0.51	0.40
G_2 (400 ppm)	0.39	0.49	0.55	0.42	0.55	0.56	0.49
G_3 (600 ppm)	0.40	0.40	0.48	0.44	0.47	0.55	0.46
Mean	0.34	0.40	0.47	0.36	0.43	0.52	

	M	G	M X G
SEm±	0.008	0.007	0.017
CD at 5%	0.024	0.019	0.048

4.14 Fresh weight of shoots (g) at 150 days after sowing.

It is evident from table 4.14 and fig. 4.14 that growing media significantly influenced the fresh weight of shoots and the maximum fresh weight of shoots (4.13 g) was recorded under treatment M_5 which was significantly superior over rest of the treatments and minimum fresh weight of shoots (2.88 g) was noted under treatment $M_{0.}$

The data on gibberellic acid concentrations had significant effect on fresh weight of shoots and maximum fresh weight of shoot (3.90 g) was recorded under G_2 while minimum fresh weight of shoot (3.26 g) recorded at G_0.

The combine effect of growing media and GA_3 had not shown any significant effect on fresh weight of shoots.

Table 4.14: Influence of growing media and gibberellic acid on fresh weight of shoots (g) at 150 days after sowing

Fresh weight of shoots at 150 DAS (g)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	2.34	3.34	3.47	3.52	3.36	3.52	3.26
G_1 (200ppm)	2.82	3.58	3.82	3.55	3.57	3.92	3.54
G_2 (400ppm)	3.12	4.13	4.02	3.59	3.94	4.61	3.90
G_3 (600 ppm)	3.24	3.52	3.68	3.39	3.83	4.45	3.68
Mean	2.88	3.64	3.75	3.51	3.68	4.13	

	M	G	M X G
SEm±	0.127	0.104	0.255
CD at 5%	0.364	0.297	NS

4.15 Dry weight of shoots (g) at 150 days after sowing

It is clear table 4.15 and fig 4.15 that growing media was significantly influenced dry weight of shoots at 150 days after sowing. Maximum dry weight of shoot (0.99 g) was recorded under treatment M_5 which was found to be significantly superior over rest of the treatments and minimum dry weight of shoot (0.63 g) was noted in treatment M_0.

The data on gibberellic acid concentration had significant effect on dry weight accumulation of shoot after 150 days of sowing. Maximum dry weight of shoot 0.93 g was recorded under G_2 which was found to be significantly superior over rest of the treatments and minimum dry weight of shoots (0.73 g) was noted under G_0.

The interaction of growing media and gibberellic acid showed non significant effect on dry matter accumulation in shoots.

Table 4.15: Influence of growing media and gibberellic acid on dry weight of shoots (g) at 150 days after sowing

Dry weight of shoots at 150 DAS (g)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	0.58	0.67	0.78	0.75	0.72	0.85	0.73
G_1 (200ppm)	0.61	0.76	0.87	0.77	0.79	0.97	0.80
G_2 (400 ppm)	0.64	1.07	0.96	0.78	0.98	1.13	0.93
G_3 (600 ppm)	0.67	0.80	0.85	0.74	0.90	1.01	0.83
Mean	0.63	0.83	0.87	0.76	0.85	0.99	

	M	G	M X G
SEm±	0.029	0.024	0.058
CD at 5%	0.082	0.067	NS

4.16 Fresh weight of roots (g) at 150 days after sowing.

A perusal of data presented in table 4.16 and fig. 4.16 indicate that the fresh weight of roots was significantly influenced by growing media. Maximum fresh weight of roots (0.99 g) was recorded under M_5 and found significantly superior over rest of growing media and minimum fresh weight of roots (0.67 g) was noted under $M_{0.}$

As regards to gibberellic acid concentration, it significantly influenced the fresh weight of roots at 150 days after sowing. Maximum fresh weight of 0.92 g was recorded under G_2 which was found significantly superior over rest of the treatments and minimum fresh weight of root (0.74 g) was noted under $G_{0.}$

The combined effect of growing media and gibberellic acid on fresh weight was found non significant.

Table 4.16: Influence of growing media and gibberellic acid on fresh weight of roots (g) at 150 days after sowing

Fresh weight of roots at 150 DAS (g)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	0.64	0.71	0.76	0.71	0.75	0.89	0.74
G_1 (200ppm)	0.65	0.78	0.84	0.77	0.83	0.95	0.80
G_2 (400 ppm)	0.72	0.90	1.10	0.75	0.92	1.15	0.92
G_3 (600 ppm)	0.68	0.81	0.92	0.71	0.82	0.98	0.82
Mean	0.67	0.80	0.90	0.73	0.83	0.99	

	M	G	M X G
SEm±	0.027	0.022	0.054
CD at 5%	0.077	0.063	NS

4.17 Dry weight of roots (g) at 150 days after sowing

It is clear from table 4.17 and fig. 4.17 that dry weight of roots was significantly influenced by the growing media. Maximum dry weight of roots was 0.49 g under treatment M_5 which found significantly superior over rest of growing media while minimum 0.29 g in M_0.

As regards the concentrations of gibberellic acid significantly influenced the dry weight of roots at 150 days after sowing and maximum dry weight of roots (0.44 g) was recorded under G_2 and significantly superior over rest of the treatments whereas minimum dry weight of roots 0.38 g was noted under $G_{0.}$

The interaction of growing media and gibberellic acid did not showed significant effect on fresh weight of root. However, maximum dry weight was recorded under G_2M_5 (0.52 g) and it was minimum under G_0M_0 (0.24 g).

Table 4.17: Influence of growing media and gibberellic acid on dry weight of roots (g) at 150 days after sowing

Dry weight of roots at 150 DAS (g)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	0.24	0.40	0.44	0.33	0.40	0.47	0.38
G_1 (200ppm)	0.28	0.39	0.45	0.35	0.43	0.48	0.40
G_2 (400 ppm)	0.34	0.43	0.51	0.39	0.46	0.52	0.44
G_3 (600 ppm)	0.30	0.41	0.49	0.40	0.42	0.50	0.42
Mean	0.29	0.41	0.47	0.37	0.43	0.49	

	M	G	M X G
SEm±	0.017	0.014	0.034
CD at 5%	0.049	0.040	NS

4.18 Seedling vigour index I (cm)

The data pertaining to seedling vigour index was computed and statistically analyzed. The results are presented in table 4.18 and fig. 4.18.

The data revealed that growing media significantly increased the seedling vigour (cm). Maximum seedling vigour index I (3717.73 cm) was recorded under M_5 and minimum seedling vigour index I (2670.25 cm) was in M_0 at 150 days after seed sowing.

As regards the GA_3, it did not showed significant effect on seedling vigour (cm).

The interaction of growing media and gibberellic acid period did not showed significant effect on seedling vigour index I (cm). However, maximum seedling vigour index I (3900.37 cm) was recorded under G_2M_5.

Table 4.18: Influence of growing media and gibberellic acid on seedling vigour index I (cm)

Seedling vigour index I (cm)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	2546.03	2656.20	3029.60	3030.33	3417.17	3418.07	3016.23
G_1 (200 ppm)	2521.47	3418.60	3615.40	2692.47	3637.00	3691.37	3262.72
G_2 (400 ppm)	2775.27	3481.13	3691.80	3081.47	3302.53	3900.37	3372.09
G_3 (600 ppm)	2838.23	3101.63	3321.40	3040.60	3365.67	3861.10	3254.77
Mean	2670.25	3164.39	3414.55	2961.22	3430.59	3717.73	

	M	G	M X G
SEm±	143.956	117.540	287.912
CD at 5%	411.116	NS	NS

4.19Seedling vigour index II (g).

In case of seedling vigour index II the results are presented in table 4.19 and fig.4.19.

The data revealed that growing media and GA_3 significantly increased the seedling vigour II (g). Data indicates the maximum seedling vigour index II (125.33 g) was noted under M_5 and minimum seedling vigour index II (70.98 g) was recorded under M_0 at 150 days after seed sowing.

Gibberellic acid concentration had significant effect on seedling vigour index II and maximum seedling vigour index II (108.99 g) was recorded under G_2 and it showed superiority over rest of treatments while minimum 89.02 g under $G_{0.}$

The interaction of growing media and gibberellic acid period did not showed significant effect on seedling vigour index II. However, maximum seedling vigour index (136.13 g) was recorded under G_2M_5 and it was minimum (65.93 g) under $G_0M_{0.}$

Table 4.19: Influence of growing media and gibberellic acid on seedling vigour index II (g)

Seedling vigour index II (g)							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	65.93	74.67	89.17	97.20	97.90	109.23	89.02
G_1 (200 ppm)	68.57	99.73	114.73	81.03	105.23	125.17	99.08
G_2 (400 ppm)	71.47	124.47	118.90	93.07	109.93	136.13	108.99
G_3 (600 ppm)	77.93	93.50	101.27	94.33	105.53	130.80	100.56
Mean	70.98	98.09	106.02	91.41	104.65	125.33	

	M	G	M X G
SEm±	4.602	3.758	9.204
CD at 5%	13.143	10.731	NS

4.20 Survival percentage of seedlings after 150 days after sowing.

Survival percentage of seedling at 150 days after sowing was computed and presented in table 4.20 and fig.4.20.

The data revealed that growing media and GA_3 significantly influenced the survival percentage of seedling at 150 DAS. Data indicates that maximum survival percentage (86.01) was recorded under M_5 comprising soil + vermicompost + AZO + PSB and minimum (76.49) under M_0 at 150 days after seed sowing.

Gibberellic acid concentration had significant effect on survival percentage. Maximum survival percentage of 83.75 was recorded under G_1 which was found statistically at par with G_2 whereas minimum percentage of 76.60 was noted under G_0.

The interaction of growing media and gibberellic acid period did not showed significant effect on survival percentage of seedlings.

Table 4.20: influence of growing media and gibberellic acid on survival percentage of seedlings at 150 days after sowing

Survival percentage of seedling at 150 DAS							
Treatment	M_0 (Soil)	M_1 (Soil+FYM)	M_2 (Soil+VC)	M_3 (Soil+BF)	M_4 (Soil+FYM +BF)	M_5 (Soil+VC +BF)	Mean
G_0 (0 ppm)	74.74	76.59	77.38	74.08	77.46	79.37	76.60
G_1 (200 ppm)	78.70	81.02	84.72	81.22	88.43	88.43	83.75
G_2 (400 ppm)	77.78	80.09	87.04	79.50	86.57	87.83	83.13
G_3 (600 ppm)	74.74	78.70	78.71	75.66	79.05	88.43	79.21
Mean	76.49	79.10	81.96	77.61	82.88	86.01	

	M	G	M X G
SEm±	1.709	1.396	3.418
CD at 5%	4.881	3.985	NS

DISCUSSION

In this chapter, an attempt has been made to discuss the findings of the present investigation entitled **"Studies on effect of GA_3 and growing media on seed germinability, growth and survivability of Custard apple (*Annona squamosa* L.)"**. It was conducted to study the individual effect as well as combined effect of different growing media and gibberellic acid concentrations on seed germination, seedling growth and survival of seedling.

The findings are briefly discussed and interpreted in support of the findings of the previous research work pertaining to this topic:

5.1 Days taken to start germination

It is obvious from the present research that days taken to start germination was significantly minimum under growing media M_5 having soil + vermicompost + AZO + PSB. Days taken to start germination were slightly better in the treatments having vermicompost over their respective FYM treatments. It might be due to variation in characteristic of different media. Medium M_5 has relatively high content of humus-like compounds, active micro organisms, enzymes as well as physical and nutritional condition of media which increased the physiological activities of seed and initiate the early germination. The finding is similar to Sahni et al. (2008) and Vasu et al. (2010) who reported that 10 g inoculation of *Azotobacter* showed 100% germination and also reduced the average time taken to start germination.

Gibberellic acid concentration also significantly affected initiation of seed germination. The minimum days taken to initiate the germination was under G_3 (600 ppm) while the maximum days under control (G_0) when seed soaking in water alone. This increment in germination is due to exogenous application of Gibberellic acid which antagonizes the ill effect of inhibitors (Brain and Hemming, 1958) along with increase in cell wall plasticity and better water absorption. The findings are supported by Ratan and Reddy (2004) who reported that the GA_3 600 ppm took minimum time to germinate the seeds of Custard apple.

The interaction of growing media and gibberellic acid showed non significant effect on initiation of seed germination and the minimum days (30.00 days) taken to initiate germination were recorded under the treatment combination G_3M_5 Comprising soil + vermicompost + AZO + PSB + 600 ppm GA_3 as compared to other combinations of growing media and concentration of GA_3. It is probably due to the synergistic combination of both the factors. The finding was supported by Jain and Parmar (1993).

5.2 Days taken to 50% germination

The present research reveals that the growing media and GA_3 showed significant effect on germination. Significantly the minimum days taken to 50 % germination (46.83 days) under the growing media M_5 and maximum (51.42 days) taken to 50 % germination under the media M_0.

