



STUDIES ON SEED GERMINATION AND SEEDLING GROWTH IN ANNONA (Annona squamosa L.)

By
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THESIS SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF SCIENCE IN HORTICULTURE

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
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RAJENDRANAGAR, HYDERABAD - 500 030

JANUARY, 1991

CERTIFICATE

Mr. PEYYALA BABU RATAN has satisfactorily prosecuted the course of research and that the thesis entitled STUDIES ON SEED GERMINATION AND SEEDLING GROWTH IN ANNONA (Annona squamosa L.) submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

Date: 24 January, 1991



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CERTIFICATE

This is to certify that the thesis entitled **STUDIES ON SEED GERMINATION AND SEEDLING GROWTH IN ANNONA (Annona squamosa L.)** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE** of the Andhra Pradesh Agricultural University, is a record of the bonafide research work carried out by **Mr. PEYYALA BABU RATAN** under my guidance and supervision. The subject of the thesis has been approved by the Student Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been fully acknowledged by the author of the thesis.

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Date: 28 January, 1991


(PEYYALA BABU RATAN)

LIST OF CONTENTS

Chapter	Title	Page No.
I	INTRODUCTION	1 - 3
II	REVIEW OF LITERATURE	4 - 17
III	MATERIALS AND METHODS	18 - 29
IV	RESULTS	30 - 179
V	DISCUSSION	180 - 192
VI	SUMMARY	193 - 198
	LITERATURE CITED	199 - 207
	APPENDICES	208

LIST OF TABLES

Table No.	Title	Page No.
1.1	Effect of water soaking on the germination of Annona seeds.	31
1.2	Effect of water soaking of Annona seeds on plant height and root length of seedlings.	34
1.3	Effect of water soaking of Annona seeds on stem diameter and leaf dry weights of seedlings.	42
1.4	Effect of water soaking of Annona seeds on number of leaves and leaf area of seedlings.	39
1.5	Effect of water soaking of Annona seeds on stem and root dry weight of seedlings.	44
1.6	Effect of water soaking of Annona seeds on relative growth rate.	47
1.7	Effect of water soaking of Annona seeds on leaf weight ratio and leaf area ratio of seedlings.	49
1.8	Correlation, coefficients amongst germination and seedling attributes in water soaked Annona seeds.	52
2.1	Effect of Acid Scarification on Annona seed germination.	55
2.2	Effect of Acid Scarification on Annona seeds on plant height and root length of seedlings.	58
2.3	Effect of Acid Scarification on Annona seeds on number of leaves and leaf area of seedlings.	64
2.4	Effect of Acid Scarification on Annona seeds on stem diameter and leaf dry weight of seedlings.	66

Contd.

Table No.	Title	Page No.
2.5	Effect of Acid Scarification on Annona seeds on stem and root dry weight of seedlings.	69
2.6	Effect of Acid Scarification on Annona seeds on relative growth rate.	71
2.7	Effect of Acid Scarification on Annona seeds on leaf weight ratio and leaf area ratio of seedlings.	73
2.8	Correlation, coefficients amongst germination and seedling attributes in acid scarified Annona seeds.	76
3.1	Effect of Gibberellic acid on Annona seed germination.	79
3.2	Effect of pre-soaking of Annona seeds in Gibberellic acid on plant height and root length of seedlings.	82
3.3	Effect of pre-soaking of Annona seeds in Gibberellic acid on stem diameter and leaf dry weight of seedlings.	91
3.4	Effect of pre-soaking of Annona seeds in Gibberellic acid on number of leaves and leaf area of seedlings.	88
3.5	Effect of pre-soaking of Annona seeds in Gibberellic acid on stem and root dry weight of seedlings.	93
3.6	Effect of pre-soaking of Annona seeds in Gibberellic acid on relative growth rate of seedlings.	96
3.7	Effect of pre-soaking of Annona seeds in Gibberellic acid on leaf area ratio and leaf weight ratio of seedlings.	98

Contd.

Table No.	Title	Page No.
3.8	Correlation, coefficients amongst germination and seedling attributes in Gibberellic acid treated Annona seeds.	101
4.1	Effect of thiourea on germination of Annona seeds.	103
4.2	Effect of pre-soaking of Annona seeds in thiourea on plant height and root length of seedlings.	108
4.3	Effect of pre-soaking of Annona seeds in thiourea on number of leaves and leaf area of seedlings.	112
4.4	Effect of pre-soaking of Annona seeds in thiourea on stem diameter and leaf dry weight of seedlings.	115
4.5	Effect of pre-soaking of Annona seeds in thiourea on stem and root dry weights of seedlings.	118
4.6	Effect of pre-soaking of Annona seeds in thiourea on relative growth rate of seedlings.	120
4.7	Effect of pre-soaking of Annona seeds in thiourea on leaf weight ratio and leaf area ratio of seedlings.	123
4.8	Correlation coefficients amongst germination and seedling attributes in thiourea treated Annona seeds.	125
5.1	Effect of Potassium nitrate on the germination of Annona seeds.	128
5.2	Effect of pre-soaking of Annona seeds in potassium nitrate on plant height and root length of seedlings.	131

Contd.

Table No.	Title	Page No.
5.3	Effect of pre-soaking of Annona seeds in potassium nitrate on number of leaves and leaf area of seedlings.	137
5.4	Effect of pre-soaking of Annona seeds in potassium nitrate on stem diameter and leaf dry weight of seedlings.	139
5.5	Effect of pre-soaking of Annona seeds in potassium nitrate on stem and root dry weights of seedlings.	142
5.6	Effect of pre-soaking of Annona seeds in potassium nitrate on relative growth rate.	144
5.7	Effect of pre-soaking of Annona seeds in potassium nitrate on leaf weight ratio and leaf area ratio of seedlings.	147
5.8	Correlation coefficients amongst germination and seedling attributes in potassium nitrate treated Annona seeds.	149
6.1	Effect of pre-soaking of Annona seeds in different combinations of chemicals on germination.	152
6.2	Effect of pre-soaking of Annona seeds in different combinations of chemicals on plant height and root length of seedlings.	156
6.3	Effect of pre-soaking of Annona seeds in different combinations of chemicals on number of leaves and leaf area of seedlings.	163
6.4	Effect of pre-soaking of Annona seeds in different combinations of chemicals on stem diameter and leaf dry weight of seedlings.	166

Contd.

Table No.	Title	Page No.
6.5	Effect of pre-soaking of Annona seeds in different combinations of chemicals on stem and root dry weight of seedlings.	169
6.6	Effect of pre-soaking of Annona seeds in different combinations of chemicals on relative growth rate.	172
6.7	Effect of pre-soaking of Annona seeds in different combinations of chemicals on leaf weight ratio and leaf area ratio of seedlings.	175
6.8	Correlation coefficients amongst germination and seedling attributes in the Annona seeds treated with different combinations of chemicals.	178

LIST OF ILLUSTRATIONS

Number	Title	Page No.
1.1	Influence of Annona seed soaking in water on germination.	32
1.2	Influence of Annona seed soaking in water on plant height.	35
1.3	Influence of Annona seed soaking in water on stem diameter.	37
2.1	Influence of Annona seed scarification on germination.	56
2.2	Influence of Annona seed scarification on plant height.	59
2.3	Influence of Annona seed scarification on stem diameter.	62
3.1	Influence of Annona seed soaking in Gibberellic acid on germination.	80
3.2	Influence of Annona seed soaking in Gibberellic acid on plant height.	83
3.3	Influence of Annona seed soaking in Gibberellic acid on stem diameter.	86
4.1	Influence of Annona seed soaking in thiourea on germination.	104
4.2	Influence of Annona seed soaking in thiourea on plant height.	107
4.3	Influence of Annona seed soaking in thiourea on stem diameter.	110
5.1	Influence of Annona seed soaking in potassium nitrate on germination.	129
5.2	Influence of Annona seed soaking in potassium nitrate on plant height.	132

Contd.

Number	Title	Page No.
5.3	Influence of Annona seed soaking in potassium nitrate on stem diameter.	135
6.1	Influence of Annona seed soaking in different combinations of chemicals on germination.	153
6.2	Influence of Annona seed soaking in different combinations of chemicals on plant height.	157
6.3	Influence of Annona seed soaking in different combinations of chemicals on stem diameter.	161

LIST OF APPENDICES

Appendix No.	Title	Page No.
1	Meteorological data during the period of investigation (October, 1989 to February, 1990)	208

LIST OF ABBREVIATIONS

cm	centimetre
cm ²	square centimetre
g	grams
GA	Gibberellic acid
h	hours
H ₂ SO ₄	Sulphuric acid
ha ⁻¹	per hectare
KNO ₃	Potassium nitrate
LAR	Leaf area ratio
LWR	Leaf weight ratio
mm	millimetre
RGR	Relative growth rate
plant ⁻¹	per plant

ACKNOWLEDGEMENTS

By the grace of the almighty, I have tried to put my humble efforts to fulfil the task assigned to me by the learned members of Advisory Committee.

It gives me an immense pleasure and find no words to express my deep sense of gratitude and indebtedness to **Dr.S.Eswara Reddy**, Associate Professor, Department of Horticulture, College of Agriculture, Rajendranagar and Chairman of the Advisory Committee for suggesting Research problem, day to day encouragement, keen interest, valuable and affectionate guidance and invaluable suggestions during course of investigation and preparation of the thesis.

I am profoundly indebted to the revered members of my Advisory Committee **Dr.Y.Narayana Reddy**, Professor and Head, Department of Horticulture, **Dr.I.V.Subba Rao**, Professor, Department of Plant Physiology, **Dr.B.Murali Mohana Reddy**, Seed Research Officer, College of Agriculture, Rajendranagar for their constant encouragement and useful suggestions during the research work and in completion of the thesis.

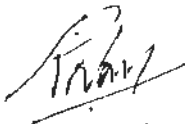
I take this opportunity to express my deep sense of honour, love and gratitude towards my revered parents, sister, brother, brother-in-law and grand mother for their constant encouragement that kept me enthusiastic throughout my educational career.

During the course of my work the help and cooperation received from my friends G.Srinu, Rayudu, B.Srinu, Dharmaja, Babu, Ravi, Samma, R.Srinu, Ramanji, Binny, Satyanarayana, Sreekanth, Surf, Ramana, Kasturi, Raviprakash and others are gratefully acknowledged.

My special thanks goes to Sri.K.Muralidhar Rao, Assistant Director of Horticulture and all staff members of Department of Horticulture, College of Agriculture, Rajendranagar for their constant criticism and help during preparation of my thesis.

A word of appreciation goes to Y.Prasad Rao, Sagar, Narsimha Rao and Murthy of M/s.PRASA COMPUTERS for neatly executing the thesis work through computer.

Finally, the financial support in the form of stipend extended by the government of Andhra Pradesh is duly appreciated and acknowledged.


(BABU RATAN)

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Name of the Author : P.BABU RATAN

Title of the thesis : STUDIES ON SEED GERMINATION
AND SEEDLING GROWTH IN ANNONA
(Annona squamosa L.)

Degree to which it is submitted : MASTER OF SCIENCE IN
HORTICULTURE

Faculty : AGRICULTURE

Major field : HORTICULTURE

Major Advisor : Dr.S.ESWARA REDDY

University : ANDHRA PRADESH AGRICULTURAL
UNIVERSITY

Year of submission : 1991

ABSTRACT

Experiments on the germination of Annona (Annona squamosa L.) seeds were conducted during October 1989 to February 1990 at the Horticultural Garden, College of Agriculture, Rajendranagar, Hyderabad. The germination of freshly harvested Annona seeds is poor and the seeds remain dormant for 30 to 90 days causing problems in raising root stocks. Hence, the influence of pre-sowing treatments like soaking in water for 12h, 24 h, 36 h or 48 h, acid scarification for 2 min, 4 min or 6 min, growth regulator i.e., GA 200, 400 or 600 ppm for 12 h or 24 h, dormancy breaking chemicals i.e., potassium nitrate 0.5 per cent or 1 per cent and thiourea 0.5 per cent or 1 per cent for 12 h or 24 h as well as combinations of above said best treatments on seed germination and subsequent seedling growth in Annona cv. Balanagar were studied. Each experiment was laid out in a randomised block design, replicated five times.

Seeds soaked in water for 24 h needed 17.4 days for initiation of germination and recorded a maximum germination of 71 per cent. Seeds treated with GA 400 ppm for 12 h recorded 69 per cent germination and took 16.4 days for initiation of germination. Seeds soaked in water for 24 h + GA 400 ppm for 12 h took 15.0 days for commencement of germination with a final germination of 58 per cent. Scarification treatments

had intermediate effect. Soaking in thiourea 0.5 per cent or potassium nitrate 1 per cent solution gave a marginal improvement in germination percentage. Velocity of germination was maximum with seeds soaked in water for 24 h + potassium nitrate 1 per cent for 12 h. Seeds soaked in GA 400 ppm for 12 h recorded maximum seedling vigour.

Seedlings which resulted from seeds treated with GA 400 ppm for 12 h had a maximum plant height, more root length and also higher stem and root dry weights. Stem diameter, however, was more in seedlings obtained from seeds treated with GA 200 ppm solution for 24 h. Seedlings from seeds treated with GA 600 ppm solution for 12 h had a maximum number of leaves, leaf area and leaf dry matter per plant. Leaf weight ratio as well as leaf area ratios were maximum with GA 600 ppm for 12 h treatment. Hence, pre-sowing treatment with GA 400 ppm for 12 h could be suggested for improving Annona seed germination and subsequent seedling growth.

The number of days taken for initiation of germination had a negative correlation with final germination, seedling vigour, velocity of germination, plant height, stem diameter, leaf area and number of leaves. Velocity of germination had a positive relationship with seedling vigour in five out of six experiments and the number of days as well as velocity of germination inturn related positively with germination percentage, plant height, number of leaves and leaf area. Days taken for commencement of germination and velocity of germination were good indices for final germination which inturn were positive indices for seedling vigour and plant height.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Custard apple (*Annona squamosa*. L) locally known as sitaphal is one of the five edible species of the genus *Annona*. Annonas were introduced into India by the Portuguese in the later part of the 16th century. It grows in semiwild condition in vast areas in the states like Andhra Pradesh, Tamilnadu and Orissa.

Ber, pomegranate, phalsa etc., were extensively tried for dry land farming. Custard apple is another fruit suitable for dry land horticulture and is gaining popularity with orchardists. Accordingly, custard apple hitherto confined to shrub jungles, is of late being cultivated in the states of Maharashtra and Andhra Pradesh.

Most of the *Annona* species are being propagated by both sexual and asexual methods. The value of vegetative propagation was recognised by several workers because of great genetic variation among seedling plants in the yield and quality of fruits.