Initiation of seed germination was significantly affected by gibberellic acid. The minimum days (47.17 days) taken to 50% germination under G_3 (600 ppm) while the maximum days (51.06 days) taken to under G_0. The findings are supported by Ynoue et al. (1999) who reported that the GA_3 150 ppm reduced the average time of germination on kiwi fruit seeds.

The interaction effect of growing media and gibberellic acid found to be non significant on 50% seed germination, however, the minimum days (44.33 days) taken to 50% germination were noted under the treatment combination of G_3M_5. It might be due to synergistic effect of both factor help to early initiation of seed germination. The finding was supported by Jain and Parmar (1993).

5.3 Percentage of germination in each treatment

In the present study, significantly the highest germination percentage (77.50%) was obtained under the media M_5 comprising soil + vermicompost + AZO + PSB. This finding is supported by Sinish et al. (2005) who reported that combined inoculation of AZO, PSB and AMF in the potting mixture induced better germination percentage.

Gibberellic acid concentration showed significant effect on percentage of germination at 60 DAS. The maximum germination percentage of 73.89 was recorded under G_3 (600 ppm GA) and the minimum germination (59.44%) was recorded under G_0. It might be due to GA_3 which accelerate the activity of specific enzymes such as α-amylase, which have brought an increase in availability of starch assimilation resulting an early germination.

Interaction effect of growing media and gibberellic acid did not show significant effect on seed germination percentage whereas maximum germination percentage (86.67%) was noted under the combination of growing media and gibberellic acid G_3M_5 (soil + vermicompost + AZO + PSB + 600 ppm). It may be due to synergistic effect of both factors.

5.4 Height of shoot (cm)

Growing media had showed significant effect on maximum height of shoots (i.e. 4.09, 8.33, 12.06 and 17.68 cm), respectively at 60, 90, 120 and 150 DAS under the treatment $M_{5.}$ The results are in conformity with the results of Shristava and Bhel (2002), Sinish et al. (2005) and Kumar and Sharma (2007). Growing media comprising soil + vermicompost + AZO + PSB (M_5) creates sufficient porous space to let the excess water drain away and pertaining adequate aeration for the better seedling growth, it may also be helped to increase physiological activities of seed which is essential for cell division, cell elongation resulting more nutrients absorption from the soil media. The results obtained were closely related with the finding of Kumar and Sharma (2007) in *Jatropa curcus.*

As regards the gibberellic acid concentration, maximum height of shoots (3.97, 7.65, 11.83 and 17.60 cm) was recorded under G_2 (400 ppm) at 60, 90, 120 and 150 DAS, respectively. Basically, plant height is a genetically controlled character but several studies have indicated that plant height can be increased by application of synthetic plant growth regulators. However, in the present investigation a significant difference in plant height was noticed by the application of different concentration of GA_3. It might be due to GA_3 effect on elongation of internodes, as GA_3 is known to enhance cell elongation (Krishnamoorthy and Sandooja, 1981). Increase in plant height has also been reported by Ratan and Reddy (2004).

Interaction effect of growing media and gibberellic acid shows non significant and maximum height of shoot at successive growth period was observed under treatment combination G_2M_5 i.e. 4.61, 8.89, 12.97 and 18.63 cm at 60, 90, 120 and 150 days after sowing, respectively whereas minimum height was recorded under $G_0M_{0.}$

5.5 Number of leaves per seedling

As regards the number of leaves per seedling, the maximum mean number of leaves per seedling was observed under treatment M_5 (4.78, 9.05, 16.10 and 21.32) at 60, 90, 120 and 150 days after sowing, respectively. The improvement in vegetative character might be due to the ability of *Azotobacter* to fix atmospheric nitrogen which may share its role in increasing the percentage of mineral nutrient in soil. In addition, it increases the surface area of root hairs followed by increase in average absorption of mineral nutrients and ready vermicompost relatively contains more exchangeable plant nutrient especially N_2 (responsible for vegetative growth) than FYM. The results of Kumar and Sharma (2007) in *Jatropa curcus,* Krishna et al. (2008) and Peng et al. (2013) have close conformity with present findings.

As regards the gibberellic acid concentration, GA_3 showed significant effect on number of leaves and maximum number of leaves per seedling (4.71, 9.00, 16.10 and 21.06) was recorded under $G_{2.}$ The production of more number of leaves in GA_3 treatments may be due to the vigorous growth and more number of branches induced by GA_3 facilitates better harvest of sunshine by the plants to produce more number of leaves. Similar findings were also reported by Venkata Rao and Reddy (2005) in mango.

The interaction effect of growing media and gibberellic acid showed non significant effect at 60, 90, 120 and 150 days after sowing. However, maximum number of leaves per seedling was recorded in G_2M_5 (5.33, 9.73, 16.93 and 22.07 at 60, 90, 120 and 150 days after sowing, respectively). It may be due to synergistic effect of both factors.

5.6 Girth of stem (mm)

Significantly maximum girth of stem (2.71, 3.13, 3.53 and 4.16 mm) was recorded at 60, 90, 120 and 150 DAS in M_4 (soil + FYM + AZO + PSB) whereas minimum girth under treatment $M_{0.}$ Girth of stem was slightly better in the treatments having FYM over their respective vermicompost treatments. The probable reason may be that the medium M_4 has high anchorage or support to the plant, water retention capacity, allows oxygen diffusion to the roots and permits gaseous exchange between roots and the atmosphere outside root substrate. Similar findings were also reported by Taiwo (2004) and Parasana et al. (2012).

As regards to GA_3, the significantly maximum girth of stem (2.57, 2.98, 3.29 and 3.89 mm) was recorded under G_1 and minimum girth of stem was recorded under G_0. The increase in seedling girth by application of gibberellic acid was also reported by Venkata Rao and Reddy (2005) in mango.

5.7 Length of seedling (cm)

The significantly maximum height of seedling (43.81cm) at 150 DAS was recorded under the treatment M_5 comprising soil + vermicompost + AZO + PSB. The present investigations are in conformity with the results of Shristava and Bhel (2002) Sinish et al. (2005), Sahni et al. (2008). Probable reasons may be that the media M_5 creates sufficient porous space to let the excess water drain away and pertaining adequate aeration for the better seedling growth. The excellent plant growth in vermicompost was possibly due to some plant growth promoters in worm casts which increase physiological activities of seed, essential for cell division and cell enlargement. Krishnamoothy and Vajranrabhaian (1986) who reported that some plant growth promoters such as cytokinins and auxins are present in worm cast. It also contains rich source of nutrient than FYM. The results obtained were closely related with the finding of Kumar and Sharma (2007) in *Jatropa curcus.*

As regard to GA_3, a significant increase in height of seedlings (42.13 cm) at 150 days after sowing was observed. Gibberellins are well known for inter-nodal cell elongation, thereby leading to increase in seedling length. These findings are supported by Ratan and Reddy (2004).

5.8 Root length (cm)

Significantly maximum root length of 26.13 cm was obtained under treatment M_5 at 150 days after sowing whereas the minimum root length was obtained under treatment M_0 (18.76 cm). It might be due to media having soil + vermicompost + AZO + PSB that create sufficient porous space to permit adequate aeration, water holding capacity, improved soil texture and structure, maintained soil temperature and improved soil health and nutrient status of medium for better root growth. Application of vermicompost enhances the activity of some microbial populations which increase the level of N. This was due to higher N fixer in experimental plot than control. The findings are agreement with the findings of Pathak et al. (2009).

As regards the $GA_{3,}$ Maximum root length of 24.52 cm was recorded under G_2 which was significantly superior over rest of the treatments. Exogenous application of GA_3 induced the activity of gluconeogenic enzymes during early stages of seed germination and this could be the reason for improved germination and vigour characteristics that is reflected in terms of increase in root length. Similar findings were also reported by Wagh et al. (1998).

5.9 Number of roots per seedling

At 150 days after sowing, the maximum number of roots per seedling (50.37) was observed under M_5 whereas treatments M_0 was recorded minimum. The excellent plant growth in vermicompost was possibly due to some plant growth promoters in worm casts. This improvement of vegetative growth might be due to the role of vermicompost in improving the soil's physiochemical structure, also promotes biological properties of soil, increasing soil ventilation by increasing the porosity and a big source of nutrient elements especially nitrogen and phosphorus. The results of Chopde et al. (1999) are close conformity with present findings.

The effect of GA_3 had significant effect on number of roots/seedling. Significantly maximum number of roots (48.90) was noted under $G_{2.}$ Vigrous root growth due to GA_3 might have resulted in more production of photosynthates and their translocation through phloem to the root zone, which might be responsible for improving the root growth. Similar findings were reported by Wagh et al. (1998).

5.10 Leaf Area Index (LAI) and Leaf Area Duration (LAD)

Growing media significantly influenced the Leaf Area Index (LAI) and Leaf Area Duration (LAD). The Leaf Area Index (1.08) and Leaf Area Duration (9434.29 cm^2.days) was higher under treatment M_5 comprising soil + vermicompost + AZO + PSB at 150 days after sowing. The growing media had higher magnitude for LAD over remaining treatments which was attributed to increase in LA and LAI influenced by treatment. It might be due to role of nitrogen enhancing persistence and longevity of LA, which is a key factor in terms of photosynthesis productivity of the plants, that assimilates higher amount of photosynthates production and if the mobilization is proper to the sink, it will enhance the economic productivity. The findings are supported by Peng et al. (2013).

The effect of GA_3 had significant effect on Leaf Area Index and Leaf Area Duration Significantly maximum Leaf Area Index (1.11) and Leaf Area Duration (9715.76) was noted under 400 ppm (G_2). This was higher ascribed to higher magnitude increases in parameter associated with the LA. The finding was supported by Munde and Gajbhiye (2010).

The treatment combination G_2M_5 was recorded maximum Leaf Area Index (1.32) and Leaf Area Duration (11559.9). However, minimum Leaf Area Index and Leaf Area Duration was noted under treatment combination $G_0M_{0.}$ The increase of Leaf Area Index due to rich source of nutrient present in media comprising soil + vermicompost + AZO + PSB with 400 ppm $GA_{3.}$

5.11 Light Transmission Ratio (LTR)

In the present study, significantly maximum Light Transmission Ratio 55.19 at interval of 120 and 150 days after sowing was computed under M_0 media and the minimum Light Transmission Ratio 36.65 was recorded under $M_{5.}$ The findings of Munde and Gajbhiye (2010) are close conformity with present findings.

The maximum Light Transmission Ratio (57.52) was recorded under G_0 and minimum (37.22) was recorded under treatment $G_{2.}$ The findings are supported by Munde and Gajbhiye (2010).

The interaction of growing media and GA_3 showed significant effect on Light Transmission Ratio. The significantly maximum Light Transmission Ratio (67.71) was obtained under treatment combination of G_0M_0 and minimum Light Transmission Ratio (31.63) was obtained under treatment combination of $G_2M_{5.}$

The results were significantly correlated with the LAI which exhibited the lowest and highest magnitude for the above treatments. The low light transmission through the crop canopy is reflected in higher value of LAI, more the canopy size more light interception and less transmission through the canopies (Thakur and Kaur, 2001).

5.12 Energy Interception (EI)

In the present study, all the treatment growing media, gibberellic acid concentration and their combination effect showed significant effect on the experiment concern**.** The probable reason may be that Interception of light by a crop canopy is strongly related to total leaf area. A crop will thus intercept more PAR and hence grow faster if it develops leaf area rapidly. Similar findings were reported by Maddonni and Otegui (1996).

5.13 Fresh and dry weight of shoot and roots (g)

The maximum fresh and dry weight (4.13 g and 0.99 g) of shoots and roots (0.99 g and 0.49 g) respectively were obtained at 150 days after sowing under treatment M_5 comprising soil + vermicompost + AZO + PSB. Probable reasons may be that the media M_5 contains rich source of nutrient. The excellent plant growth in vermicompost was possibly due to some plant growth promoters in worm casts which increase physiological activities, essential for cell division, cell enlargement or both. The findings are supported by Roy and Shrivastava (2011) and Joshi et al. (2015).

Gibberellic acid had shown significant effect on fresh and dry weight accumulation of shoot and root. Maximum fresh and dry weight of shoots (3.90 g and 0.93 g) and roots (0.92 g and 0.44 g) observed under 400 ppm concentration (G_2) at 150 DAS. Increase in fresh weight of roots is due to the influence of GA_3 on different plant parts, which could be due to its effect in stimulating cell division, cell elongation, auxin metabolism, cell wall plasticity and permeability of cell membrane leading to enhanced growth. Increase in the dry weight of different plant parts due to improved mobilization of nutrients due to the application of GA_3, which promotes plant growth and development. The findings are agreement with the findings of Rahemi and Baninasab (2000).

5.14 Seedling vigour index I (cm)

In the present study, significantly maximum seedling vigour index at 150 days after sowing (3717.73 cm) was computed under growing media comprising soil + vermicompost + AZO + PSB (M_5) and minimum (2670.25 cm) under $M_{0.}$ The findings are supported by Krishna et al*.* (2008). All the treatments promoted significantly higher vigour of seedlings, when compared to control. Particularly, treatment with vermicompost recorded highest vigour index-I and vigour index-II. The probable reason of highest seedling vigour in vermicompost can be that it has relatively high content of humus-like compounds, active micro organisms, enzymes as well as physical and nutritional condition which increased the physiological activities of plant. The findings are supported by Bhardwaj (2014).

As regards the GA_3 as well as interaction of media and $GA_{3,}$ did not showed significant effect on seedling vigour (cm).

5.15 Seedling vigour index II (g)

In the present study, significantly maximum seedling vigour index II (125.33 g) at 150 days after sowing was computed under M_5 followed by M_2 (106.02 g) and minimum seedling vigour index II (70.98 g) was recorded under M_0. The probable reason is same to seedling vigour index I. The findings are supported by Bhardwaj (2014).

The maximum seedling vigour index II (108.99 g) was recorded under G_2 and it was superior over rest of treatments while minimum seedling vigour index II (89.02 g) was recorded under $G_{0.}$ The seedling vigor significantly differed due to invigouration of seeds. The highest seedling vigour in GA_3 was attributed to enlarged embryos, higher rate of metabolic activity and respiration, better utilization and mobilization of metabolites to growth points and higher activity of enzymes. Enzymatic and hormonal mechanism stimulate metabolic process such as sugar mobilization, protein hydrolysis, oxidation etc. (Earlplus and Lambeth, 1974), which leads to increase in root length, shoot length and seedling dry weight, in turn increase in seedling vigour. The present results are in conformity with the results of Gurung et al. (2014).

5.16 Survival percentage of seedlings

In the present study, growing media and GA_3 significantly influenced the survival percentage of seedling at 150 DAS. Maximum survival percentage (86.01) was recorded under growing media M_5 comprising soil + vermicompost + AZO + PSB and minimum (76.49) under M_1 at 150 days after seed sowing. These findings are supported by Parasana et al. (2012).

Gibberellic acid concentration had significant effect on survival percentage. Maximum survival percentage (83.75) was recorded under G_1 which was at par with G_2 while it was minimum (76.00) under $G_{0.}$

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

The present investigation entitled "Studies on effect of GA_3 and growing media on seed germinability, growth and survivability of Custard apple (*Annona squamosa* L.)" was conducted at Fruit Research Station, Imalia, Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.) during December 2014 to April 2015. The experimental material for the present investigation comprised of twenty four treatment combination of six growing media viz. M_0 (Soil), M_1 (Soil + FYM), M_2 (Soil + Vermicompost), M_3 (Soil + Azotobacter + PSB), M_4 (Soil + FYM + Azotobacter + PSB), M_5 (Soil + Vermicompost + Azotobacter + PSB) and four concentration of gibberellic acid viz. G_0 (0 ppm), G_1 (200 ppm), G_2 (400 ppm), G_3 (600 ppm).The experiment was laid out in Factorial Randomized Block Design with three replication with the following objectives:

1. To study the effect of GA_3 on germination, growth and survival of seedling.
2. To find out the effect of growing media on germination, growth and survival of seedling.
3. To find out the interaction effect of GA_3 and growing media on seed germination, growth and survival of seedling.

Observations were recorded on the basis of five random competitive plants selected from each treatment separately for morphological and physiological parameters as per standard procedure. The important findings of the investigation are summarized below.

(a) Growing media

All germination parameters like days taken to start germination (31.50), days taken to 50% germination (46.83), percent of germination in each treatment at 60 DAS (77.50) and almost growth parameters like height of shoots (4.09, 8.33, 12.06 and 17.68 cm) at 60, 90, 120 and 150 DAS, respectively, number of leaves per seedling (4.78, 9.05, 16.10 and 21.32) at 60, 90, 120 and 150 DAS, respectively, Leaf Area Index (1.08), Leaf Area Duration (9434.29 cm^2.days), Light transmission ratio (36.65), Energy Interception (0.52), height of seedling (43.81 cm), root length (26.13 cm), number of roots/seedling (50.37), fresh weight of shoots (4.13 g), dry weight of shoots (0.99 g), fresh weight of roots (0.99 g), dry weight of roots (0.49 g), Seedling vigour index I (3717.73 cm), Seedling vigour index II (125.33 g) were found significantly superior under M_5 growing media comprising soil + vermicompost + AZO + PSB followed by M_2 (soil + vermicompost), M_4 (soil + FYM + AZO + PSB), M_1 (soil + FYM), M_3 (soil + AZO + PSB), M_0 (only soil) at 60, 90, 120 and 150 days after sowing, respectively. But mean value of girth of stem (2.71, 3.13, 3.53 and 4.16 mm) at 60, 90, 120 and 150 DAS, respectively, was observed slightly better in the treatments having FYM and bio-fertilizers (M_4) closely followed by M_1 (soil + FYM) and M_5 (Soil + Vermicompost + Azotobacter + PSB. Survival of seedling (86.01%) was highest in media M_5 which was at par with $M_{4.}$

(b) Concentration of gibberellic acid (GA_3)

As regards the $GA_{3,}$ the concentration of 600 ppm (G_3) was observed superior in germination point of view like days taken to start germination (32.61), days taken to 50% germination (47.17), percent of germination in each treatment (73.89) and found statistically at par with other concentration of GA_3 except G_0 (water soaked seed). But almost growth parameters like height of shoots (3.97, 7.65, 11.83 and 17.60 cm) at 60, 90, 120 and 150 DAS, respectively, number of leaves per seedling (4.71, 9.00, 16.10 and 21.06 per seedling) at 60, 90, 120 and 150 DAS, respectively, Leaf Area Index (1.11), Leaf Area Duration (9715.76 cm^2.day), Light transmission ratio (37.22), Energy Interception (0.49), height of seedling (42.13 cm), root length (24.52 cm), number of roots/seedling (48.90), fresh weight of shoots (3.90 g), dry weight of shoots (0.93 g), fresh weight of roots (0.92 g), dry weight of roots (0.44 g), seedling vigour index II (108.99 g) at different stages after sowing was observed significantly superior under G_2 (400 ppm GA_3) but in respect to Seedling vigour index I (3372.09 cm) at 150 days after sowing, the concentration of 400 ppm (G_2) showed non significant superiority over rest of the concentrations of gibberellic acid. Only girth of stems (2.57, 2.98, 3.29 and 3.89 mm) at 60, 90, 120 and 150 DAS, respectively and survival percentage of seedlings (83.75) were slightly better in the concentration of 200 ppm (G_1) than 400 ppm.

(c) Interaction of different growing media and GA_3

As regards the interactions, all germination parameters, survival parameter and almost growth parameters like height of shoots, number of leaves per seedling, girth of stem, height of seedling, root length, number of roots/seedling, fresh weight of shoots, dry weight of shoots, fresh weight of roots, dry weight of roots, Seedling vigour index I (cm), Seedling vigour index II (g) were found not significant. However, G_2M_5 treatment combination [seed soaked in 400 ppm GA and sown in soil + vermicompost + AZO + PSB] recorded superior and G_0M_0 combination (control) was found inferior in respect to survival and most of growth parameters. But as regards the girth of stem G_1M_4 was found superior. In some growth parameters like Leaf Area Index (LAI), Leaf Area Duration (LAD), Light transmission ratio (LTR) and Energy Interception (Ei), interaction was found significant. In respect to germination, G_3M_5 treatment combination [seeds soaked in 600 ppm GA concentration and sown in soil + vermicompost + AZO + PSB] showed superiority over rest of the treatment combinations whereas minimum was observed in control (G_0M_0).

6.2 Conclusion

As regards the $GA_{3,}$ increase in germination percentage and decrease in number of days taken to initiation of germination was noticed in seeds due to application of GA_3 600 ppm. In relation to growth and survival of seedling, 400 ppm concentration of GA was best and significantly increased the growth of Custard apple seedlings.

From present investigation, it was concluded that the growing media M_5 (soil + vermicompost + AZO + PSB) found superior over rest of the media, which significantly increased the germination, growth and survival of Custard apple.

The interaction effect of growing media and GA_3 showed non significant effect on germination, most of growth and survival parameters of custard apple. It was concluded that G_2M_5 combination [seed soaked in 400 ppm GA and sown in soil + vermicompost + AZO + PSB] was the best combination with respect to growth and survival of custard seedling and in germination point of view, G_3M_5 treatment combination [seed soaked in 600 ppm GA concentration and sown in soil + vermicompost + AZO + PSB] was the best.

6.3 Suggestion for further work

On the basis of results, the following suggestions are recommended for rapidly abundant seed germination, growth and survival of custard apple seedlings.

1. Further research work must be needed to confirm the findings of the present investigation in Jabalpur condition.
2. The same experiment should be conducted in other agro-climatic conditions.
3. Different ratio of soil, FYM and vermicompost should be included in further studies.
4. Different concentrations of GA and its soaking time should be included in further studies.

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APPENDICES

Analysis of variance table showing the mean sum of square for various parameters under different treatments

Appendix–1. ANOVA for height of shoots (cm) at 60, 90, 120, 150 days after sowing

Source of variance	d.f.	Mean sum of squares			
		60 DAS	90 DAS	120 DAS	150 DAS
G	3	2.642	1.894	4.290	8.450
M	5	2.645	8.021	5.193	9.157
M × G	15	0.081	0.266	0.182	0.878
Error	46	0.057	0.196	0.109	0.585
Total	71				

At 5% level of significance

Appendix -2. ANOVA for Numbers of leaves/seedling at 60, 90, 120 and 150 days after sowing

Source of variance	d.f.	Mean sum of squares			
		60 DAS	90 DAS	120 DAS	150 DAS
G	3	6.208	6.925	8.171	7.039
M	5	3.915	4.287	4.032	6.040
M × G	15	0.446	0.384	0.547	0.447
Error	46	0.252	0.247	0.301	0.436
Total	71				

At 5% level of significance

Appendix-3. ANOVA for girth of stem (mm) at 60, 90, 120 and 150 days after sowing

Source of variance	d.f.	Mean sum of squares			
		60 DAS	90 DAS	120 DAS	150 DAS
G	3	1.216	0.470	0.493	0.532
M	5	1.636	1.105	0.982	1.088
M × G	15	0.259	0.104	0.142	0.283
Error	46	0.164	0.154	0.163	0.184
Total	71				

At 5% level of significance

Appendix-4. ANOVA for days taken to start germination, 50% germination, percentage of germination.

Source of variance	d.f.	Mean sum of squares		
		Days taken to start germination	50% germination	Percentage of germination at 60 DAS
G	3	27.444	52.204	750.000
M	5	32.256	32.033	472.222
M × G	15	0.900	2.048	52.222
Error	46	4.981	6.487	122.041
Total	71			

At 5% level of significance

Appendix-5. ANOVA for height of seedling, root length, number of roots/ seedling, fresh and dry weight of shoots at 150 days after sowing.

Source of variance	d.f.	Mean sum of squares				
		Height of seedling (cm) at 150 DAS	Root length (cm) at 150 DAS	Number of roots/seedling at 150 DAS	Fresh weight of shoots (g) at 150 DAS	Dry weight of shoots (g) at 150 DAS
G	3	69.780	29..877	57.848	1.315	0.208
M	5	168.811	99.785	138.011	1.990	0.211
M × G	15	1.598	0.519	2.469	0.131	0.024
Error	46	3.987	3.375	9.009	0.195	0.014
Total	71					

At 5% level of significance

Appendix-6. ANOVA for fresh and dry weight of roots, seedling vigour index I, seedling vigour index II, survival percentage of seedling at 150 days after sowing.

Source of variance	d.f.	Mean sum of squares				
		Fresh weight of roots (g) at 150 DAS	Dry weight of roots (g) at 150 DAS	Seedling vigour index I (cm) at 150 DAS	Seedling vigour index II (g) at 150 DAS	Survival percentage of seedling at 150 DAS
G	3	0.103	0.013	405024.215	1207.861	205.505
M	5	0.159	0.063	1684660.756	3881.828	154.486
M × G	15	0.008	0.001	135712.905	264.292	12.751
Error	46	0.009	0.004	248680.162	254.160	35.054
Total	71					

At 5% level of significance

Appendix-7. ANOVA for Leaf Area Index, Light Transmission Ratio, Leaf Area Duration and Energy Interception.

Source of variance	d.f.	Mean sum of squares			
		LAI	LTR	LAD	Ei
G	3	0.272	1410.477	20768112.746	0.091
M	5	0.059	587.624	4489386.319	0.060
M × G	15	0.020	43.623	1525271.427	0.004
Error	46	0.007	20.059	545846.799	0.001
Total	71				

At 5% level of significance

CURRICULUM VITAE

The author of this thesis **Mr. Sumit Jain** S/o Shri Paras Chand Jain was born 12th January, 1989 at Sawai madhopur (Rajasthan). He passed the High School Examination in the year 2005 with 78.17 percent marks from Vishwa Karma Aadarsh Vidhyapeeth and Higher Secondary Examination in the year 2007 acquiring 73.08 percent marks from Govt. Sr. Sec. School, Sawai madhopur. He joined the College of Agriculture, Jabalpur (M.P.) in the year 2009 and successfully completed the degree of B.Sc. (Ag.) from Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during the year June, 2013 with 7.34 OGPA out of 10.00 point scale.