Different vegetative methods like tip and stem cuttings (Venkataratnam and Swamy, 1956); air layering (Neitzel, 1982); budding (Ochse et al., 1961 and Ascenso and Milheiro, 1973) and grafting (Moran et al., 1972) were tried with different degree of success. The

most successful method seems to be inarching on the seedling of custard apple (Ahmed, 1936; and Samaddar and Yadav, 1970).

Custard apple is normally propagated through seed. It has been found that freshly harvested seeds do not germinate even under optimum conditions, seeds will remain dormant for 1-3 months. Further, seeds have hard seed coat which prevents them from absorbing water. Germination may also be checked some times by compounds known as germination inhibitors present in seed and seed coat due to which the seed germination is highly variable ranging from 30 to 80 per cent.

Similar problems were tackled by treating the seeds with different plant growth regulators, dormancy breaking chemicals, water or acid scarification with encouraging results in different fruits.

Among growth regulators, gibberellic acid (GA) has been very commonly used for improving the germination of seeds (Donoho and Walker, 1957; Krishnan and Kulasekaran, 1984; Sen and Ghunti, 1976; Shanmughavelu, 1970 and Singh et al., 1979) and subsequent seedling growth (Fogle, 1958; Randhawa and Negi, 1964; Randhawa and Pal, 1968 etc.,) in several fruit crops.

Different chemicals have been used for breaking the dormancy of seeds. Among them thiourea (Singh et al 1966; Biggs and Paul, 1963; Murthy and Reddy, 1989; Singh et al 1968) and potassium nitrate (KNO_3) (Choudhari and Chakravar, 1981; Reddy and Murthy, 1989; Singh et al., 1979) were found to improve the germination of seeds.

Acid scarification (Kajal, 1983; Singhrot and Makhija, 1979) for shorter periods or even soaking of seeds in water (Haq et al., 1973; Kachru et al., 1972) were found to enhance the germination in different fruit crops.

However, very little work has been done on the effects of plant growth regulators and other chemicals on seed germination and subsequent seedling growth in custard apple.

Hence, studies were conducted with gibberellic acid, thiourea, potassium nitrate, acid scarification and water soaking treatments on the seeds of *Annona squamosa* L cv. Balanagar with the objectives :

1. To study the effect of different chemicals, plant growth regulator, acid scarification and water soaking on germination percentage.
2. To evaluate the effect of different chemicals, plant growth regulator, acid scarification and water soaking on subsequent seedling growth.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Custard apple (*Annona squamosa* L.) is commonly grown from seed.

The seed can be considered as a small meristematic axis, often associated with a storage tissue and enclosed by an enveloping series of membranes and sometimes stony shells which collectively make up the seed coat. These latter structures are frequently critical to the dormancy of seeds, limiting the entry of water and oxygen mechanically limiting the enlargement of the embryo or some times altering the growth substance relationships of the enclosed tissues (Leopold and Kriedemann, 1988).

One of the most important and interesting problems encountered in seed physiology is the failure of otherwise viable seeds to recommence development immediately when supplied with water and oxygen at temperatures recognized as normally favourable for plant growth. This delay may last for a variable period of time under constant conditions and in some cases may continue indefinitely until some special condition is fulfilled. Such failure to germinate is broadly termed as "dormancy".

Freshly harvested custard apple seeds remain dormant for 1 to 3 months (Campbell and Popenoe,

1968) and fail to germinate readily, causing inconvenience to the growers.

A more simple and more generally quoted classification of dormancy types is that of Crocker (1916) who described dormancy as resulting from

1. Immature of the embryo
2. Impermeability of seed coats to water and oxygen
3. Mechanical resistance of seed coats to embryo growth
4. A combination of the above i.e., seed coat dormancy combined with a dormant embryo
5. Presence of chemical inhibitors
6. Metabolic block within the embryo.

The above abnormalities can be over come by using certain methods such as mechanical and acid scarification, soaking of seeds in water, moist chilling (stratification), light and temperature control during germination and also more successfully with chemical stimulants such as gibberellic acid, potassium nitrate, thiourea, sodium hypochloride etc.

However, very little information is documented in literature on the influence of above mentioned treatments on the seed germination and subsequent

seedling growth of custard apple. The available literature on seed germination and subsequent seedling growth of Annonaceous fruits along with other important fruit crops is reviewed in this chapter.

2.1 PRE-SOAKING OF SEEDS IN WATER

Ahmed (1936) reported that *Annona* seeds ordinarily take 40 days for germination. Germination may be hastened either by sand papering the seed coat, soaking the seed in water for 3 days or sowing in beds with a high moisture retention.

According to Kachru et al. (1972), grape seeds kept in running water for six days germinated in muslin cloth itself.

In case of litchi, seed treatment with water for 24 hours gave highest germination percentage (Kadman and Slor, 1974). The germination percentage was considerably increased in sour orange, rough lemon and trifoliate orange seeds by soaking in water. For sour orange and rough lemon the best soaking periods were 16 and 30 hours respectively (Abdalla et al., 1978).

The germination of guava seeds was improved by soaking them in tepid water before sowing. Cold water also had a beneficial effect but soaking in hot water was harmful (Haq et al., 1973).

In case of peach, stone germination was improved from 36.5 to 60 per cent by soaking in cold water for 72 hours. Seedling growth was also enhanced (Said et al., 1970). Germination of alexandria palm (*Archontophoenix alexandrae*) seed was accelerated by pre-soaking for 24 or 72 hours in water. The germination percentage was 94 and 91 per cent respectively (Nagao and Sakai, 1979).

Ayerza (1981) observed that soaking of Jojoba seeds in water at room temperature for 24 hours, gave 85 per cent germination which was the best.

Seed coat dormancy can be overcome by soaking of seeds in water for different periods. This treatment will leach out inhibitors present in the seed and also modifies hard seed coat, thereby inhibition of water into dry seed takes place during soaking period.

2.2 ACID SCARIFICATION

Singhrot and Makhija (1979) reported that pre-soaking the seed of *Zizyphus mauritiana* cv. Local Desigola in concentrated sulphuric acid for 6 minutes resulted in about 90 per cent of germination. Similarly, germination of freshly harvested ber seeds was improved by soaking in H_2SO_4 for 6 minutes (Kajal, 1983). Rives (1965) reported that dry seeds of grape

improved their germination percentage with a treatment of sulphuric acid.

Duarte (1974) reported that seeds of *Delonix regia* soaked in conc. sulphuric acid was superior to control which recorded only 6 per cent of germination.

Diana and Gaetani (1979) treated Carolea, Dolcedirossano and Olivastria olive seeds with 10 per cent sulphuric acid and observed an increased germination percentage and also early germination by 5-20 days. XU and Gu (1985) reported 98 per cent germination in *Pharbitis nil* seeds treated with sulphuric acid for 140 minutes. Hard black seeds of canna soaked sulphuric acid for 3 hours or seeds with radicle cap removed gave 172 and 82 per cent germination respectively. Untreated or hard black seeds did not germinate (Jadhav, 1960).

According to Salonki and Joshi (1983), the seeds of winged bean (*Psophocarpus tetraganolobus*) soaked in sulphuric acid solution (8:1) for five minutes gave maximum germination of 97.33 per cent as against 46.66 per cent in control.

Hoffmann and Kummerow (1962) reported that sulphuric acid scarification for 2 hours resulted in the highest germination of *Acacia caven* seed. According to Chandrasekhar (1964), seed germination of

Pueraria phaseoloides and *Desmodium ovalifolium* was improved by treatment with H_2SO_4 . Fortham (1965) reported that seeds of *Gleolitschia triemcanthos* and *Cytisus nigrican* after treatment with H_2SO_4 for 30 minutes to two hours gave the best germination percentage.

Treating of seeds having hard seed coat with concentrated sulphuric acid is an effective measure to soften the hard or impermeable seed coats. Thereby early germination takes place.

2.3 GROWTH REGULATORS

The use of gibberellic acid (GA) has become very common for improving the germination of many kinds of seeds and enhancing seedling growth. GA has been tried for breaking the seed dormancy in annona, apple, apricot, peach, plum, cherry, papaya, grape, pear, etc.

Soaking the seeds of *Annona cherimola* in GA at 10,000 ppm significantly increased the germination percentage; while GA at 1000 ppm increased the seedling growth (Duarte et al., 1974). Campbell and Popenoe (1968) treated the freshly harvested *Annona diversifolia* seeds with GA solutions of 3.5, 35, 350, 3500 or 35000 ppm concentrations. GA at 350 ppm gave

the greatest increase in germination without causing any abnormalities.

According to Krishnan and Kulasekaran (1984), seeds of ber (*Zizyphus rotundifolia*) treated for 24 hours in GA 200 ppm recorded a high percentage of germination (96%) when compared to control (8.72%). In another experiment, *Zizyphus jujuba* seeds treated with GA 400 ppm gave highest germination percentage (98%). Shoot length was maximum with 500 ppm and root length was maximum with 200ppm of GA (Shanmugavelu, 1970).

A maximum of 611.3% germination was recorded in *Citrus Jambheri*, when the seeds were soaked in 500 ppm GA solution (Singh et al., 1979). Rawash et al. (1980) soaked the seeds of *Cleopatra* mandarin and sour-orange for 24 hours in GA₃, BA or 2,4-D at different concentrations and obtained the best germination (37-41%) in mandarin treated with GA₃ at 1000 ppm as against 18-20 per cent germination in control seeds. Choudhari and Chakrawar (1982) treated the seeds of Rangapur lime for 6 or 12 hours in solutions of GA₃ (10, 20 or 40 ppm), NAA (10, 20 or 400 ppm). The best results with regard to seedling height, number of leaves per plant, stem girth and shoot fresh and dry weights were obtained with GA₃ at 40 ppm for 12 hours.

Seeds of Hill lemon and Malta were treated for six hours with GA 0, 5, 10, 15 or 20 ppm. Treatment of GA 20 ppm was the best for the germination of Hill lemon seeds, whereas GA 15 ppm was the best for Malta, resulting in two-fold increase in the germination. GA 15 ppm nearly doubled the height of plants of Hill lemon as well as Malta (Srivastava, 1969).

Shanmugavelu (1970) reported that GA 300 ppm seed treatment gave highest germination percentage (100%) and highest shoot length (27.18 cm) in *Artocarpus heterophyllus*. In cashew, GA 100 ppm and 500 ppm gave highest germination percentage (100%) and shoot length (25.67 cm) respectively. In case of *Bassia latifolia*, GA 300 ppm and 500 ppm concentrations gave best germination percentage (100%) and shoot length (15.68 cm) respectively.

Donaho and Walker (1957) soaked peach seeds for 24 hours in GA 100 to 200 ppm solutions, and obtained higher germination of non-after-ripened seeds 20 days after sowing. There was an increase in the germination percentage of Okinawa peach seed treated with 10^{-1} M concentration of GA (Biggs and Paul, 1963). Working on peach seeds, Singh et al. (1966) found that 150 ppm GA caused the highest seed germination (21.50 per cent), whereas in control the germination was only 6.10 per cent.

Zukov (1965) observed that plum seeds treated with gibberellin at 250 mg/l germinated few days earlier and seedlings were stronger. The leaves of treated plants were considerably larger than those of control. In case of almonds also, same concentration gave best germination and seedling vigour.

Leal et al. (1977) observed that avacado cv. Mexicola and Gaines Ville seeds treated with 125-1000 ppm GA resulted in quicker and maximum germination (96-100%). Carrera et al. (1986) reported that soaking of *Prunus mahaleb* seeds in GA 1000 ppm for 24 hours increased the germination percentage from 0 to 80 per cent in non stratified, non stored seeds with endocarp.

Sen and Ghunti (1976) recorded the highest germination of 89 per cent in seeds of papaya cv. Ranchi treated with GA at 200 ppm, while pre-treatment with GA at 100 ppm improved seedling height.

Eris (1976) observed that soaking of unstratified grape seeds in GA 100 ppm solution for 24 hours increased the germination percentage.

Ryndin (1962) observed that soaking the seeds of apple, cherry, pear and plum in GA solution for 12 hours increased the height of resulting seedlings and their leaf area.

Mahmut (1961) reported that soaking of *Pistacia terebinthus* seed in 500 ppm GA resulted in about 2 to 4 times as good germination as compared with water soaking for the same period.

Western pecan seeds soaked in GA 5000 ppm solution for 192 hours had germinated earlier than untreated seeds. Resultant seedlings were taller and had an increased dry weight over the control (Samuel et al., 1961).

Pre-sowing treatment with gibberellic acid gives early seed germination and good seedling growth. This may be due to activation of various hydrolytic as well as oxidative enzymes in the seed.

2.4 DORMANCY BREAKING CHEMICALS

2.4.1 Thiourea

Different chemicals have been used for breaking the dormancy of seeds and improving their germination. Thiourea has been the most effective chemical in improving the germination of seeds and is widely used by the research workers for this purpose.

Tukey and Carlson (1945) obtained fairly high percentage of germination with unstratified seeds of peach cv. Lovell by soaking them in 0.25 per cent concentrated thiourea for 6-12 hours.

Okinawa peach seeds were treated with six concentrations of thiourea and all the concentrations produced statistically significant increase in seed germination. The 10^{-1} M concentration of the chemical caused 100 per cent germination in two of the replications and 90 per cent in the third (Biggs and Paul, 1963).

Singh et al. (1966) treated peach seeds with thiourea at 5000 and 10000 ppm concentration and found that they were very effective in giving higher seed germination.

Higher germination percentage (88 per cent) of Melback grape was reported by Fox and Tellechae (1950) by treating the seeds with 0.5 per cent thiourea for 24 hours. The subsequent growth of plants treated with thiourea was better than that of the control.

Singh (1974) reported that seed treatment with thiourea in *Datura innoxia* at 1 per cent concentration improved the rate and percentage of germination significantly.

Singh et al. (1968) reported that peach seedling grown from seeds treated with thiourea at 5000 ppm caused the greatest increase in height, number of leaves and root extension as compared to all other treatments. Mederosolalde (1988) reported that seeds

of papaya cv. Maradol Roja treated with thiourea at 20 mg/litre gave 97 per cent germination.

Murthy and Reddy (1989) reported that kernels of 'Umran' jujube gave 67.00 and 75.66 per cent germination with thiourea at 0.5 and 1 per cent for 24 hours respectively under field conditions.

Krishnan and Kulasekaran (1984) observed that soaking the seeds *Zizyphus rotundifolia* in 500 ppm thiourea for 24 hours gave 92 per cent germination, whereas, control recorded only 68 per cent. Maximum number of lateral roots was also recorded due to thiourea treatment.

2.4.2 Potassium nitrate (KNO_3)

Literature on the effect of potassium nitrate on the germination of fruit crops is lacking. Very little research work was done on this aspect.

Pawpaw seeds soaked in KNO_3 for 15 minutes exhibited an increased percentage of germination and reduced the time for 50 per cent seedling emergence when compared with seeds soaked in water (Furutami and Nagao, 1987).

Singh et al. (1979) reported that seeds of Citrus karna soaked in potassium nitrate at 750 ppm for 24 hours gave the highest germination of 64 per cent.

Reddy and Murthy (1989) reported that soaking the kernals of *Zizyphus mauritiana* in 1 per cent potassium nitrate solution for 24 hours before sowing induced notable increase in root length, fresh and dry weights of root, apart from promoting germination when compared to control.

Nakamura (1972) reported that in strawberry, germination was stimulated with seed treatment of potassium nitrate at 0.1 or 0.2 per cent.

Frazao et al. (1984) soaked the seeds of *Paullinia cupana* in potassium nitrate soluton for various periods. The percentage of germination was upto 45.57 and speed of germination was highest.

Choudhari and Chakrawar (1981) reporrted that germination percentage in Rangapur lime seeds was 58.8 per cent with treatment of potassium nitrate for 12 hours.

Dormancy breaking chemicals such as thiourea and potassium nitrate will inactivate the germination inhibitors present in the seed or seed coat, resulting in early germination and good seedling growth.

2.5 COMBINATION OF DIFFERENT CHEMICAL CONCENTRATIONS

Domigella (1962) reported that germination of *Poncirus trifoliata* seeds was accelerated considerably by soaking water in GA 50 or 100 ppm. Germination was superior with combination of 200 ppm GA and water.

Scarification of seed with concentrated sulphuric acid for 1.5 h followed by soaking in water for 24 h resulted in about 53 per cent germination, two weeks after planting in *Pistacia terebinthus* (Crane and Forde, 1974).

The seeds of *Zamia furfuracea* germinated better (82.2%) by scarification with concentrated sulphuric acid for 25-30 minutes followed by soaking in 1000 ppm GA₃ for 24 hours (Dehgan and Schutzman, 1983).

Rodriguez et al. (1985) reported that germination percentage was highest (90 per cent) and rate of germination was fastest in the guava seeds soaked in water for 4 days followed by 1000 ppm gibberellic acid for 24 hours.

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CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

A number of experiments were conducted under field conditions to study the effect of different plant growth substances, dormancy breaking chemicals, acid scarification and water soaking treatments on germination and subsequent seedling growth in sitaphal (*Annona squamosa* L) seeds. Different materials used and methods followed are presented in this chapter.

3.1 EXPERIMENTAL SITE

The present investigations were carried out at the Horticultural Garden, College of Agriculture, Hyderabad, during October 1989 to February 1990. The garden is located at an altitude of 534 metres above mean sea level. Geographical bearing is $77^{\circ} 55'$ East latitude and $180^{\circ} 59'$ North latitude.

3.2 SOIL

Composite soil samples drawn from experimental site were analysed and data are presented below:

Mechanical analysis

Soil fraction		Component
1	Sand	74.6%
2	Silt	10.0%
3	Clay	15.4%
4	Textural class	Sandy loam
5	Colour	Red

Chemical Analysis

1	Soil reaction (pH)	7.48
2	Electrical conductivity (milli mhos/cm)	0.299
3	Organic carbon (%)	0.51
4	Available nitrogen (kg ha ⁻¹)	256.00
5	Available phosphorus(kg ha ⁻¹)	29.26
6	Available potassium (kg ha ⁻¹)	467.00

The analysis indicated that the soil was a red sandy loam with good drainage facility, low in available nitrogen, medium in phosphorus and high in available potassium.

3.3 CLIMATIC CONDITIONS

Meteorological data pertaining to rainfall average weekly minimum and maximum temperature and the percentage of relative humidity during the experimental period are given in Appendix I. During Experimental period (1st October 1989 to 25th February 1990) maximum temperature of 32.9° C in the 42nd standard week and minimum temperature of 8.7° C in the 3rd standard week were recorded. At 7.14 hrs, relative humidity was maximum (87 per cent) in 1st standard week and minimum (9 per cent) in 43rd standard week, whereas at 14.14 hrs relative humidity was maximum (46 per cent) in 52nd standard week and minimum (22 per cent) in 3rd standard week. Rainfall occurred in 40th (13.8 mm), 45th

(1.8 mm) and 52nd (2.6 mm) standard weeks only. Sunshine hours were ranged from 11.3 (4th standard week) to 6.2 (52nd standard week).

3.4 PREVIOUS CROP

No crop was raised on the experimental field in the previous year.

3.5 SEED MATERIAL

Seeds from fully ripened fruits of sitaphal (*Annona squamosa* L) cv. Balanagar were collected and made use of in this investigation.

3.6 MATERIALS OF THE EXPERIMENTS

EXPERIMENT I

3.6.1 Effect of pre soaking of seeds in distilled water

- 1 Soaking of seeds in distilled water for 12 hours
- 2 Soaking of seeds in distilled water for 24 hours
- 3 Soaking of seeds in distilled water for 36 hours
- 4 Soaking of seeds in distilled water for 48 hours
- 5 Control (dry seeds)

Number of replications : 5

Number of seeds per treatment : 100

Experimental design : Randomised block design

EXPERIMENT II**3.6.2 Effect of acid scarification (H_2SO_4) on seed germination and seedling growth**

- 1 Scarification for 2 minutes
- 2 Scarification for 4 minutes
- 3 Scarification for 6 minutes
- 4 Control (dry seeds)

Number of replications : 5

Number of seeds per treatment : 100

Experimental design : Randomised block design

EXPERIMENT III**3.6.3 Effect of gibberellic acid (GA) on seed germination and seedling growth**

- 1 Soaking of seeds in 200 ppm GA for 12 hours
- 2 Soaking of seeds in 200 ppm GA for 24 hours
- 3 Soaking of seeds in 400 ppm GA for 12 hours
- 4 Soaking of seeds in 400 ppm GA for 24 hours
- 5 Soaking of seeds in 600 ppm GA for 12 hours
- 6 Soaking of seeds in 600 ppm GA for 24 hours
- 7 Control (dry seeds)

Number of replications : 5

Number of seeds per treatment : 100

Experimental design : Randomised block design

EXPERIMENT IV**3.6.4 Effect of thiourea on seed germination and seedling growth**

- 1 Soaking of seeds in 0.5% thiourea for 12 hours
- 2 Soaking of seeds in 0.5% thiourea for 24 hours
- 3 Soaking of seeds in 1% thiourea for 12 hours
- 4 Soaking of seeds in 1% thiourea for 24 hours
- 5 Control (dry seeds)

Number of replications : 5

Number of seeds per treatment : 100

Experimental design : Randomised block design

EXPERIMENT V**3.6.5 Effect of potassium nitrate (KNO_3) seeds germination and seedling growth**

- 1 Soaking of seeds in 0.5% potassium nitrate for 12 hours
- 2 Soaking of seeds in 0.5% potassium nitrate for 24 hours
- 3 Soaking of seeds in 1% potassium nitrate for 12 hours
- 4 Soaking of seeds in 1% potassium nitrate for 24 hours
- 5 Control (dry seeds)

Number of replications : 5

Number of seeds per treatment : 100

Experimental design : Randomised block design

EXPERIMENT VI

3.6.6 Effect of different combinations of chemicals, growth regulator, acid scarification and water soaking on seed germination and seedling growth

- 1 Seeds soaked in distilled water for 24 hours + H_2SO_4 treatment for 4 minutes
- 2 Seeds soaked in distilled water for 24 hours + GA 200 ppm for 24 hours
- 3 Seeds soaked in distilled water for 24 hours + GA 400 ppm for 12 hours
- 4 Seeds soaked in distilled water for 24 hours + KNO_3 1% for 12 hours
- 5 Seeds soaked in distilled water for 24 hours + KNO_3 1% for 24 hours
- 6 Seeds soaked in GA 200 ppm for 24 hours + H_2SO_4 treatment for 4 minutes.
- 7 Seeds soaked in GA 200 ppm for 24 hours + KNO_3 1% for 12 hours
- 8 Seeds soaked in GA 200 ppm for 24 hours + KNO_3 1% for 24 hours
- 9 Seeds soaked in GA 400 ppm for 12 hours + H_2SO_4 treatment for 4 minutes.
- 10 Seeds soaked in GA 400 ppm for 12 hours + KNO_3 1% for 12 hours

- 11 Seeds soaked in GA 400 ppm for 12 hours KNO_3 1% for 24 hours
 - 12 Seeds soaked in KNO_3 1% for 12 hours + H_2SO_4 treatment for 4 minutes
 - 13 Seeds soaked in KNO_3 1% for 24 hours + H_2SO_4 treatment for 4 minutes
 - 14 Control (dry seeds)
- Number of replications : 5
- Number of seeds per treatment : 100
- Experimental design : Randomised block design

3.7 PREPARATION OF NURSERY BEDS

The experimental plot was ploughed twice, harrowed and levelled. Raised seed beds of 3m x 1m size were prepared.

3.8 PREPARATION OF STOCK SOLUTIONS

Stock solution of gibberellic acid was prepared by dissolving one gram of the chemical in 95 per cent alcohol and then made up to one litre by adding distilled water. Stock solutions of thiourea and potassium nitrate were prepared by dissolving 10 grams each of the chemical separately in one litre of distilled water. Gibberellic acid, thiourea and potassium nitrate solutions of required concentration were prepared by diluting the stock solution with

distilled water. The solutions thus prepared were immediately used for treating the seeds.

3.9 SEED SOAKING

Healthy and clean seeds were selected for presowing treatments with different chemical solutions as per the treatments mentioned under each experiment. The seeds soaked in distilled water were used as such for sowing in nursery beds. The seeds soaked in gibberellic acid, thiourea and potassium nitrate were thoroughly washed with distilled water and sown in nursery beds, whereas sulphuric acid treated seeds were rinsed with running water before their sowing.

3.10 SOWING

Pre-soaked seeds were sown in at a spacing of 30 x 15 cm at a depth of 2cm and covered with a thin layer of soil. The nursery beds were watered twice a day with a rose can and the beds were weeded regularly to ensure healthy growth of seedlings.

3.11 OBSERVATIONS RECORDED

3.11.1 Sampling technique

For recording observations, five plants were selected at random in each replication for all the treatments. The following observations were recorded on 7th, 14th, 21st and 28th day after germination.

3.11.2 Germiantion percentage

A seed was considered to be germinated when the plumule emerged. Germination percentage was calculated by using the following formula :

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

3.11.3 Co-efficient of velocity of germination

The rate of germination was expressed as co-efficient of velocity of germination calculated as per the formula given by Kotowski (1926).

$$\text{Co-efficient of velocity of germination} = \frac{A_1 + A_2 + \dots + A_x}{A_1T_1 + A_2T_2 + \dots + A_xT_x}$$

Where A = No. of seeds germinated

T = Time taken for initiation of germination

3.11.4 Time taken for initiation of germination

Number of days taken for initiation of germination from date of sowing was recorded.

3.11.5 Seedling vigour index

Seedling vigour index was calculated using the formula given by Abdul-baki and Anderson (1973).

Seedling
vigour index = $\frac{\text{Total length of seedling (root+hypocotyl)}}{\text{x germination percentage}}$

3.11.6 Stem diameter

The stem diameter of seedling was recorded by means of vernier calipers in mm at collar region of stem at weekly intervals.

3.11.7 Plant height

Plant height (cm) was measured from the base to the terminal tip of the plant at weekly intervals.

3.11.8 Root length

The length of root was measured from the collar region to the tip of primary root at weekly intervals.

3.11.9 Number of leaves plant⁻¹

The number of leaves was counted from the base to the tip of seedling at weekly intervals commencing from one week after initiation of germination.

3.11.10 Leaf area plant⁻¹

Area (cm²) of all the leaves present on selected plants was determined with the help of electronic leaf area meter model Ll. 3100 of LICOR instruments USA and leaf area plant⁻¹ was calculated.

3.11.11 Dry matter

Dry matter of leaves, stem, and roots was separately estimated at weekly intervals commencing from 7th day after initiation of germination. Plant parts were dried at 80° C in an oven with thermostat control for 48 hours, weighed and expressed in gram (g)

3.11.12 Relative growth rate (RGR) ($\text{g g}^{-1} \text{ day}^{-1}$)

Relative growth rate was calculated using the formula given by Blackman (1919).

$$\text{RGR} = \frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{t_2 - t_1}$$

Where W_1 and W_2 represent dry matter at the beginning and end of time interval of t_1 and t_2 respectively. The RGR was worked out at weekly intervals.

3.11.13 Leaf weight ratio (LWR) (g g^{-1})

$$\text{LWR} = \frac{\text{LW}}{W}$$

Where LW is leaf dry weight, W is total plant dry weight.

3.11.14 Leaf area ratio (LAR) ($\text{cm}^2 \text{ g}^{-1}$)

$$\text{LAR} = \frac{\text{LA}}{W}$$

Where LA is leaf area and W is total plant dry weight.

3.12 STATISTICAL ANALYSIS

The data were analysed in a computer by the method of variance outlined by Panse and Sukhatme (1978). Statistical significance was tested by F value at 5 per cent of probability. Critical differences at 0.05 level were worked out for the effects which were significant. Character association amongst various attributes were worked out (Snedecor and Chchran, 1967). The data have been depicted graphically where ever necessary.

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CHAPTER IV

RESULTS

RESULTS

The results obtained from various experiments on the germination of *Annona squamosa* seeds are presented experiment wise.

EXPERIMENT I

4.1 STUDIES ON THE INFLUENCE OF WATER SOAKING ON SEED GERMINATION AND SUBSEQUENT SEEDLING GROWTH OF ANNONA

This experiment was planned with five treatments viz., soaking of seeds in water for periods of 12, 24, 36, 48 hours and dry seeds (control). The following parameters were taken under field conditions.

4.1.1 Germination per cent

Soaking in water for 24 h gave highest germination (71 per cent) followed by soaking of seeds for 36 h (67 per cent). There was only 15 per cent germination in control (Table 1.1 and Fig.1.1). Soaking in water for 24 h was on par with soaking for 36 h and significantly differed with all other treatments.