In the year 2013, he admitted in same college for M.Sc. (Agri.) Horticulture degree programme in Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur for specialization in Fruit Science. He has successfully completed all the course requirements for master's degree with First Division.

For the fulfillment of the master's degree programme, he was allotted a research problem entitled **"Studies on effect of GA_3 and growing media on seed germinability, growth and survivability of Custard apple (*Annona squamosa* L.)."** This is duly completed by him and presented in the form of this thesis.

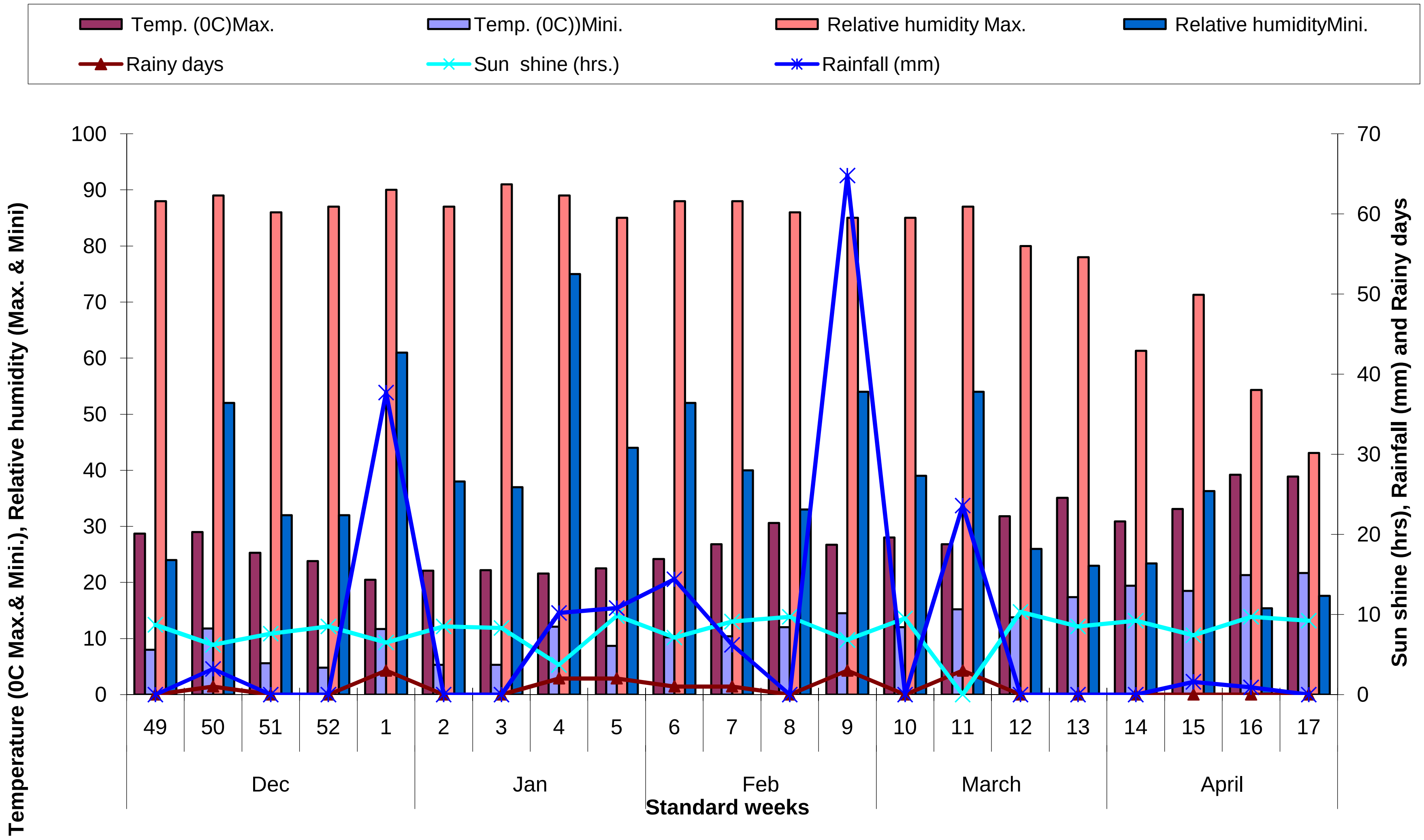

Fig. 3.1: Meteorological data during the period of investigation (December 2014- April 2015)

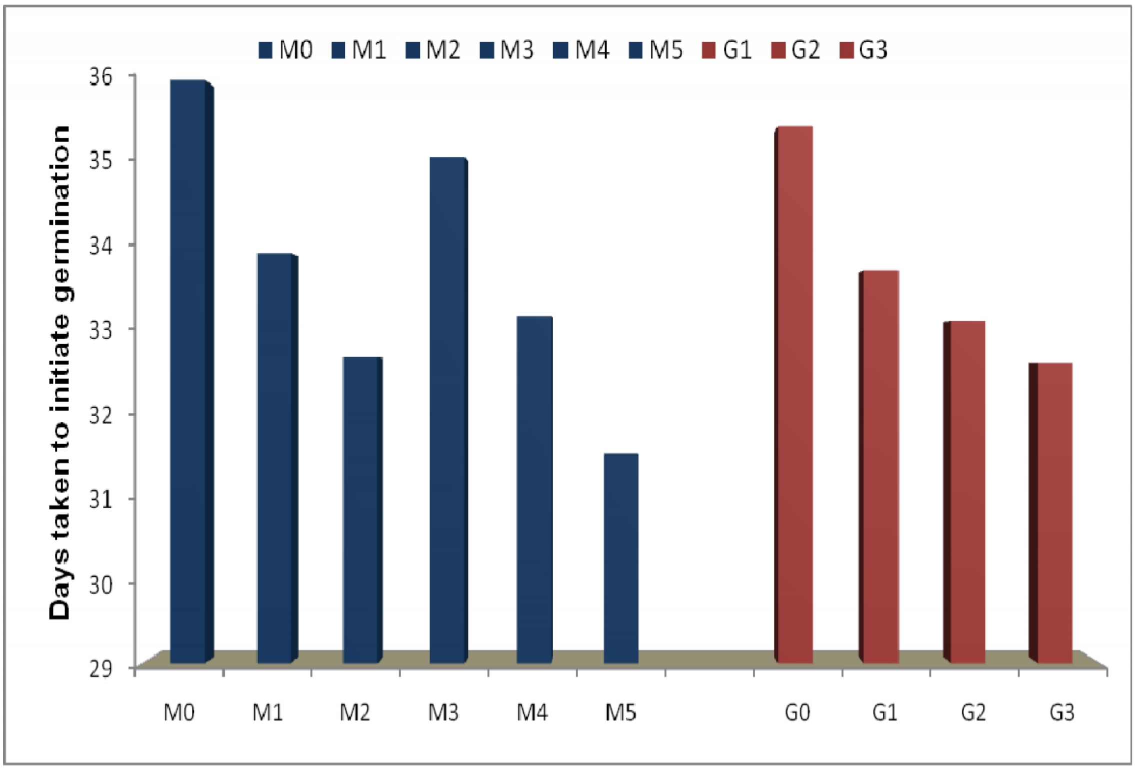

Fig. 4.1: Influence of growing media and gibberellic acid on days taken to initiate germination

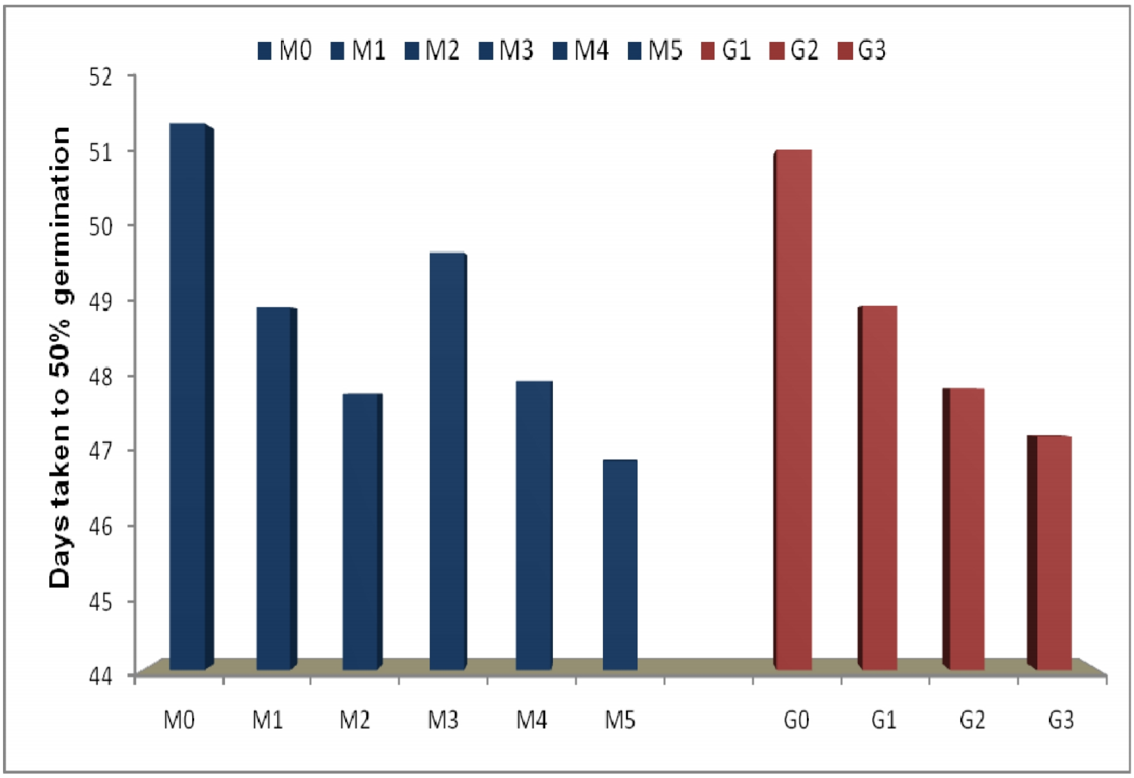

Fig. 4.2: Influence of growing media and gibberellic acid on days taken to 50% germination

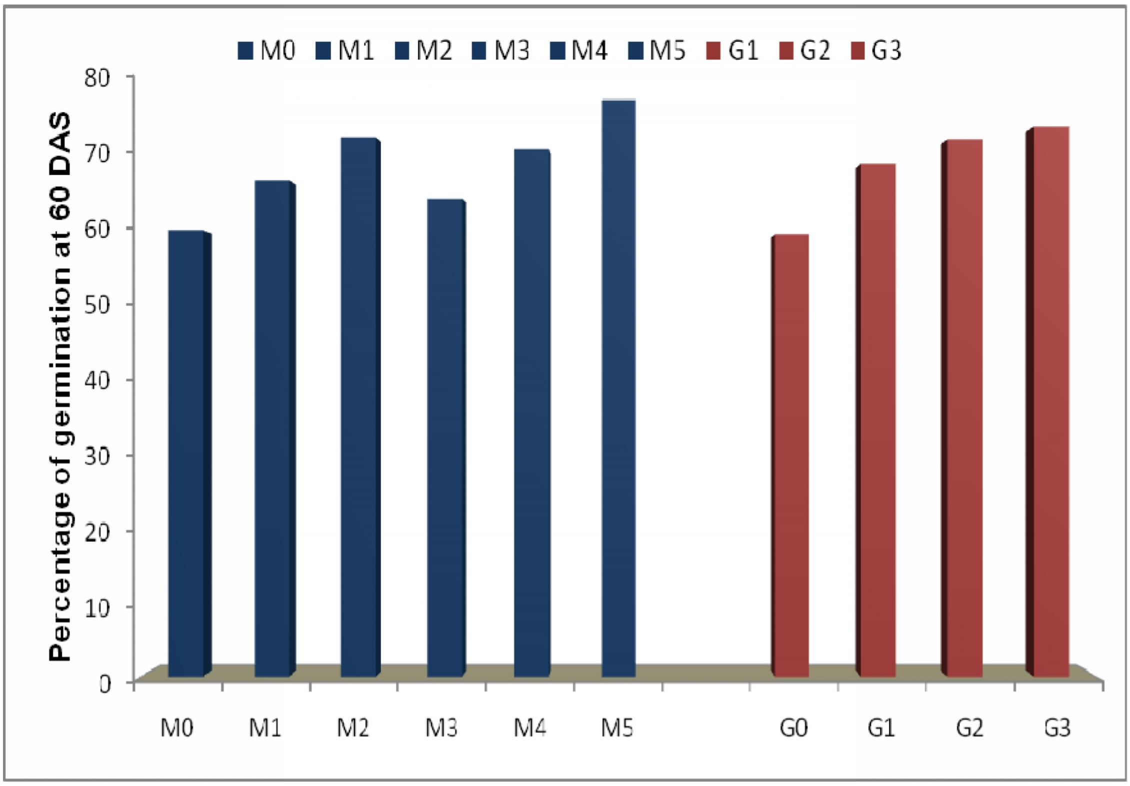

Fig. 4.3: Influence of growing media and gibberellic acid on percentage of germination at 60 DAS