4.1.2 Number of days taken for initiation of germination

Water soaking for 48 h significantly decreased the days taken for initiation of germination (Table 1.1 and Fig.1.1) and it was on par with soaking in

Table 1.1 : Effect of water soaking on the germination of *Annona* seeds

Treatments		Germination (%)	No.of days taken for initiation of germination	Coefficient of velocity of germination	Seedling vigour Index
Water	12 h	49.00	18.00	4.67	1482.74
"	24 h	71.00	17.40	5.01	1988.00
"	36 h	67.00	16.40	3.37	1607.02
"	48 h	43.00	16.00	4.77	1067.03
Dryseeds (control)		15.00	27.00	3.34	915.61
C.D. at 5%		15.54	1.40	0.57	612.46

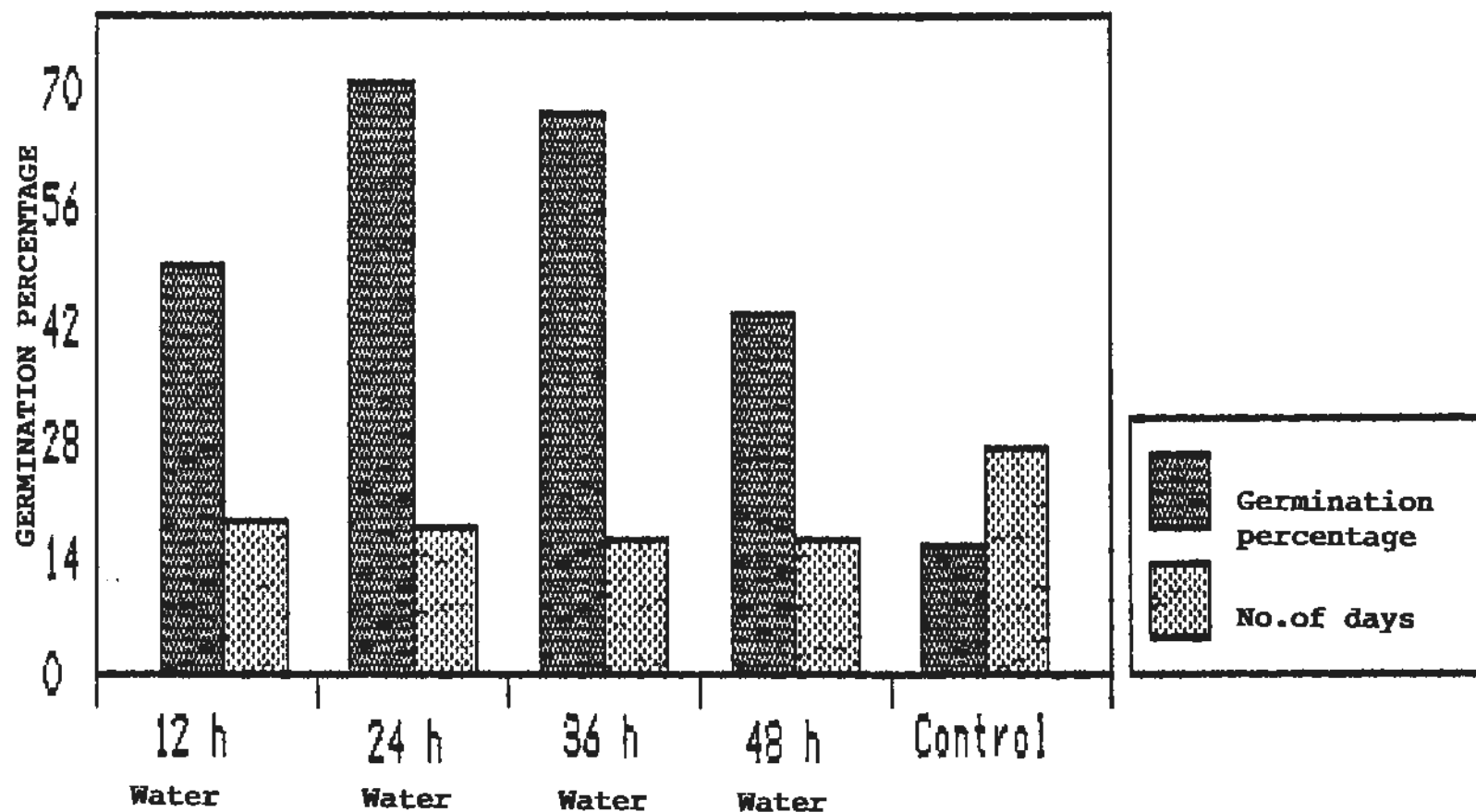


Fig. 1.1 Influence of Annona seed soaking in water on germination

water for 36 and 24 hours, whereas in control, 27 days were needed for initiation of germination. Water soaking for 24 hours (17.40) was on par with soaking for 12 hours.

4.1.3 Coefficient of velocity of germination

Water soaking significantly improved the rate of germination. The highest velocity of germination was recorded in seeds soaked in water for 36 h (5.37) among all treatments. This was followed by soaking in for 24 hours (5.01) which was on par with water soaking for 48 h and 12 hours (Table 1.1). In control velocity of germination was 3.34 only.

4.1.4 Seedling vigour index

Seeds soaked in water for 24 hours recorded maximum (1988) seedling vigour followed by water soaking for 36 h (1607.02) which was on par with the water soaked seeds for 12 h (1482.74) and significantly differed with 48 hour treatment (Table 1.1), whereas in control a minimum seedling vigour of 915.61 was recorded.

4.1.5 Plant height (cm)

Seedling heights were recorded upto an age of one month at weekly intervals (Table 1.2 and Fig.1.2). During first week there were no significant differences

Table 1.2: Effect of water soaking of Annona seeds on plant height and root length of seedlings

Treatments	Plant height (cm)				Root length (cm)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Water 12 h	9.83	14.43	17.06	22.76	3.73	4.96	7.50	7.63
" 24 h	11.13	15.30	18.40	21.80	3.63	5.40	5.83	6.20
" 36 h	11.40	11.80	16.66	21.86	4.06	6.63	5.90	7.20
" 48 h	11.00	15.90	17.06	18.03	5.30	5.43	6.70	6.80
Dryseeds (control)	8.03	9.033	9.60	11.00	2.367	5.30	5.66	6.13
C.D. at 5%	N.S.	2.05	2.30	2.09	N.S.	N.S.	1.86	N.S.

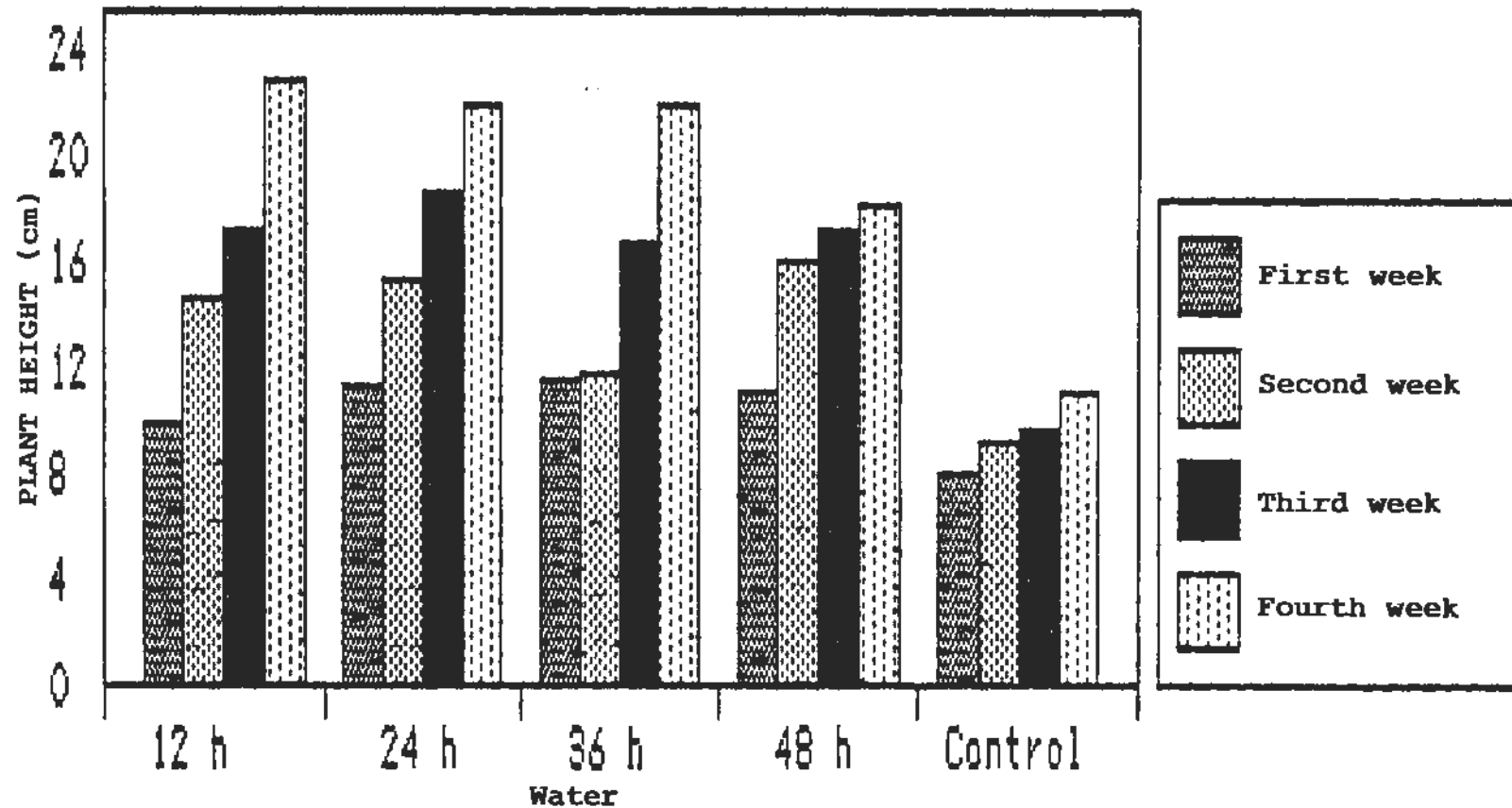


Fig.1.2: INFLUENCE OF ANNONA SEED SOAKING IN WATER ON PLANT HEIGHT

in plant heights among all treatments tested. In second week plant heights differed significantly. Maximum was recorded in plants from seeds soaked for 48 h (15.9 cm) and was on par with water soaked for 24 h (15.3 cm) and 12 h (14.43 cm) respectively. Minimum plant height (9.03 cm) was recorded with dry seeds. During third week of seedling growth, highest plant height (18.40 cm) was recorded in case of water soaking for 24 h and it was on par with all other treatments except control (9.60 cm). In fourth week, maximum plant height (22.76 cm) was recorded with water soaking for 12 h which was on par with 24 as well as 36 hour treatments and also had a significant difference with water soaking for 48 hours, whereas in control minimum height (11.00 cm) was recorded.

4.1.6 Root length (cm)

Seedling root lengths were recorded at weekly intervals upto the age of 4 weeks starting from seventh day (Table 1.2). During first and second weeks there was no significant difference in root lengths among all treatments tested. In first week, maximum root length (5.30 cm) was recorded with water soaking for 48 hours and minimum (2.36 cm) was with control. Like wise in second week, maximum and minimum root lengths were with 36 h (6.63 cm) water treatment and control (5.30 cm)

Table 1.3: Effect of water soaking of Annona seeds on stem diameter and leaf dry weights of seedlings

Treatments	Stem Diameter (mm)				Leaf dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Water 12 h	1.23	1.30	1.53	2.40	0.063	0.083	0.126	0.230
" 24 h	1.73	2.03	2.36	2.36	0.093	0.185	0.250	0.280
" 36 h	2.00	2.10	2.10	2.13	0.055	0.070	0.130	0.225
" 48 h	1.90	2.10	2.53	2.40	0.060	0.090	0.160	0.170
Dryseeds (control)	1.46	1.50	1.93	2.067	0.035	0.050	0.080	0.120
C.D. at 5%	N.S.	0.46	0.61	N.S.	0.015	0.015	0.010	0.010

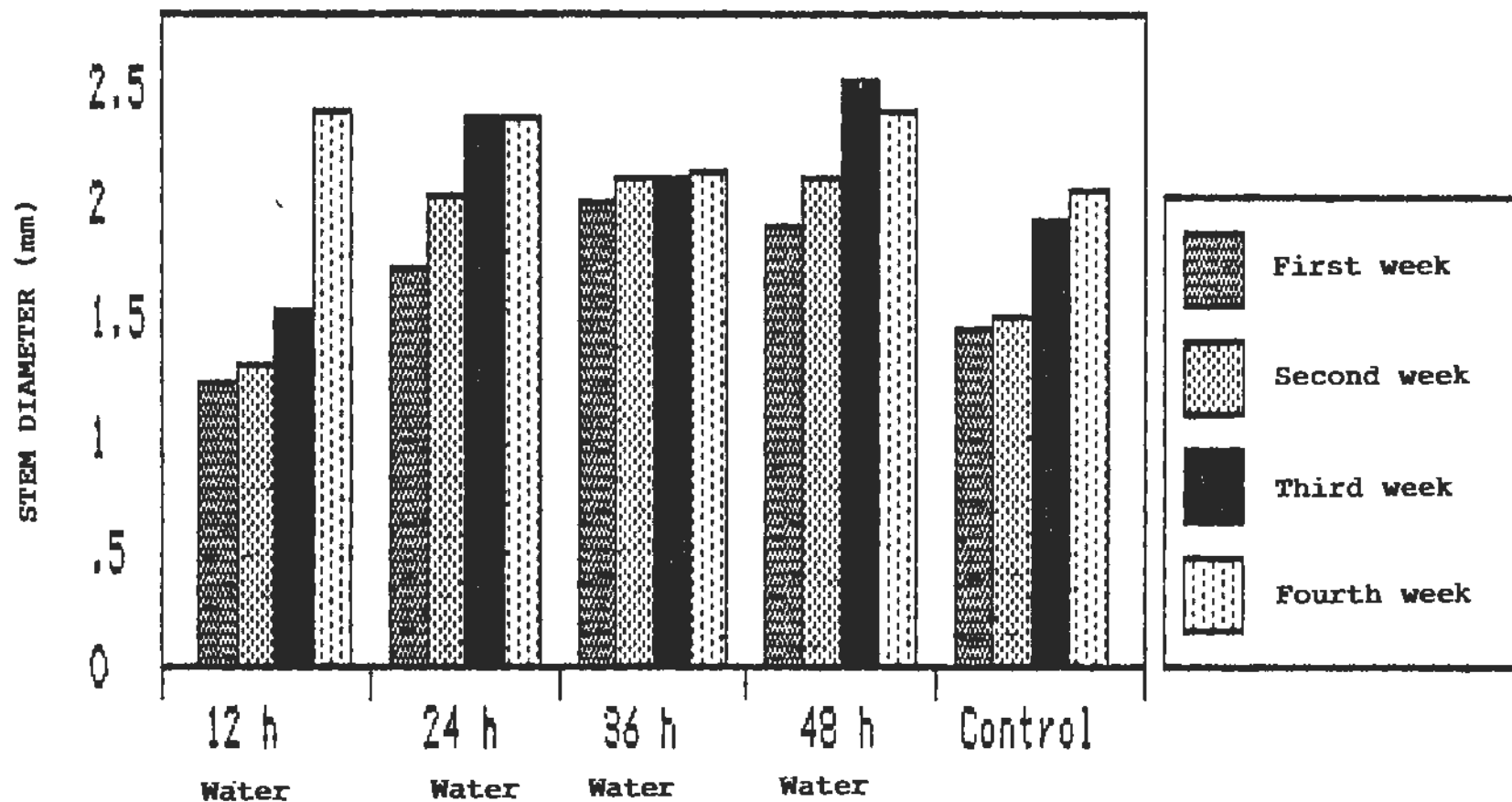


Fig. 1.3 Influence of Annona seed soaking in water on stem diameter

respectively. During third week, root lengths were significantly differed among all treatments tested. Maximum root length was obtained in water soaking for 12 h (7.50 cm) which differed significantly with all treatments except in water soaking for 36 hours (6.70 cm). Minimum root length was obtained with control i.e. dry seeds (5.66 cm). In fourth week of seedling growth there was no significant difference among all treatments. Maximum and minimum root lengths were obtained with water soaking for 12 hours (7.63 cm) and control (6.13 cm) respectively.

4.1.7 Stem diameter (mm)

The data recorded on stem diameter at weekly intervals after germination are presented in Table 1.3 and Fig.1.3. It was found that there was no significant difference in stem diameter among different treatments during first week. Maximum stem diameter (2.00 mm) was recorded when seeds were soaked in water for 36 hours and minimum stem diameter (1.23 cm) was recorded in seeds soaked in water for 12 h. At second week of seedling growth, stem diameter was maximum (2.1 mm), when seeds were soaked in water for 36 h as well as 48 hours and was on par with stem diameter (2.03 mm) in seeds soaked for 24 hours. Those were significantly different with 12 hours water soaking (1.3 mm) and control (1.5 mm).

Table 1.4: Effect of water soaking of Annona seeds on number of leaves and leaf area of seedlings

Treatments		Number of leaves per plant				Leaf area per plant (cm ²)			
		Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Water	12 h	4.66	5.33	5.66	6.00	21.78	28.69	43.55	79.50
"	24 h	4.66	6.00	6.66	7.66	31.11	63.95	83.62	93.33
"	36 h	5.00	5.33	7.00	8.00	19.01	24.19	44.94	77.78
"	48 h	4.00	5.00	5.33	6.66	20.74	31.11	55.31	58.76
Dryseeds (control)		2.66	3.00	4.00	4.33	12.09	17.28	27.65	41.48
C.D. at 5%		0.84	1.28	1.00	0.90	8.19	3.60	0.97	0.08

At third week of seedling growth a maximum stem diameter was recorded in seeds soaked in water for 48 h (2.53 mm). Remaining treatments were on par with water soaked seeds for 48 h except with 12 h water soaked seeds. Minimum stem diameter was recorded with dry seeds (control). At the end of fourth week seedlings resulted from seed soaked in water for 48 h recorded highest stem diameter (2.40 mm) and minimum diameter was with control (2.067 mm).

4.1.8 Number of leaves per plant

The data on number of leaves per plant recorded at different days after germination are presented in Table 1.4.

By the end of first week after germination, maximum number of leaves was recorded with water soaking for 36 hours (5.00) and minimum number of leaves (2.66) in control. Water soaking for 36 hours, 24 h and 12 h were on par with each other and significantly differed with control in respect of number of leaves. When the seedlings were two weeks old, number of leaves present was maximum (6.0) with seeds soaked in water for 24 hours and was minimum (3.0) in control. At the age of three weeks, maximum number of leaves (7.0) was recorded with water soaking of seeds for 36 h

which significantly differed with rest of the treatments, whereas in control, minimum number of leaves (4.0) was recorded. During fourth week, maximum number of leaves was recorded with seeds soaked in water for 36 h (8.0) which was on par with seeds soaked for 24 h and significantly differed with all other treatments. Minimum number of leaves (4.33) was recorded on seedlings from dry seeds.

4.1.9 Leaf area per plant (cm^2)

Leaf area per plant was recorded at weekly intervals of seedling growth and presented in Table 1.4.

During first week, leaf area was at maximum (31.11 cm^2) with seeds soaked in water for 24 h. It significantly differed with all other treatments tested. Total leaf area decreased on seedlings from seeds soaked in water for 24 h, followed by 12 h, 48 h, 36 h and control. At the end of second week of seedling growth, maximum leaf area (63.95 cm^2) was recorded with water soaking for 24 h. It was followed by soaking of seeds in water for 48 h, 12 h and 36 hours. Seed soaking in water for 24 h was significantly superior to all other treatments in respect of total leaf area. A minimum leaf area (17.28 cm^2) was recorded in control. During third week, maximum leaf

area (83.62 cm^2) was recorded with water soaking of seeds for 24 h. It was significantly superior to remaining treatments, whereas minimum (27.65 cm^2) was recorded in control. In the fourth week also, seeds soaked in water for 24 h recorded maximum leaf area (93.33 cm^2) which differed significantly from remaining treatments. A minimum leaf area (41.48 cm^2) was recorded in untreated seeds.

4.1.10 Leaf dry weight (g)

The data on leaf dry weight per plant were recorded at weekly intervals and presented in Table 1.3.

At the end of first week, seeds soaked in water for 24 h produced significantly more leaf dry weight (0.093 g) among all other treatments tested. It was followed by soaking of seeds in water for 12 h, 48 h and 36 h. In control, minimum leaf dry weight (0.035 g) was recorded. At the end of second week, soaking of seeds in water for 24 h recorded significantly more leaf dry weight (0.185 g) among all other treatments tested and was followed by seeds soaked in water for 48 h, 12 h, and 36 hours, whereas minimum leaf dry weight was produced in control (0.050 g). At the end of third week seeds soaked in water for 24 hours recorded significantly highest leaf dry weight. It was followed by

Table 1.5: Effect of water soaking of *Annona* seeds on stem and root dry weights of seedlings

Treatments	Stem dry weight (g)				Root dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Water 12 h	0.033	0.060	0.086	0.130	0.013	0.020	0.030	0.085
" 24 h	0.095	0.108	0.150	0.175	0.085	0.095	0.130	0.145
" 36 h	0.047	0.055	0.065	0.125	0.035	0.045	0.055	0.095
" 48 h	0.035	0.043	0.075	0.100	0.045	0.055	0.070	0.100
Dryseeds (control)	0.023	0.095	0.100	0.150	0.013	0.025	0.040	0.045
C.D. at 5%	0.0083	0.0145	N.S.	0.024	0.0072	0.0092	0.018	0.0073

water soaked seeds for 48 h, 36 h and 12 h treatments. In control, minimum leaf dry weight was recorded. Subsequently, at the end of fourth week water soaked seeds for 24 h recorded significantly more leaf dry weight which was followed by soaking of seeds in water for 24 h, 36 h and 48 h. Minimum leaf dry weight was recorded in control.

4.1.11 Stem dry weight (g)

Data on the dry weight of seedlings at weekly intervals were recorded and presented in Table 1.5.

At end of first, week soaking of seeds in water for 24 h recorded significantly highest stem dry weight (0.095 g) among all the treatments tested. It was followed by seeds soaked in water for 36 h, 48 h and 12 h treatments, whereas in control dry weight was 0.023 g. At the end of second week, seeds soaked in water for 24 h gave highest stem dry weight (0.108 g) and was on par with control (0.095 g), and was significantly more than water soaking of seeds for 12 h, 36 h and 48 h, whereas minimum stem dry weight was recorded with soaking in water for 48 h (0.043 g). By the third week, seeds soaked in water for 24 h gave highest stem dry weight (0.150 g), whereas seeds soaked in water for 36 h recorded minimum dry weight (0.065 g). There was no significant difference among all treatments in

third week. At the end of fourth week, seeds soaked in water for 24 h gave significantly more stem dry weight (0.175 g) among all treatments tested. It was followed by seeds soaked in water for 12 h, 36 h and control treatments, whereas water soaked seeds for 48 h recorded low stem dry weight (0.1 g).

4.1.12 Root dry weight (g)

Dry weight of root was recorded at weekly intervals and presented in Table 1.5.

At the end of first week, seeds soaked in water for 24 h recorded significantly more root dry weight (0.085 g) among all treatments. It was followed by seeds soaked in water for 48 h, 36 h, and 12 h treatments, whereas in control only 0.013 g root dry weight was recorded. In second week also, seeds soaked for 24 h in water gave maximum root dry weight (0.095 g) which significantly differed among all the treatments. Root dry weight was in a decreasing order in the seedlings from the seeds soaked in water for 24 h followed by soaking for 48 h, 36 h and control, whereas minimum was recorded with seeds soaked in water for 12 h (0.020 g). At the end of third week also seeds soaked in water for 24 h recorded significantly highest root dry weight among all treatments and was followed by soaking of seeds in water for 48 h, 36 h

Table 1.6 : Effect of water soaking of *Annona* seeds on relative growth rate

Treatments	Relative growth rate		
	7-14 days	14-21 days	21-28 days
Water 12 h	0.061	0.057	0.087
" 24 h	0.051	0.040	0.021
" 36 h	0.038	0.055	0.082
" 48 h	0.044	0.068	0.028
Dryseeds (control)	0.131	0.037	0.051
C.D. at 5%	0.00017	0.00168	0.000081

and control, whereas seeds soaked in water for 12 h recorded minimum root dry weight (0.030 g). At the end of fourth week also, seeds soaked in water for 24 h recorded significantly more dry weight among all treatments. It was followed by 48 h, 36 h and 12 h treatments, whereas control recorded a minimum root dry weight of 0.045 g.

4.1.13 Relative growth rate

The data on relative growth rate are presented in Table 1.6.

During seventh to fourteenth day of seedling growth maximum relative growth rate was recorded in control (0.131) it was significantly differed from all treatments and followed by seeds soaked in water for 12 h, 24 h, 48 h and 36 h treatments. Lowest was recorded in 36 h treatment (0.038). During fourteenth day and twenty first day, seeds soaked in water for 48 h was recorded highest relative growth rate (0.068) and it was followed by seeds soaked in water for 12 h, 36 h, and 24 h treatments, whereas the control produced a minimum of 0.037. During twenty first day and twenty eighth day, seeds soaked in water for 12 h recorded significantly more relative growth rate followed by seeds soaked in water for 36 h, control and 48 h.

Table 1.7: Effect of water soaking of *Annona* seeds on leaf weight ratio and leaf area ratio of seedlings

Treatments	Leaf Weight Ratio				Leaf Area Ratio			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Water 12 h	0.594	0.509	0.519	0.517	205.47	176.01	179.51	178.65
" 24 h	0.333	0.481	0.471	0.458	115.22	166.10	162.66	158.18
" 36 h	0.423	0.412	0.520	0.506	146.23	142.29	179.76	179.76
" 48 h	0.428	0.474	0.525	0.459	148.14	163.73	181.34	181.34
Dryseeds (control)	0.515	0.294	0.364	0.381	177.91	101.64	125.68	131.68
C.D. at 5%	0.0017	N.S.	0.0165	0.00072	0.1664	0.2353	0.2353	0.1176

Soaking of seeds in water for 24 h recorded minimum relative growth rate (0.021).

4.1.14 Leaf Weight Ratio

Leaf weight ratios were worked out at weekly intervals and presented in Table 1.7.

At the end of first week, seeds soaked in water for 12 h recorded a significantly highest leaf weight ratio among rest of treatments. It was followed by control, water soaking for 48 h or 36 h treatments. Seeds soaked in water for 24 h recorded the least leaf weight ratio (0.333). During second week also, seeds soaked in water for 12 h recorded maximum leaf weight ratio. It was followed by soaking in water for 24 h, 48 h and 36 h treatments, whereas in control minimum leaf weight was recorded. During third week, seeds soaked for 48 h recorded maximum leaf weight ratio (0.525) which was on par with soaking in water for 36 h and 12 h treatments. Minimum leaf weight ratio was recorded with control (0.364). During fourth week, seeds soaked for 12 h again recorded significantly highest leaf weight ratio when compared to all other treatments tested. This was followed by seeds soaked in water for 36 h, 48 h, and 24 h treatments, whereas minimum leaf weight ratio was recorded in control.

4.1.15 Leaf Area Ratio

Leaf area ratios were calculated at weekly intervals and presented in Table 1.7.

During first week, seeds soaked in water for 12 h recorded significantly highest leaf area ratio (205.47). It was followed by control, soaking in water for 48 h and 36 h treatments. Minimum leaf area ratio was recorded with seeds soaked in water for 24 h treatment. During second week also, seeds soaked in water for 12 h recorded significantly highest leaf area ratio among all treatments tested. It was followed by seeds soaked in water for 24 h, 48 h and 36 h treatments, whereas in control the minimum leaf area ratio was recorded. In the third week, seeds soaked in water for 48 h recorded significantly highest leaf area ratio (181.34). It was followed by soaking for 36 h, 12 h and 24 h treatments. Minimum leaf area ratio was recorded with control (125.68). In fourth week, seeds soaked in water for 48 h recorded maximum leaf area ratio (181.34) which significantly differed with all other treatments, whereas minimum leaf area ratio was recorded with control.

Table 1.8: Correlation coefficients amongst germination and seedling attributes in water soaked *Annona* seeds

Seedling attributes	Seedling vigour index	Coefficient of velocity of germination	Stem diameter	Plant height	Root length	Number of leaves per plant	Leaf area per plant	Germination percentage
Days for initiation of germination	-0.706**	-0.831**	-0.535**	-0.825**	-0.317	-0.828**	-0.693**	-0.696**
Seedling vigour index		0.737**	0.204	0.829**	0.018	0.814**	0.854**	0.991**
Coefficient of velocity of germination			0.344	0.740**	0.381	0.823**	0.708**	0.722**
Stem diameter				0.533**	0.176	0.316	0.434*	0.190
Plant height					0.301	0.785**	0.907**	0.773**
Root length						0.170	0.170	0.037
Number of leaves per plant							0.776**	0.812**
Leaf area per plant								0.812**

** Significant at 1% level

* Significant at 5% level

4.1.16 Correlations amongst germination and seedling attributes

The correlation coefficients calculated amongst various germination and seedling attributes are given in Table 1.8.

The final germination percentage had an appreciable negative relationship with days taken for commencement of germination (-0.696). But the relationship was highly positive with seedling vigour, velocity of germination, height, number of leaves and leaf area. The days taken for commencement of germination had a negative and strong correlation with vigour, velocity of germination, stem diameter, height of seedlings, number of leaves and leaf area. Seedling vigour had a positive correlation with velocity of germination, height of seedling, number of leaves and leaf area. Velocity of germination also had strong positive correlation with height of seedling, number of leaves and leaf area. Stem diameter was positively correlated with leaf area. Number of leaves and leaf area were positively correlated with each other.

EXPERIMENT II

4.2 STUDIES ON THE INFLUENCE OF ACID SCARIFICATION (H_2SO_4) ON ANNONA SEED GERMINATION AND SUBSEQUENT SEEDLING GROWTH

Annona seeds were treated with concentrated sulphuric acid (H_2SO_4) for a period of 2 min, 4 min or 6 min to find out the effect of acid scarification on seed germination and subsequent seedling growth. Dry seeds i.e. without any treatment were considered as control. The results obtained under field conditions are presented.