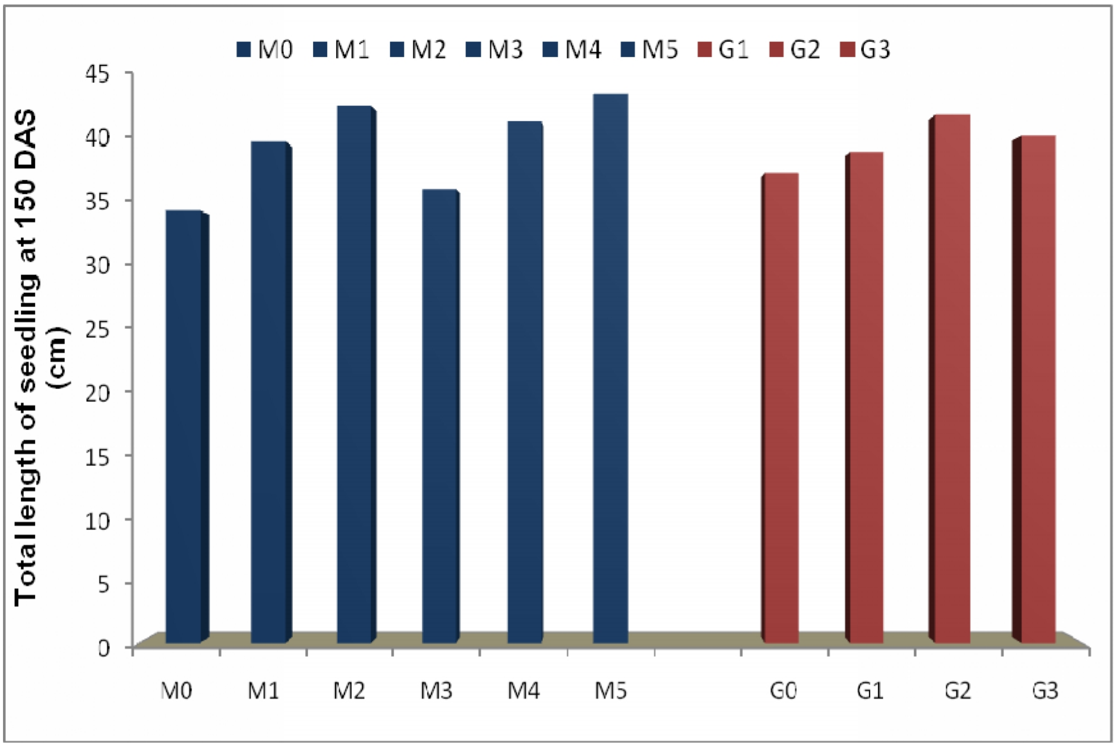

Fig. 4.7: Influence of growing media and gibberellic acid on height of seedling at 150 DAS

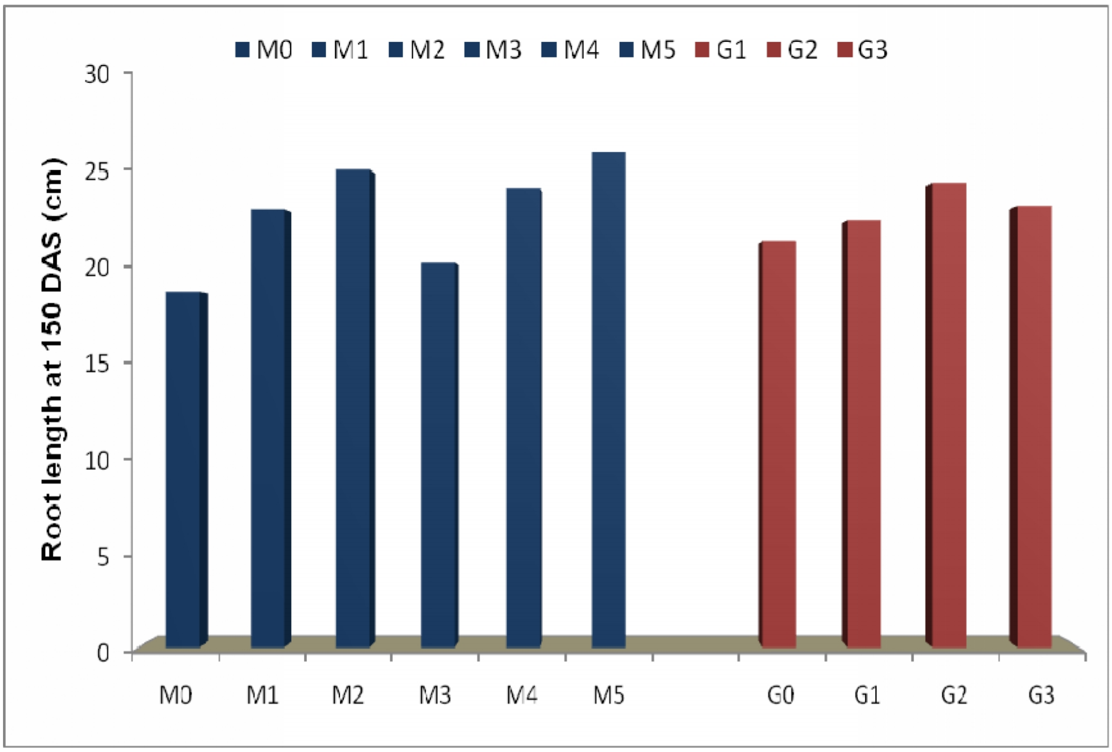

Fig. 4.8: Influence of growing media and gibberellic acid on root length at 150 DAS

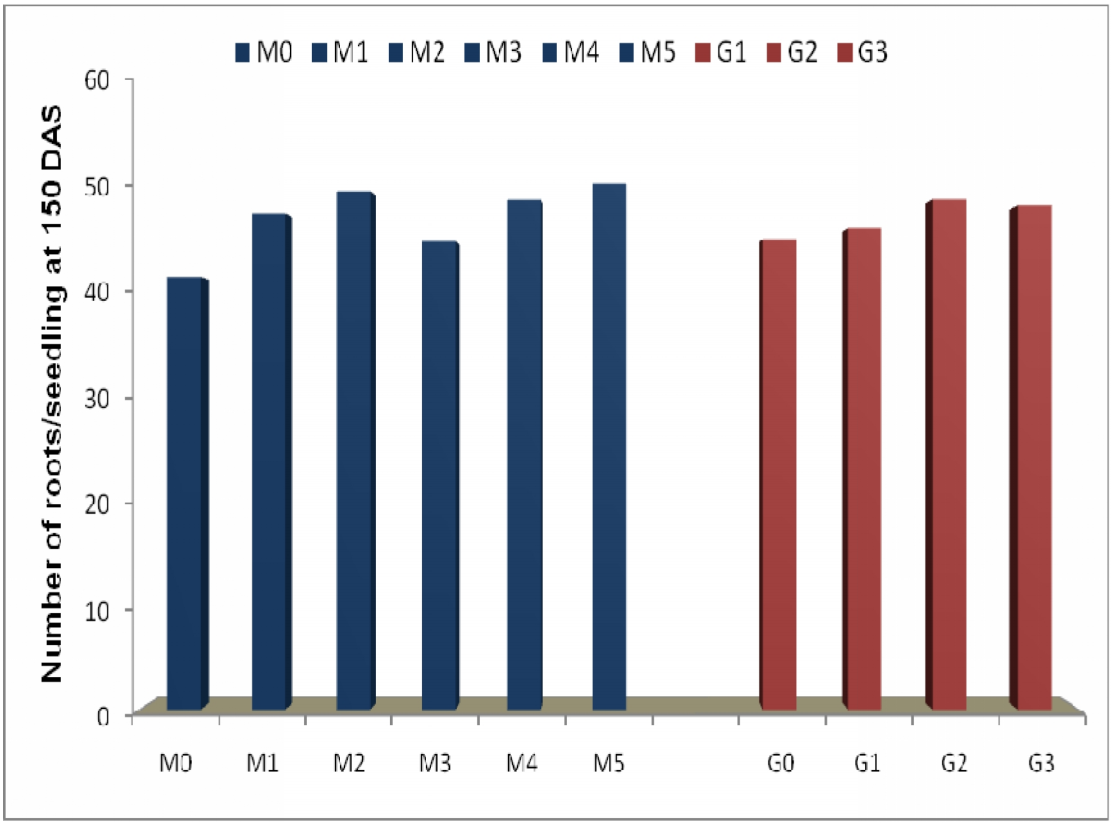

Fig. 4.9: Influence of growing media and gibberellic acid on number of roots/seedling at 150 DAS

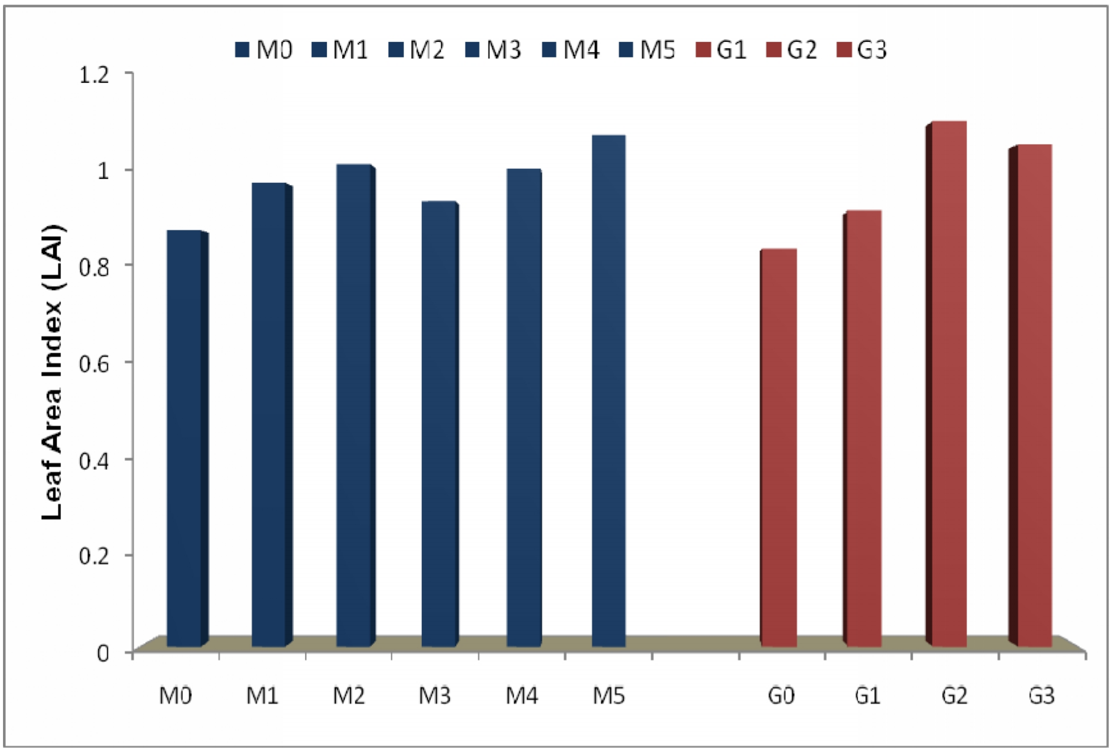

Fig. 4.10 : Influence of growing media and gibberellic acid on Leaf Area Index (LAI)

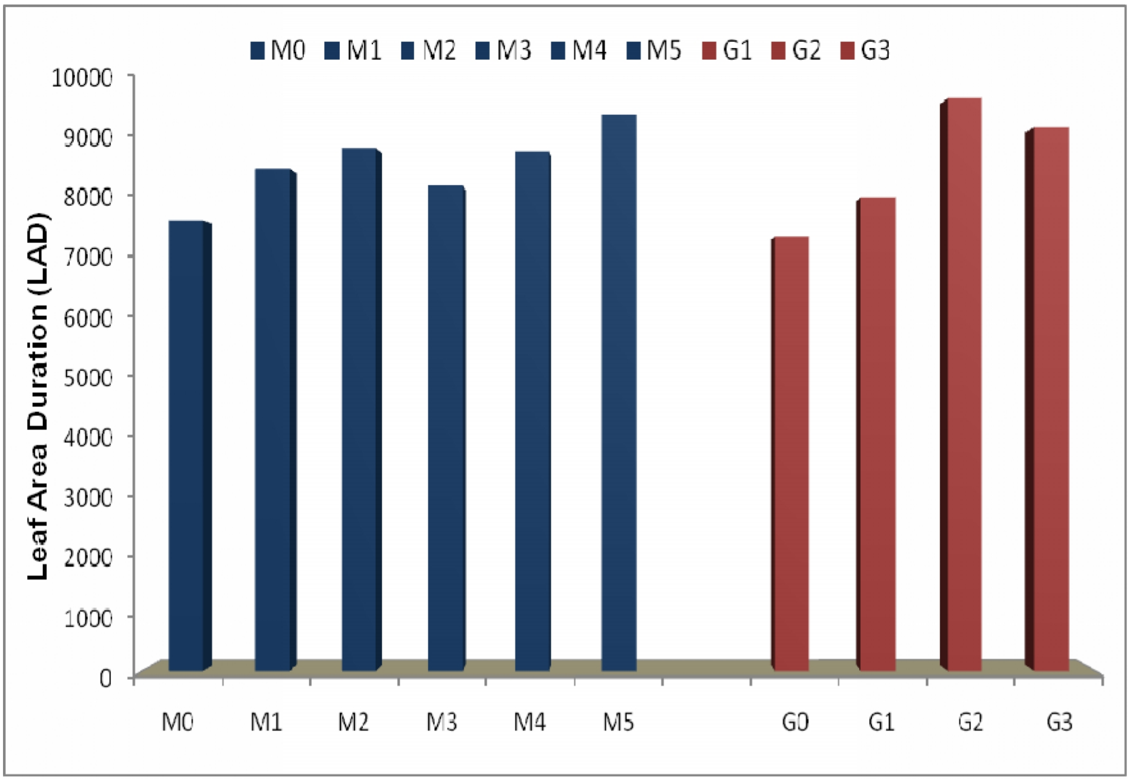

Fig. 4.11 : Influence of growing media and gibberellic acid on Leaf Area Duration (LAD)

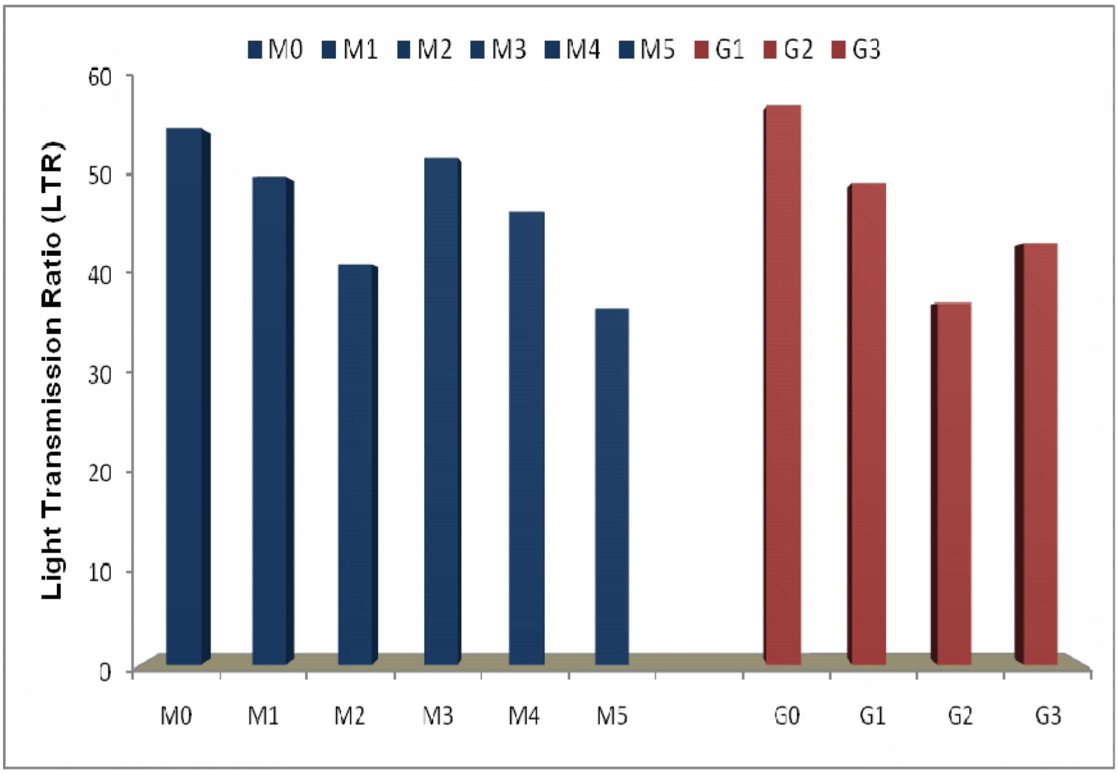

Fig. 4.12 : Influence of growing media and gibberellic acid on Light Transmission Ratio (LTR)

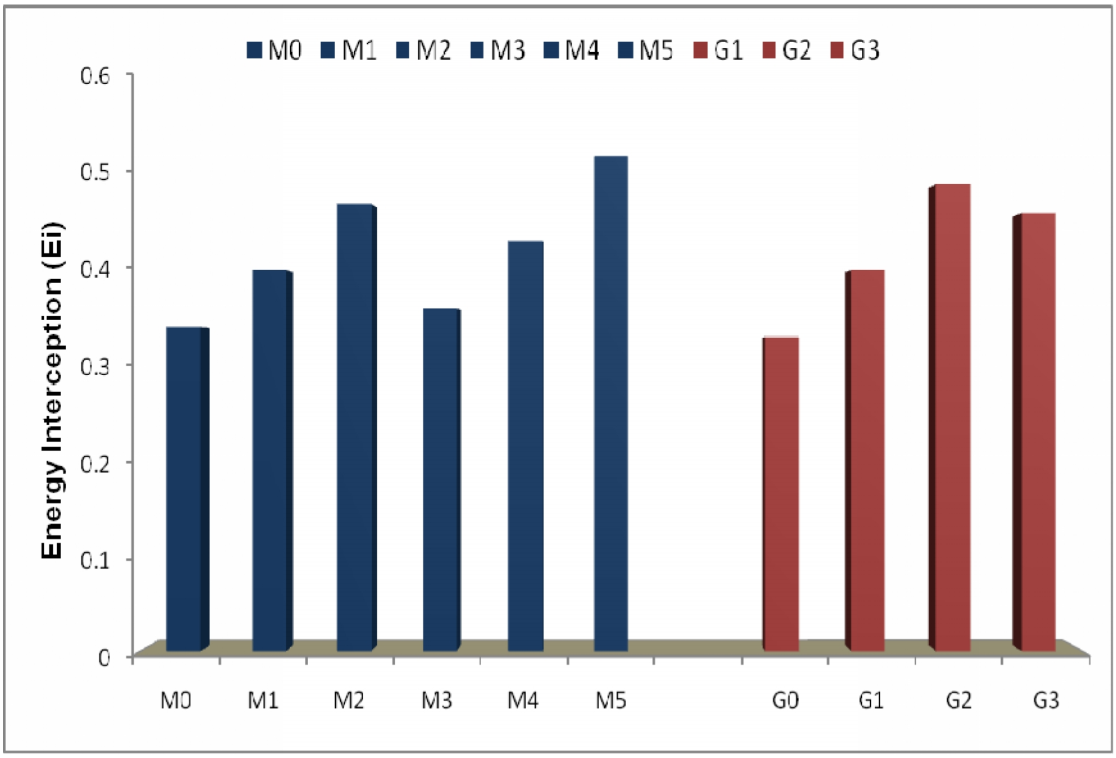

Fig. 4.13 : Influence of growing media and gibberellic acid on Energy Interception (Ei)

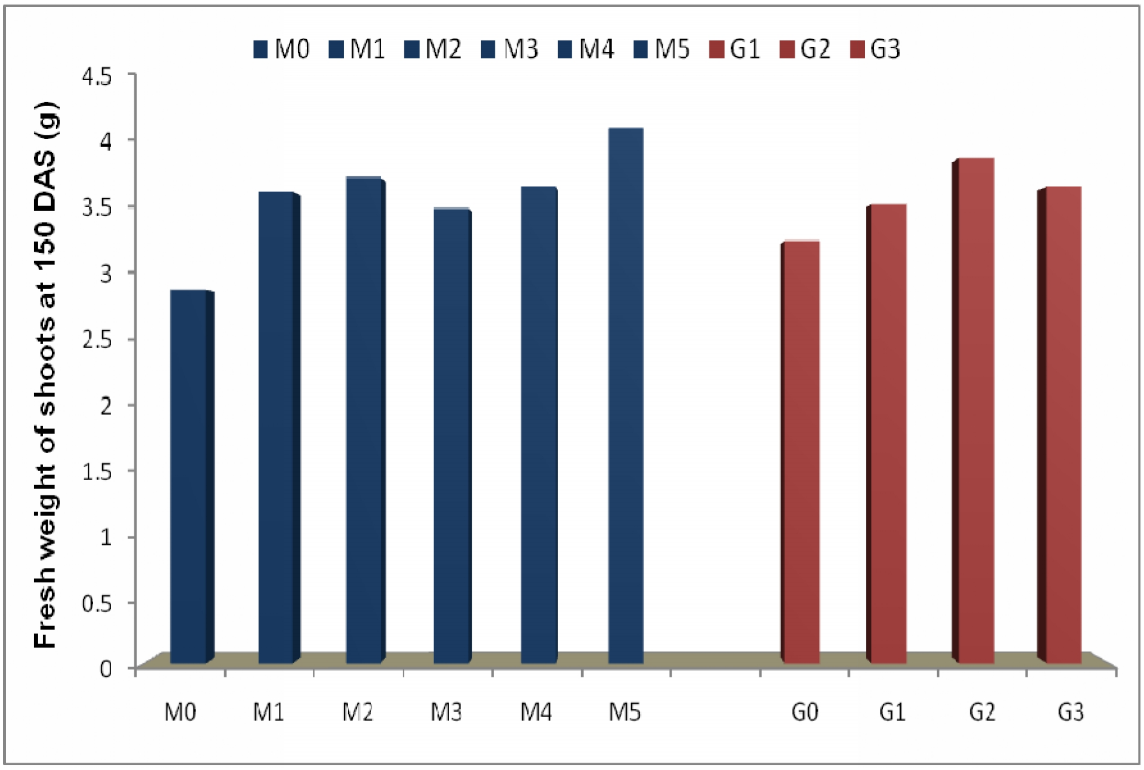

Fig. 4.14 : Influence of growing media and gibberellic acid on fresh weight of shoots at 150 DAS

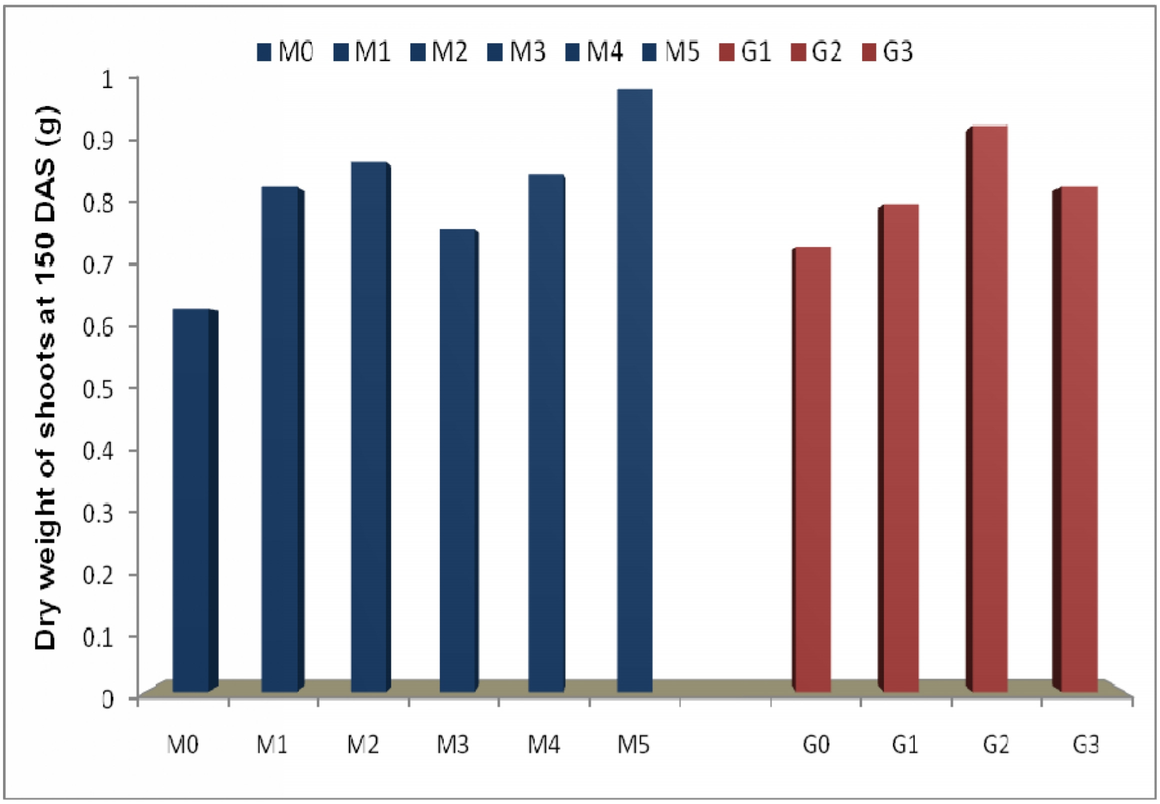

Fig. 4.15 : Influence of growing media and gibberellic acid on dry weight of shoots at 150 DAS