4.2.1 Germination percentage

The data recorded on germination percentage are presented in Table 2.1 and Fig.2.1.

Seeds soaked in concentrated sulphuric acid for 4 min recorded significantly highest germination (58.0) among all treatments, whereas sulphuric acid treated seeds for 6 min and 2 min recorded 42.0 and 31.0 per cent of germination respectively. In control, only 12.0 per cent of seeds were germinated.

4.2.2 Number of days taken for initiation of germination

Minimum number of days (20.0) were taken for initiation of germination by the seeds treated with

Table 2.1: Effect of acid scarification on *Annona* seed germination

Treatments	Germination (%)	No. of days taken for initiation of germination	Coefficient of velocity of germination	Seedling vigour Index
Scarification (H ₂ SO ₄)				
for 2 min.	31.0	22.0	4.61	640.46
4 min.	58.0	20.0	4.80	1281.80
6 min.	42.0	20.0	4.51	768.13
Control (dry seeds)	12.0	30.0	3.34	205.56
C.D. at 5%	11.00	2.19	0.243	222.38

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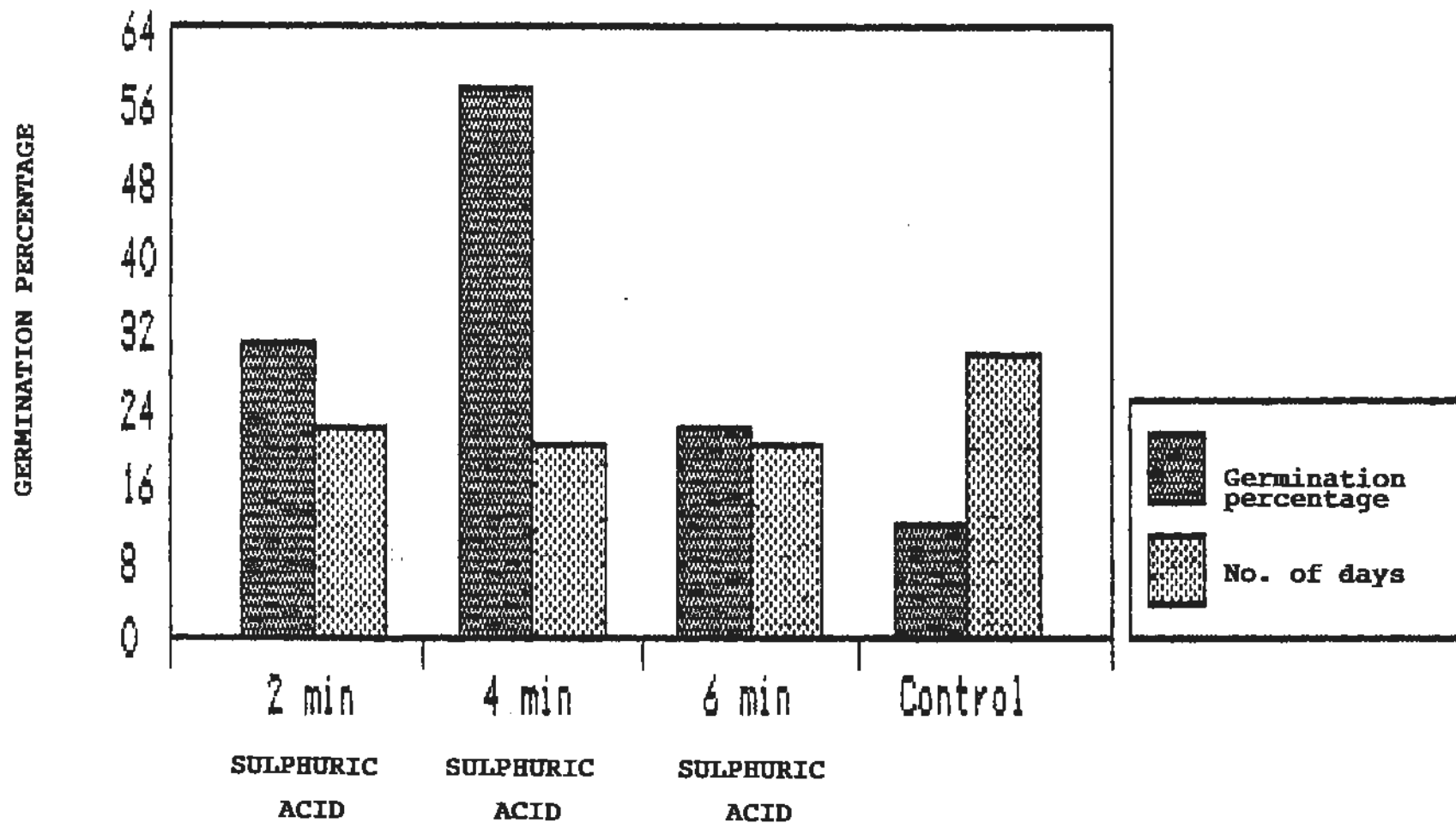


Fig. 2.1 Influence of ann ona seed scarification on germination

sulphuric acid for 4 min as well as 6 min, whereas seeds treated with sulphuric acid for 2 min needed 22 days for the initiation of germination (Table 2.1 and Fig.2.1). In control, germination started only after 30 days of sowing.

4.2.3 Coefficient of velocity of germination

A significant variation in velocity of germination was recorded. Maximum velocity of germination (4.80) was recorded with seeds treated in sulphuric acid for 4 min (Table 2.1). It was on par with seeds treated with sulphuric acid for 2 min and significantly superior to 6 min treatment. In control, minimum velocity of germination was recorded (3.34).

4.2.4 Seedling vigour index

The data recorded on seedling vigour are presented in Table 2.1.

It was found that seeds soaked in sulphuric acid for 4 min recorded significantly highest vigour (1281.8) among all treatments, whereas treatment with sulphuric acid for 6 min (768.13) was on par with 2 min treatment (640.46). In control, minimum vigour was recorded (205.56).

Table 2.2: Effect of acid scarification of *Annona* seeds on plant height and root length of seedlings

Treatments	Plant height (cm)				Root length (cm)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Scarification (H ₂ SO ₄)								
for 2 min.	7.46	9.73	10.40	13.66	2.20	4.06	6.60	7.00
4 min.	8.63	9.96	10.36	14.80	5.20	5.30	7.03	7.26
6 min.	7.73	8.76	8.90	11.16	1.36	3.80	6.23	7.13
Control (dry seeds)	8.10	8.76	9.60	11.0	2.86	4.70	5.46	6.16
C.D. at 5%	N.S.	0.878	N.S.	N.S.	1.10	N.S.	N.S.	N.S.

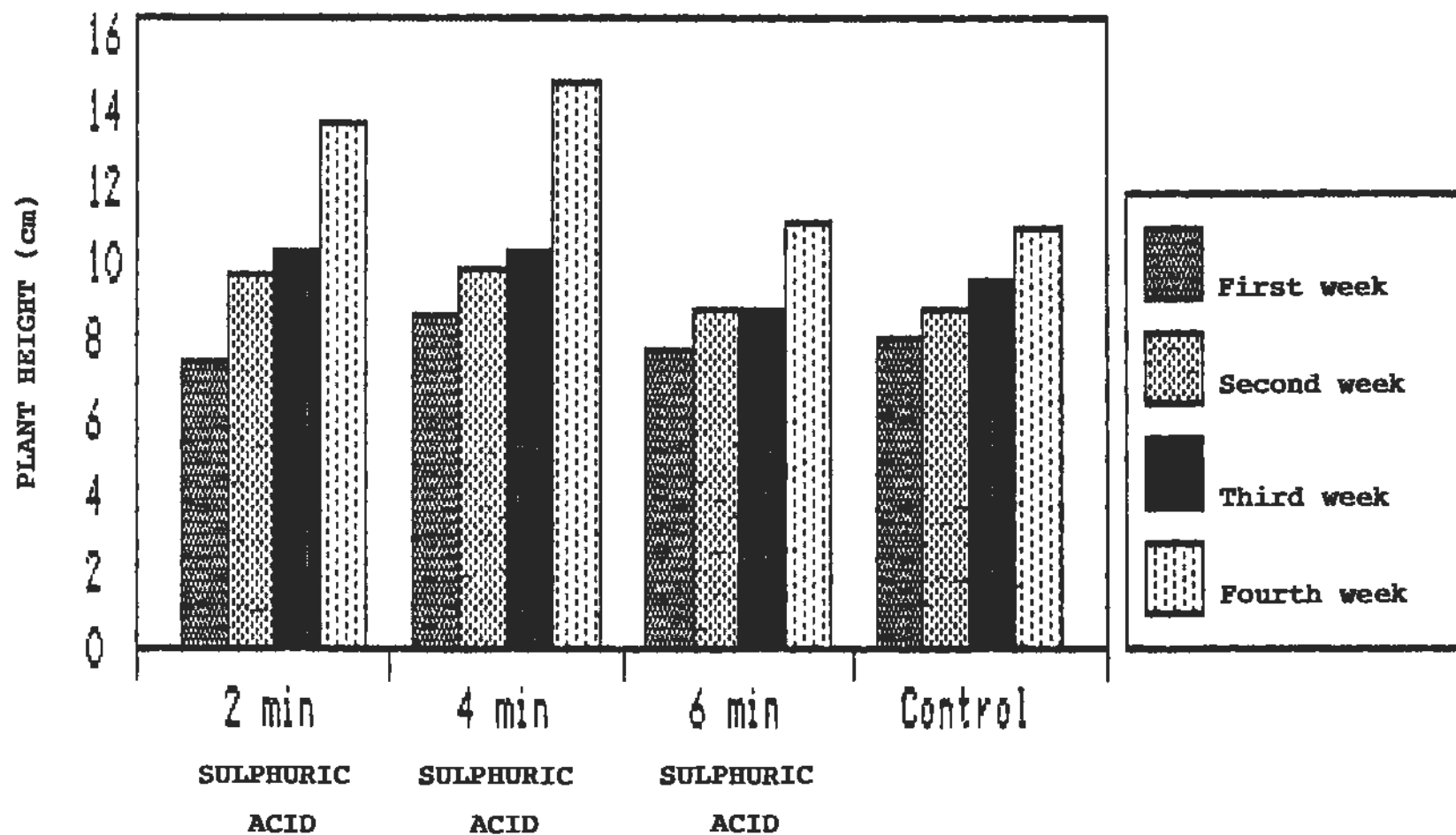


Fig. 2.2 Influence of Annona seed scarification on plant height.

4.2.5 Plant height (cm)

The data recorded on plant height at weekly intervals are presented in Table 2.2 and Fig.2.2.

There was no significant difference in plant height under different treatments at the end of first week. The seeds treated with concentrated sulphuric acid for 4 min and 2 min recorded maximum (8.63 cm) and minimum (7.46 cm) heights respectively. At the second week, seeds treated with concentrated sulphuric acid for 4 min recorded significantly maximum height (9.96 cm), whereas seeds treated with sulphuric acid for 2 min recorded 9.73 cm height. Minimum plant height was observed in control (8.76 cm) as well as with seeds treated with sulphuric acid for 6 min (8.76 cm). At the third week, plant heights did not differ significantly among all treatments. Seeds treated with concentrated sulphuric acid for 2 min and for 4 min recorded 10.4 cm, 10.36 cm heights respectively. At the fourth week also, plant heights did not differ significantly. Maximum plant height was recorded with sulphuric acid treated seeds for 4 min (14.8 cm) closely followed by seeds treated with sulphuric acid for 2 min (13.66 cm), whereas, minimum plant height (11.0 cm) was recorded in control.

4.2.6 Root length (cm)

The data recorded on root length at weekly intervals are presented in Table 2.2.

At the end of first week, seeds treated with concentrated sulphuric acid for 4 min recorded significantly maximum root length (5.2 cm) among all treatments tested. The control and sulphuric acid treatment for 2 min recorded 2.86 cm and 2.2 cm root lengths respectively, whereas scarified seeds for 6 min recorded minimum root length (1.36 cm). At the second week, root length in all treatments did not differ significantly. Seeds treated with sulphuric acid for 4 min and 6 min produced maximum (5.3 cm) and minimum (3.8 cm) root lengths. At the age of third week also, root length did not differ significantly in all treatments tested. Maximum and minimum root length was produced with sulphuric acid treatment for 4 min (7.03 cm) and control (5.46 cm) respectively. At the age of fourth week, it was found that there was no significant difference among all treatments in respect of root length. Treating of seeds with concentrated sulphuric acid for 4 min recorded maximum (7.26 cm) root length, whereas in control minimum root length was recorded (6.16 cm). The other treatments fell in between above treatments.

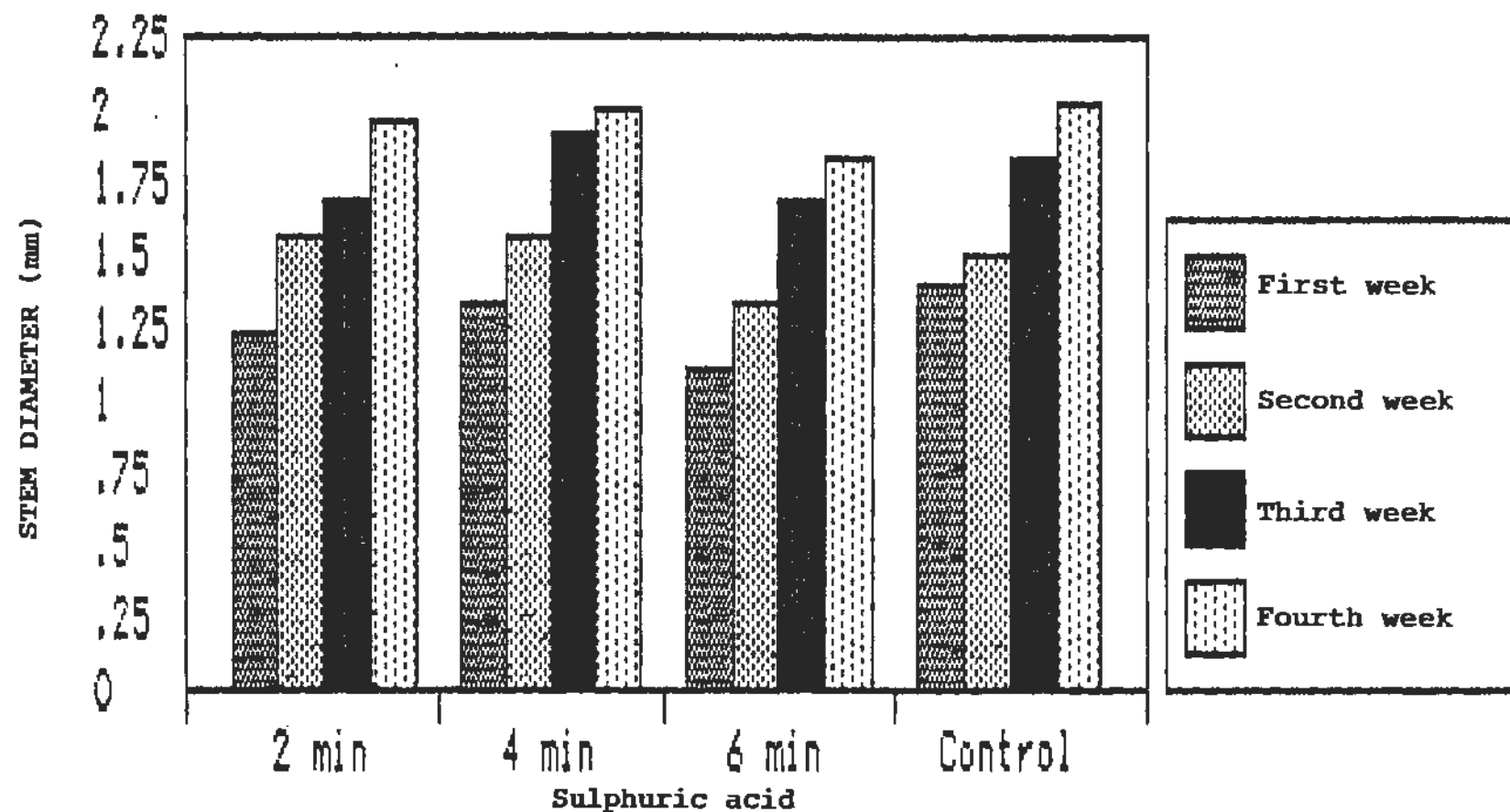


Fig.2.3: INFLUENCE OF ANNONA SEED SCARIFICATION ON STEM DIAMETER

4.2.7 Stem diameter (mm)

The data recorded on stem diameter at weekly intervals are presented in Table 2.4 and Fig.2.3.