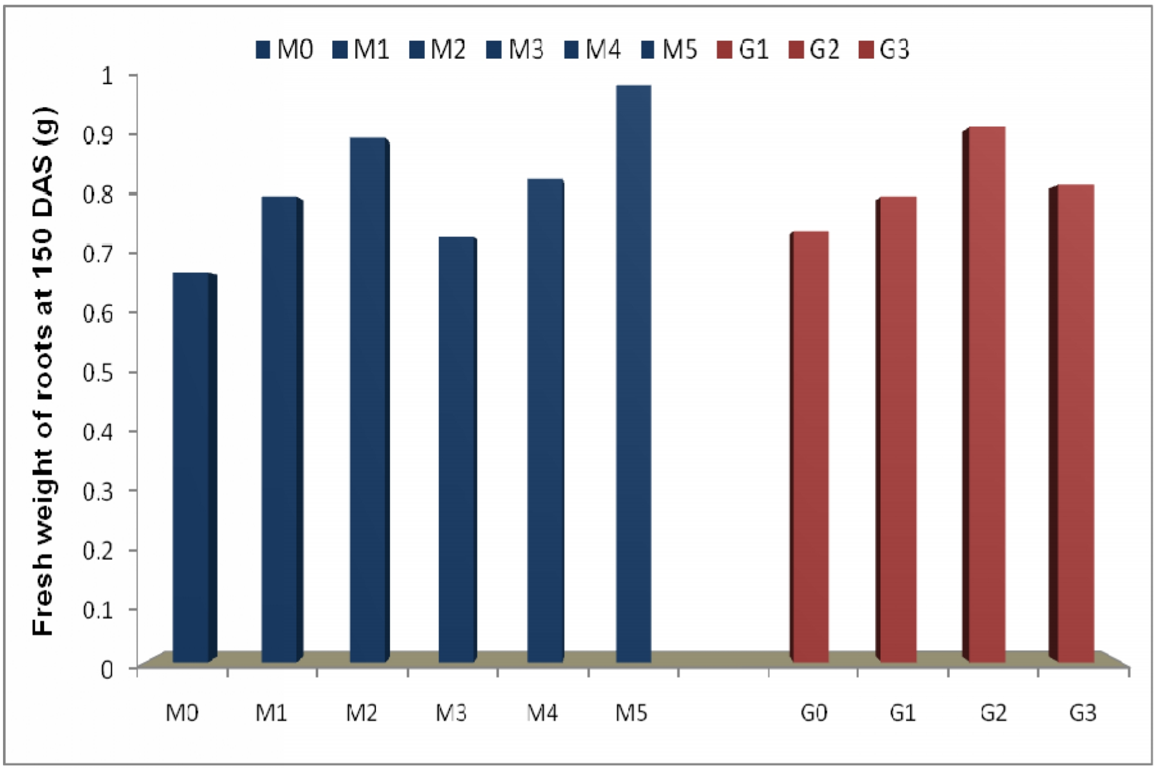

Fig. 4.16 : Influence of growing media and gibberellic acid on fresh weight of roots at 150 DAS

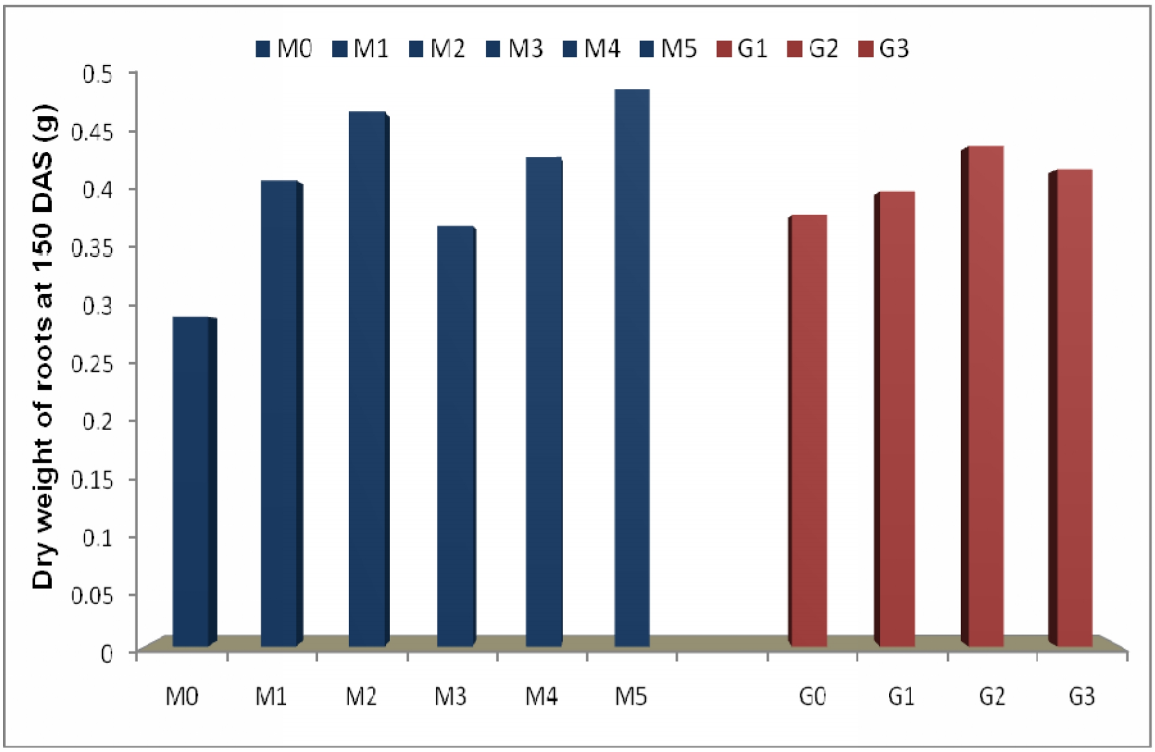

Fig. 4.17 : Influence of growing media and gibberellic acid on dry weight of roots at 150 DAS

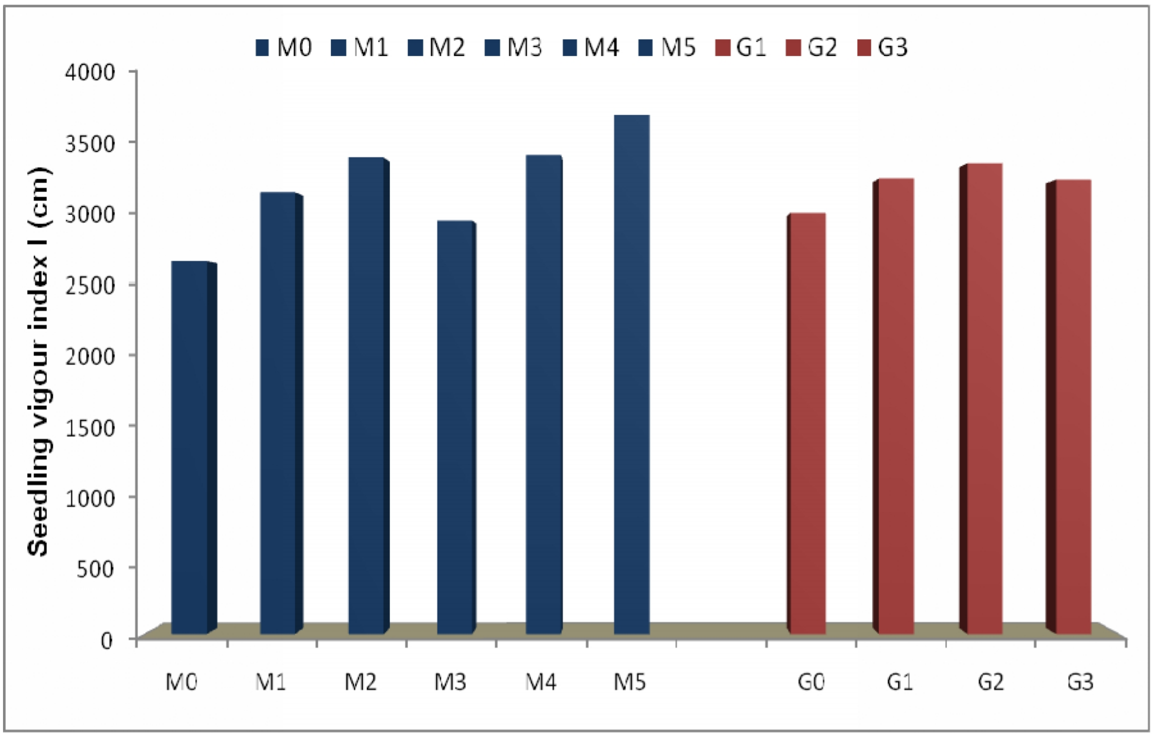

Fig. 4.18 : Influence of growing media and gibberellic acid on seedling vigour index I (cm) at 150 DAS

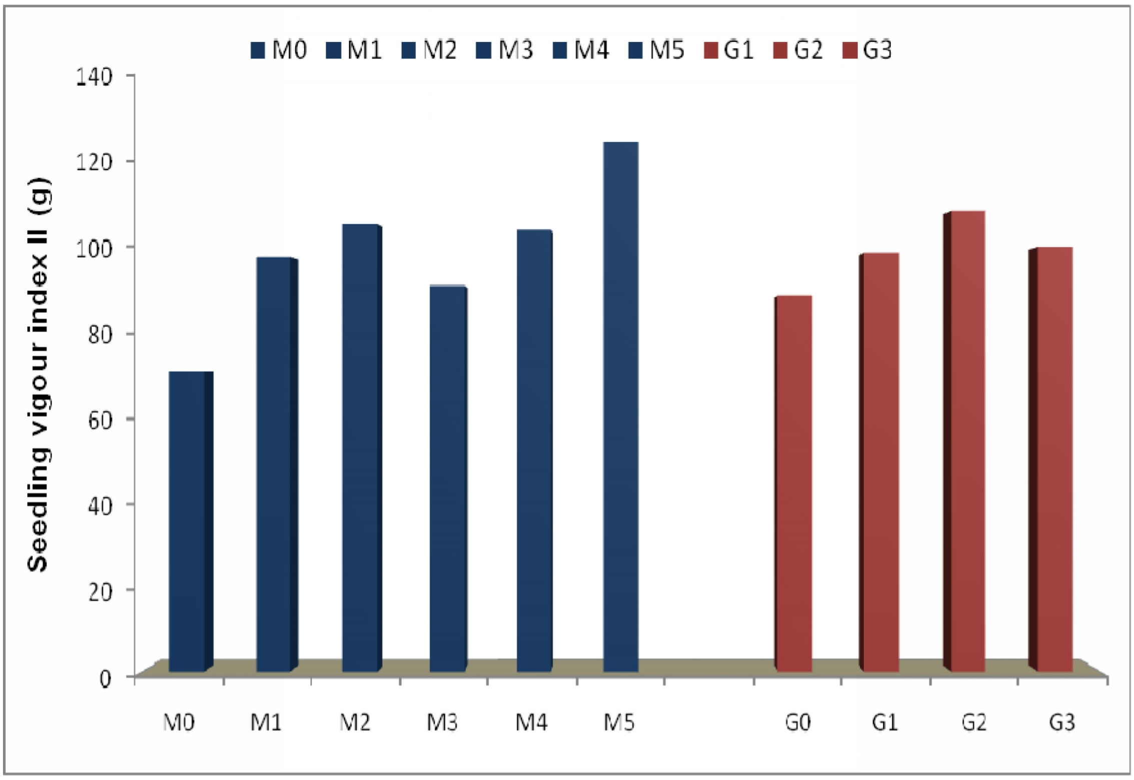

Fig. 4.19 : Influence of growing media and gibberellic acid on seedling vigour index II (g) at 150 DAS

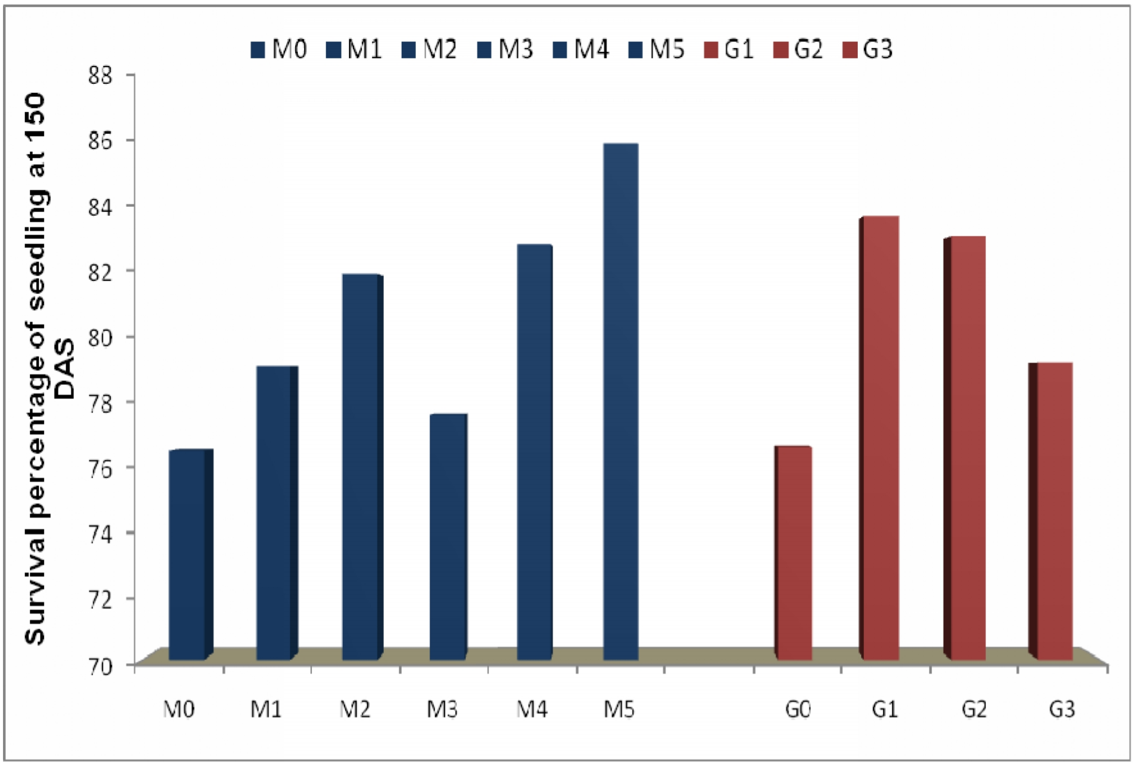

Fig. 4.20 : Influence of growing media and gibberellic acid on survival percentage of seedling at 150 DAS

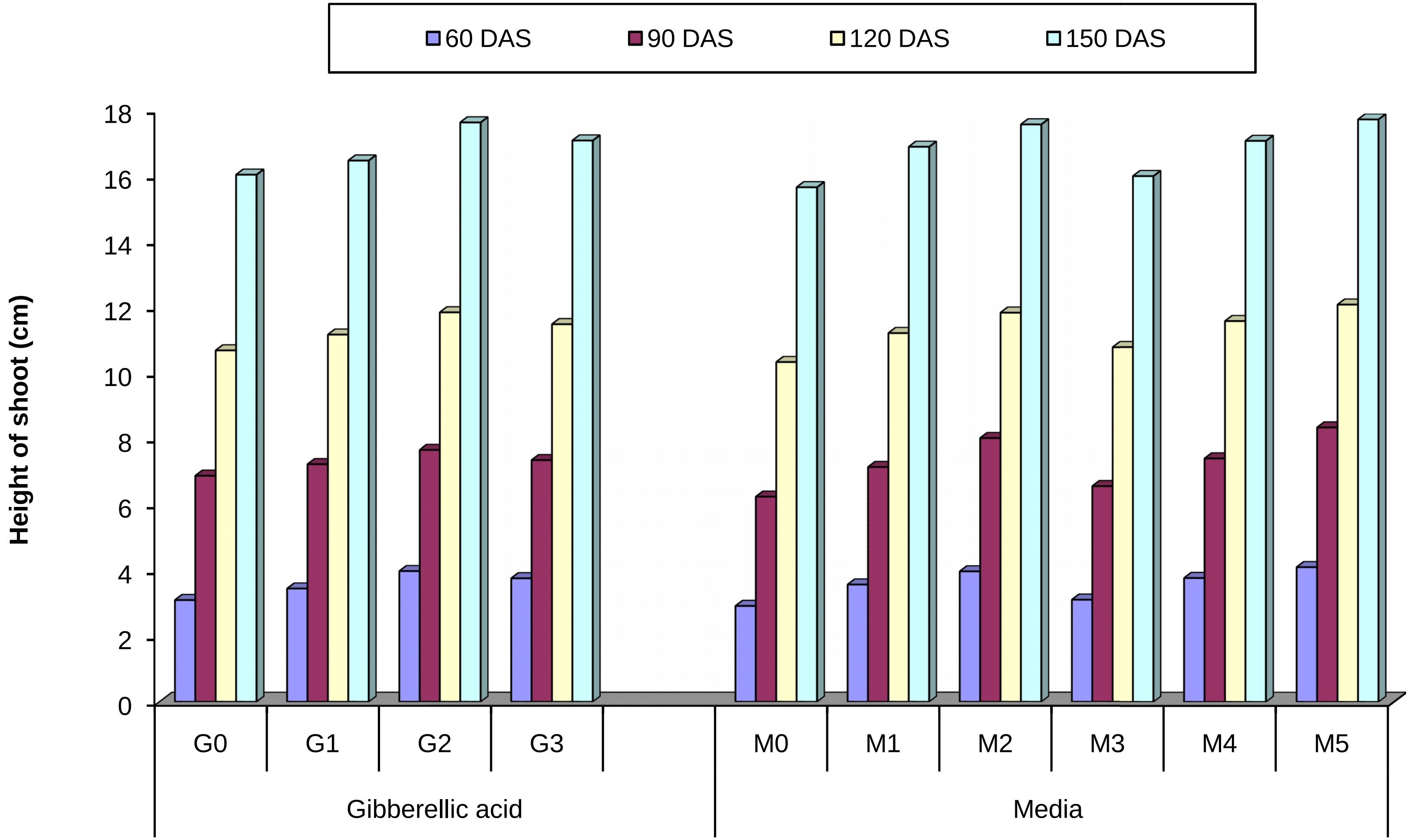

Fig. 4.4: Influence of growing media and gibberellic acid on heigh of shoots at different stages

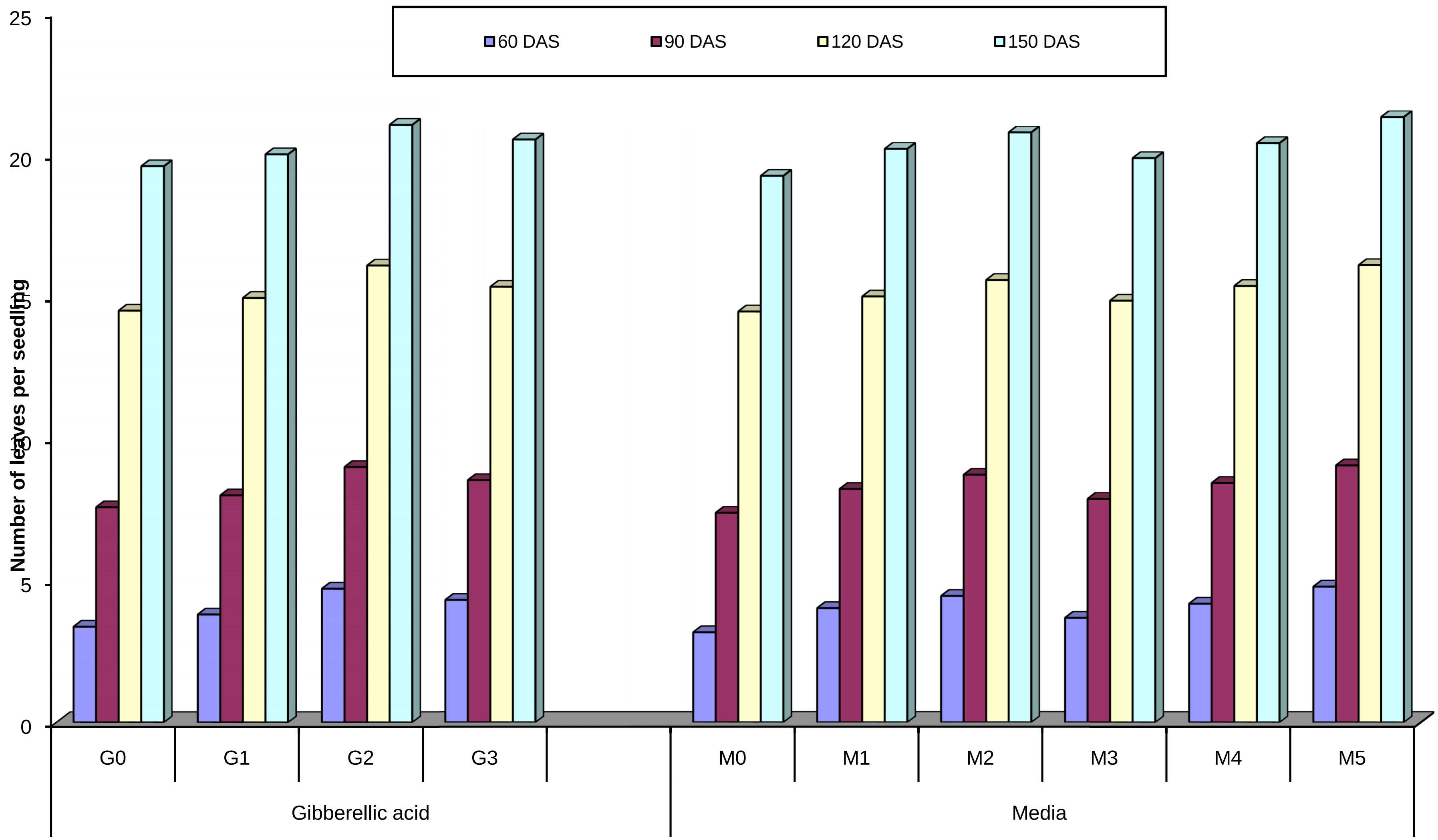

Fig. 4.5: Influence of growing media and gibberellic acid on number of leaves at different stages

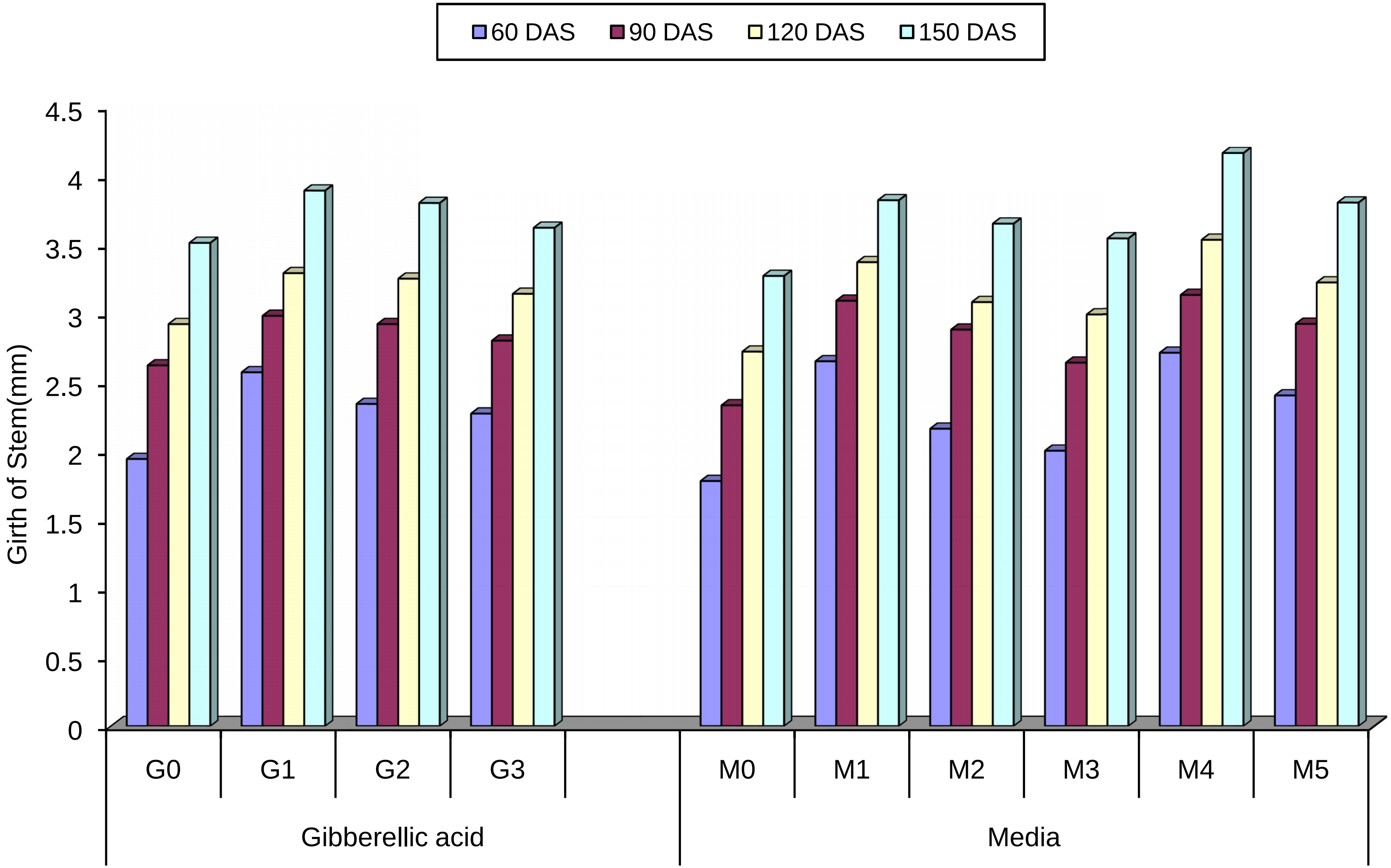

Fig. 4.6: Influence of growing media and gibberellic acid on heigh of shoots at different stages