At the end of first week, maximum stem diameter (1.4 mm) was recorded in control and it was significantly superior to all other treatments, whereas minimum stem diameter was recorded with seeds treated with concentrated sulphuric acid for 6 min (1.1 mm). Other treatments are intermediary between above said treatments. At the end of the second week, it was found that there was no significant difference among all treatments tested. Maximum and minimum stem diameter was recorded with seeds treated with concentrated sulphuric acid for 4 min (1.56 mm) and 6 min (1.33 mm) respectively. At the end of third week also, stem diameter did not differ significantly in all the treatments. Seeds treated with concentrated sulphuric acid for 4 min (1.93 mm) and 6 min (1.7 mm) recorded maximum and minimum stem diameter respectively. At the end of fourth week, maximum diameter was recorded in control (2.03 mm), whereas minimum stem diameter was recorded with seeds treated with concentrated sulphuric acid for 6 min (1.83mm).

Table 2.3: Effect of acid scarification of *Annona* seeds on number of leaves and leaf area of seedlings

Treatments	Number of leaves per plant				Leaf area per plant (cm ²)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Scarification (H ₂ SO ₄)								
for 2 min.	2.66	4.00	5.33	6.66	15.55	22.81	31.11	48.36
4 min.	3.66	4.66	6.33	7.66	19.02	32.84	41.48	50.12
6 min.	3.66	4.33	5.00	6.33	5.18	29.37	34.56	43.21
Control (dry seeds)	2.66	3.00	4.00	4.33	12.09	13.82	25.92	41.48
C.D. at 5%	N.S.	N.S.	1.33	0.88	0.0201	0.0509	0.025	0.062

4.2.8 Number of leaves per plant

The data recorded on number of leaves are presented in Table 2.3.

At the end of first week, there was no significant difference among all treatments in respect of number of leaves. Seeds treated with concentrated sulphuric acid for 4 min (3.66 mm) and untreated seeds (2.66 mm) recorded maximum and minimum leaves per plant. At the age of second week, number of leaves did not differ significantly among all treatments. Maximum (4.66) and minimum (3.00) number of leaves was recorded with scarified seeds for 4 min and control respectively. At the age of third week seeds treated with concentrated sulphuric acid for 4 min recorded significantly more number of leaves (6.33) and it was on par with scarification of seeds for 2 min. However, minimum number of leaves was recorded in control. At the fourth week, seeds treated with concentrated sulphuric acid for 4 min recorded significantly more number of leaves (7.66) among all treatments tested. In control, minimum number of leaves (4.33) was recorded.

4.2.9 Leaf area per plant (cm²)

The data recorded on leaf area per plant at weekly intervals are presented in Table 2.3.

Table 2.4: Effect of acid scarification of *Annona* seeds on stem diameter and leaf dry weight of seedlings

Treatments	Stem diameter (mm)				Leaf dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Scarification (H ₂ SO ₄)								
for 2 min.	1.23	1.56	1.70	1.96	0.045	0.066	0.090	0.140
4 min.	1.33	1.56	1.93	2.00	0.055	0.095	0.120	0.145
6 min.	1.10	1.33	1.70	1.83	0.015	0.085	0.1	0.125
Control (dry seeds)	1.40	1.50	1.83	2.03	0.035	0.040	0.075	0.120
C.D. at 5%	0.202	N.S.	N.S.	N.S.	N.S.	0.0059	0.017	0.014

At the end of first week, seeds soaked in concentrated sulphuric acid for 4 min recorded significantly highest leaf area (19.02 cm^2) and it was followed by treatments like scarification of seeds for 2 min and control. Minimum leaf area (5.18 cm^2) was recorded in treatment with concentrated sulphuric acid for 6 min. At the second week also scarified seeds for 4 min recorded maximum leaf area (32.84 cm^2). It was significantly superior to all other treatments, whereas seeds treated with concentrated sulphuric acid for 2 min and 4 min recorded 22.81 cm^2 and 29.37 cm^2 leaf area respectively. In control, minimum leaf area was recorded. At the third week, leaf area recorded in all the treatments differed significantly and maximum was recorded with control (25.92 cm^2). At the fourth week also sulphuric acid scarified seeds for 4 min produced maximum leaf area (50.12 cm^2) which was closely followed by seeds scarified for 2 min and 6 min. Minimum leaf area was recorded in control (41.48 cm^2).

4.2.10 Leaf dry weight (g)

The data recorded on leaf dry weight at weekly intervals are presented in Table 2.4.

It was found that there was no significant difference among all treatments at the end of first

week of seedling growth. Maximum and minimum leaf dry weight was recorded with seeds treated with concentrated sulphuric acid for 4 min (0.055 g) and 6 min (0.15 g) respectively. At the end of second week, leaf dry weight significantly differed among all treatments tried. Seeds scarified for 4 min and control recorded maximum (0.095 g) and minimum (0.040 g) leaf dry weight respectively. At the third week also, seeds treated with concentrated sulphuric acid for 4 min recorded significantly more dry weight (0.12 g). It was followed by seeds scarified for 6 min and 4 min, whereas, leaf dry weight was minimum in control. At the fourth week dry weight differed significantly in all treatments. Leaf dry weight was maximum with seeds treated with concentrated sulphuric acid for 4 min (0.145) closely followed by scarification for 2 min, whereas in control dry weight was minimum.

4.2.11 Stem dry weight (g)

The data recorded on stem dry weight at weekly intervals are presented in Table 2.5.

At the end of first week, there was no significant difference among all treatments in respect of stem dry weight. Maximum (0.097 g) and minimum (0.02 g) stem dry weight was recorded with sulphuric acid treated seeds for 4 min and control respectively. At

Table 2.5: Effect of acid scarification of *Annona* seeds on stem and root dry weights of seedlings

Treatments	Stem dry weight (g)				Root dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Scarification (H ₂ SO ₄)								
for 2 min.	0.043	0.045	0.055	0.075	0.011	0.025	0.040	0.045
4 min.	0.097	0.110	0.120	0.160	0.095	0.1	0.135	0.150
6 min.	0.050	0.095	0.100	0.123	0.050	0.070	0.074	0.085
Control (dry seeds)	0.020	0.094	0.100	0.100	0.010	0.025	0.020	0.050
C.D. at 5%	N.S.	0.013	0.0089	0.013	0.0101	0.012	0.012	0.0046

the end of second week also, maximum dry weight (0.11 g) was recorded with sulphuric acid treated seeds for 4 min which was significantly superior to all treatments tried. Stem dry weight was minimum (0.045 g) in seeds treated in sulphuric acid for 2 min. At the end of third week, stem dry weight differed significantly among all treatments. Seeds scarified for 4 min recorded maximum dry weight (0.12 g) and was followed by scarification for 6 min, whereas dry weight was minimum in scarified seeds for 2 min. At the end of fourth week also, sulphuric acid treated seeds for 4 min recorded significantly more dry weight (0.16 g) which was significantly superior to all treatments. It was closely followed by scarified seeds for 6 min. Minimum stem dry weight was recorded with sulphuric acid treated seeds for 2 min.

4.2.12 Root dry weight (g)

The data on root dry weight are presented in Table 2.5.

At the end of first week, root dry weight differed significantly among all treatments. The maximum dry weight was recorded with seeds treated with sulphuric acid for 4 min (0.095 g) and it was followed by seeds treated with sulphuric acid for 6 min, whereas in control minimum dry weight was recorded. At the end

Table 2.6: Effect of acid scarification of *Annona* seeds on relative growth rate

Treatments	Relative growth rate		
	7-14 days	14-21 days	21-28 days
Scarification (H ₂ SO ₄)			
for 2 min.	0.105	0.044	0.049
4 min.	0.031	0.030	0.028
6 min.	0.031	0.011	0.030
Control (dry seeds)	0.113	0.068	0.025
C.D. at 5%	N.S.	0.00003	N.S.

of second week also, root dry weight differed significantly among all treatments. Maximum and minimum dry weights were recorded with seeds scarified for 4 min (0.1 g) and control (0.025 g) respectively. At the age of third week also, maximum dry weight (0.135 g) was recorded in seeds treated with sulphuric acid for 4 min which was significantly superior to all other treatments. Root dry weight was minimum (0.020 g) in control. At the fourth week, dry weight differed significantly among all treatments. Dry weight was maximum (0.15 g) in seeds treated with sulphuric acid for 4 min. It was significantly superior to control as well as scarification for 6 min, whereas minimum root dry weight was recorded (0.045 g) in seeds scarified for 2 min.

4.2.13 Relative Growth Rate

The data on relative growth rate are tabulated in Table 2.6.

Between seven and fourteen days relative growth rate recorded was maximum in untreated dry seeds (0.113), whereas seeds treated with sulphuric acid for 2 min, 4 min and 5 min recorded 0.105, 0.031, and 0.111 relative growth rate respectively. Between fourteen and twenty one days relative growth rate significantly differed among all treatments. Among them, maximum

Table 2.7: Effect of acid scarification of Annona seeds on leaf weight ratio and leaf area ratio of seedlings

Treatments	Leaf weight ratio				Leaf area ratio			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Scarification (H ₂ SO ₄)								
for 2 min.	0.692	0.485	0.486	0.538	239.23	167.72	168.16	186.11
4 min.	0.224	0.311	0.320	0.319	77.59	107.67	110.61	110.15
6 min.	0.130	0.340	0.370	0.375	45.08	117.52	128.00	129.75
Control (dry seeds)	0.467	0.242	0.283	0.381	161.32	83.75	97.81	131.68
C.D. at 5%	0.00039	0.002	0.0041	0.00028	0.227	0.176	1.85	0.322

relative growth rate (0.068) was recorded in control, whereas treatments like scarification for 2 min, 4 min and 6 min recorded 0.044, 0.030 and 0.011 relative growth rate respectively. Between twenty one and twenty eight days maximum and minimum relative growth rate was recorded in seeds treated with sulphuric acid for 2 min (0.049) and control (0.025) respectively.

4.2.14 Leaf Weight Ratio

Leaf weight ratio was calculated at weekly intervals and presented in Table 2.7.

At the end of first week, leaf weight ratio differed significantly among all treatments. Maximum leaf weight ratio was recorded with seed treated with sulphuric acid for 2 min (0.692), whereas control and sulphuric acid treated seeds for 4 min recorded 0.467 and 0.224 leaf weight ratio respectively. At the end of second week, significantly maximum leaf weight ratio was recorded in seeds treated with sulphuric acid for 2 min (0.485). It was followed by scarification for 6 min and 4 min. Minimum leaf weight ratio was recorded in control (0.242). At the end of third week, scarification for 2 min recorded significantly maximum leaf weight ratio, whereas it was minimum in control. At the end of fourth week, leaf weight ratio at differed significantly among all treatments. Maximum leaf

weight ratio was obtained with sulphuric acid treated seeds for 2 min (0.538). This was followed by treatments like scarification of seeds for 6 min and control. Minimum leaf weight ratio was recorded with scarification for 4 min (0.319).

4.2.15 Leaf area ratio

At the first week, seed scarification for 2 min recorded significantly more leaf area ratio (239.23) followed by control (161.32). Scarification for 4 min (77.59) and 6 min (45.08) were next least to control (Table 2.7).

At the age of second week, seeds treated with sulphuric acid for 2 min recorded significantly maximum leaf area ratio (167.72). It was followed by treatment for 6 min and 4 min, whereas in control leaf area ratio was minimum (83.75). At the age of third week also, significantly maximum leaf area ratio was from seeds scarified for 2 min (168.16) followed by scarification for 6 min and 2 min, whereas in control leaf area ratio was found to be minimum. At the age of fourth week, seeds treated with sulphuric acid for 2 min recorded significantly more leaf area ratio (186.11) followed by treatment for 6 min and control in respect of leaf area ratio. Leaf area ratio recorded was minimum (110.15) in seeds treated with sulphuric acid for 4 min.

Table 2.8: Correlation coefficients amongst germination and seedling attributes in acid scarified *Annona* seeds

Seedling attributes	Seedling vigour index	Coefficient of velocity of germination	Stem diameter	Plant height	Root length	Number of leaves per plant	Leaf area per plant	Germination percentage
Days for initiation of germination	-0.69076**	-0.86931**	0.22915	-0.44941*	-0.48012*	-0.78317**	-0.60896**	-0.71314**
Seedling vigour index		0.80222**	0.00363	0.57040**	0.58273**	0.76851**	0.71581**	0.98916**
Coefficient of velocity of germination			-0.11808	0.54445*	0.56881**	0.89860**	0.77652**	0.8007**
Stem diameter				0.01365	0.32026	-0.10027	0.08031	-0.04290
Plant height					0.02867	0.67837**	0.85918**	0.47859*
Root length						0.44446	0.39356	0.60188**
Number of leaves per plant							0.84734**	0.7353**
Leaf area per plant								0.63186**

** Significant at 1% level

* Significant at 5% level

4.2.16 Correlations amongst germination and seedling growth attributes

The correlation values worked out for various germination and seedling growth attributes are presented in Table 2.8.

The final germination percentage was positively correlated with seedling vigour, velocity of germination, plant height, root length, number of leaves and root length. But with number of days taken for initiation of germination was negatively correlated which in turn had a negative relationship with seedling vigour, velocity of germination, plant height, root length, number of leaves and leaf area. The seedling vigour had a strong positive relationship with velocity of germination, plant height, root length, number of leaves and leaf area. Velocity of germination was positively correlated with plant height, root length, number of leaves and leaf area. The plant height, number of leaves and leaf area were positively correlated with each other.

Experiment III

4.3 STUDIES ON THE INFLUENCE OF ANNONA SEED SOAKING IN GIBBERELLIC ACID ON GERMINATION AND SUBSEQUENT SEEDLING GROWTH

This experiment was planned with seven treatments. Annona seeds were soaked in gibberellic acid. Three different concentrations of GA used were 200 ppm, 400 ppm and 600 ppm. Seeds were soaked in each concentration for 12 hours, or 24 hours separately. Dry seeds were considered as control. The results on various aspects recorded under field conditions are presented.

4.3.1 Germination percentage

Seeds treated with GA 400 ppm for 12 h (Table 3.1) gave highest germination (69 per cent) followed by GA 200 ppm for 24 h (64 per cent). There was only 13 per cent of germination in control (Table 3.1 and Fig.3.1). GA 200 ppm for 24 h was on par with GA 400 ppm for 24 h and GA 600 ppm for 12 hours. Soaking the seeds in GA 200 ppm for 12 h was significantly superior to GA 600 ppm for 24 h in improving germination.

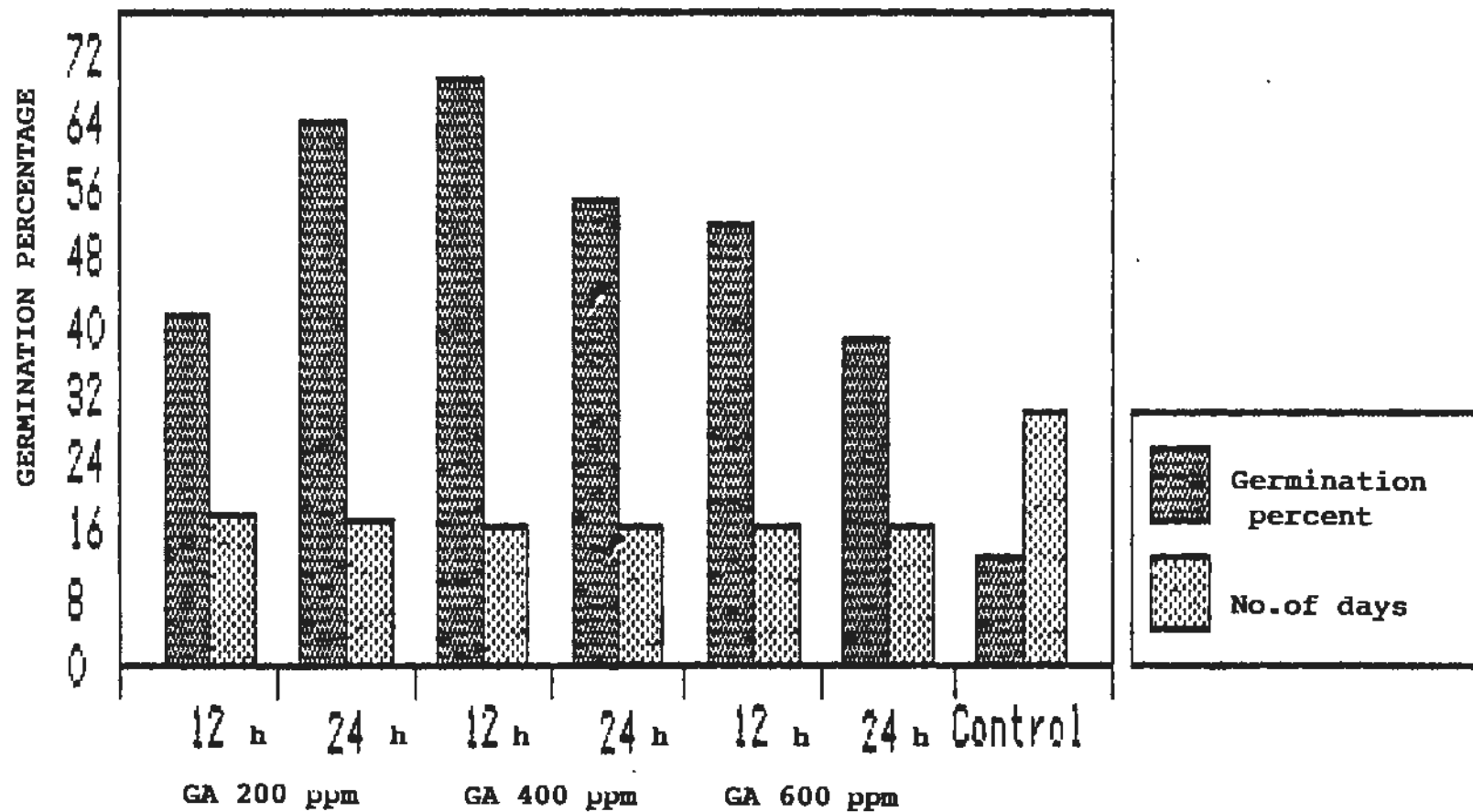


Fig. 3.1 Influence of Annona seed soaking in gibberellic acid on germination

Table 3.1: Effect of Gibberellic acid on *Annona* seed germination

Treatments	Germination (%)	No. of days taken for initiation of germination	Coefficient of velocity of germination	Seedling vigour Index
GA 200 ppm				
12 h	41.00	17.60	4.84	1050.26
24 h	64.00	17.00	5.13	2173.50
GA 400 ppm				
12 h	69.00	16.40	4.98	2403.84
24 h	55.00	16.20	4.81	1644.50
GA 600 ppm				
12 h	52.00	16.00	4.95	1694.72
24 h	38.00	16.00	5.14	1054.88
Control (dry seeds)	13.00	30.00	3.30	225.29
C.D. at 5%	18.49	1.52	0.25	564.02

4.3.2 Number of days taken for initiation of germination

The data on number of days taken for initiation of germination presented in Table 3.1 and Fig.3.1 indicated that seeds soaked in GA 600 ppm for 12 h as well as 24 hours required minimum number of days for initiation of germination (16 days). This was followed by seeds soaked in GA 400 ppm for 24 h (16.2 days) and 12 h (16.4 days). Seeds soaked in GA 200 ppm for 12 h and 24 h needed 17 days and 17.6 days respectively. Dry seeds i.e., control, however, required 30 days for germination.

4.3.3 Coefficient of velocity of germination

Data pertaining to coefficient of velocity of germination are presented in Table 3.1.

Velocity of germination was more in seeds soaked in GA 600 ppm for 24 h (5.14). This was closely followed by 200 ppm for 24 h (5.13). Seed soaking in GA 200 ppm for 24 h was significantly superior to control. In control, velocity of germination was only 3.30.

4.3.4 Seedling vigour index

Seeds soaked in GA 400 ppm for 12 h recorded highest seedling vigour (2403.84). This was on par

Table 3.2: Effect of pre soaking of Annona seeds in gibberellic acid on plant height and root length of seedlings

Treatments	Plant height (cm)				Root length (cm)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
GA 200 ppm								
12 h	9.36	13.56	16.33	21.10	3.80	4.76	5.83	6.10
24 h	12.86	14.63	19.46	22.40	3.80	6.23	7.23	9.10
GA 400 ppm								
12 h	9.06	14.00	16.56	25.33	2.86	4.13	6.00	12.23
24 h	8.73	13.23	15.50	21.70	4.36	4.56	5.10	8.20
GA 600 ppm								
12 h	9.86	14.63	15.30	22.53	6.10	6.66	6.80	10.06
24 h	8.80	12.86	19.26	21.63	2.00	2.63	2.90	6.13
Control (dry seeds)	8.13	9.03	9.70	11.10	3.36	3.93	4.63	6.23
C.D. at 5%	N.S.	1.98	1.40	1.73	N.S.	2.19	1.81	3.78

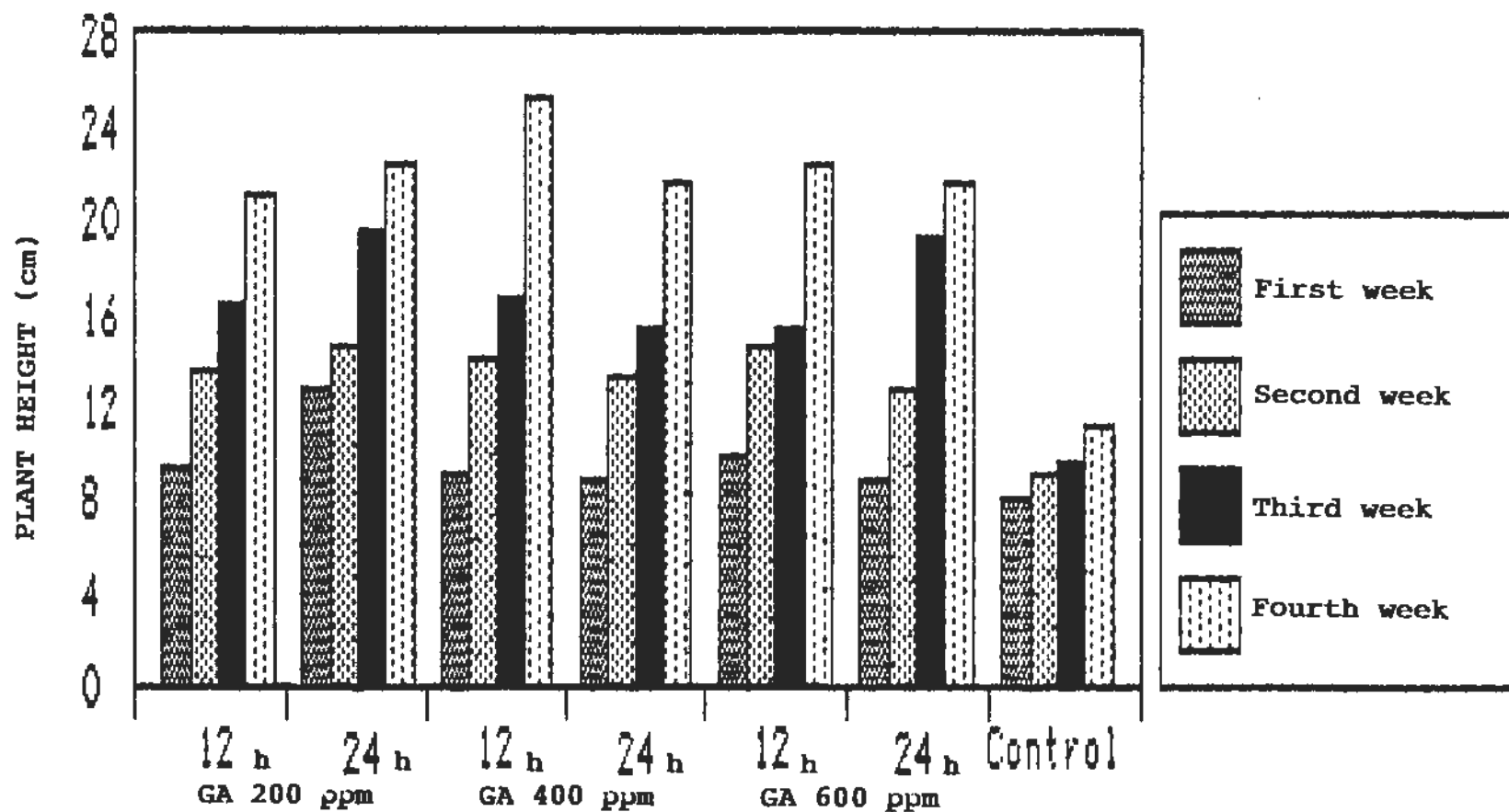


Fig.3.2: INFLUENCE OF ANNONA SEED SOAKING IN GIBBERELLIC ACID ON PLANT HEIGHT

with seeds soaked in GA 200 ppm for 24 h (Table 3.1), which was significantly superior to seed soaking in GA 400 ppm for 24 h, GA 200 ppm for 12 h and GA 600 ppm for 24 h treatments. Seed soaking in GA 600 ppm for 12 h (1694.72) was on par with GA 400 ppm for 24 h (1644.5) treatment.

4.3.5 Plant height (cm)

The data on height of seedlings recorded at weekly intervals are presented in Table 3.2 and Fig.3.2.

At the first week, maximum plant height was obtained from seeds soaked in GA 200 ppm for 24 h (12.86) and minimum was recorded with control. There was no significant difference among rest of treatments during first week. At second week, seeds soaked in GA 200 ppm for 24 h and GA 600 ppm for 12 h recorded a maximum plant height (14.63 cm). These two treatments were significantly superior to soaking in GA 200 ppm for 12 h, GA 400 ppm for 24 h and GA 600 ppm for 24 h, whereas in control only 9.03 cm height was recorded. At the age of third week, seeds soaked in GA 200 ppm for 24 h recorded a maximum plant height (19.46 cm). It was closely followed by GA 600 ppm for 24 h treatment (19.26 cm). Seeds soaked in GA 200 ppm for 24 h differed with all the other treatments. In

control plant height observed was only 9.70 cm. During fourth week, seeds soaked in GA 400 ppm for 12 h recorded significantly higher plant height among all treatments (25.33 cm). This was followed by soaking in GA 600 ppm for 12 h and GA 200 ppm for 24 h, whereas minimum plant height was obtained with control.

4.3.6 Root length (cm)

Data pertaining to root length of seedlings are presented in Table 3.2.

Seeds soaked in GA 600 ppm for 12 h recorded maximum root length (6.10 cm) and minimum was recorded with seeds soaked in GA 600 ppm for 24 h (2.0 cm). During first week, there was no significant difference among all treatments tested. In second week, seeds soaked in GA 600 ppm for 12 h recorded maximum root length (6.66 cm). It was on par with soaking in GA 200 ppm for 24 h or 12 h and GA 400 ppm for 24 h, whereas minimum root length was obtained with GA 600 ppm for 24 h (2.63 cm). In third week, seeds soaked in GA 200 ppm for 24 h recorded maximum root length (7.23 cm), followed by GA 600 ppm for 12 h, GA 400 ppm for 12 h and GA 200 ppm for 12 h, whereas minimum root length was obtained with seeds soaked in GA 600 ppm for 24 h (2.90 cm). During fourth week, seeds treated with GA 400 ppm for 12 h recorded significantly more root

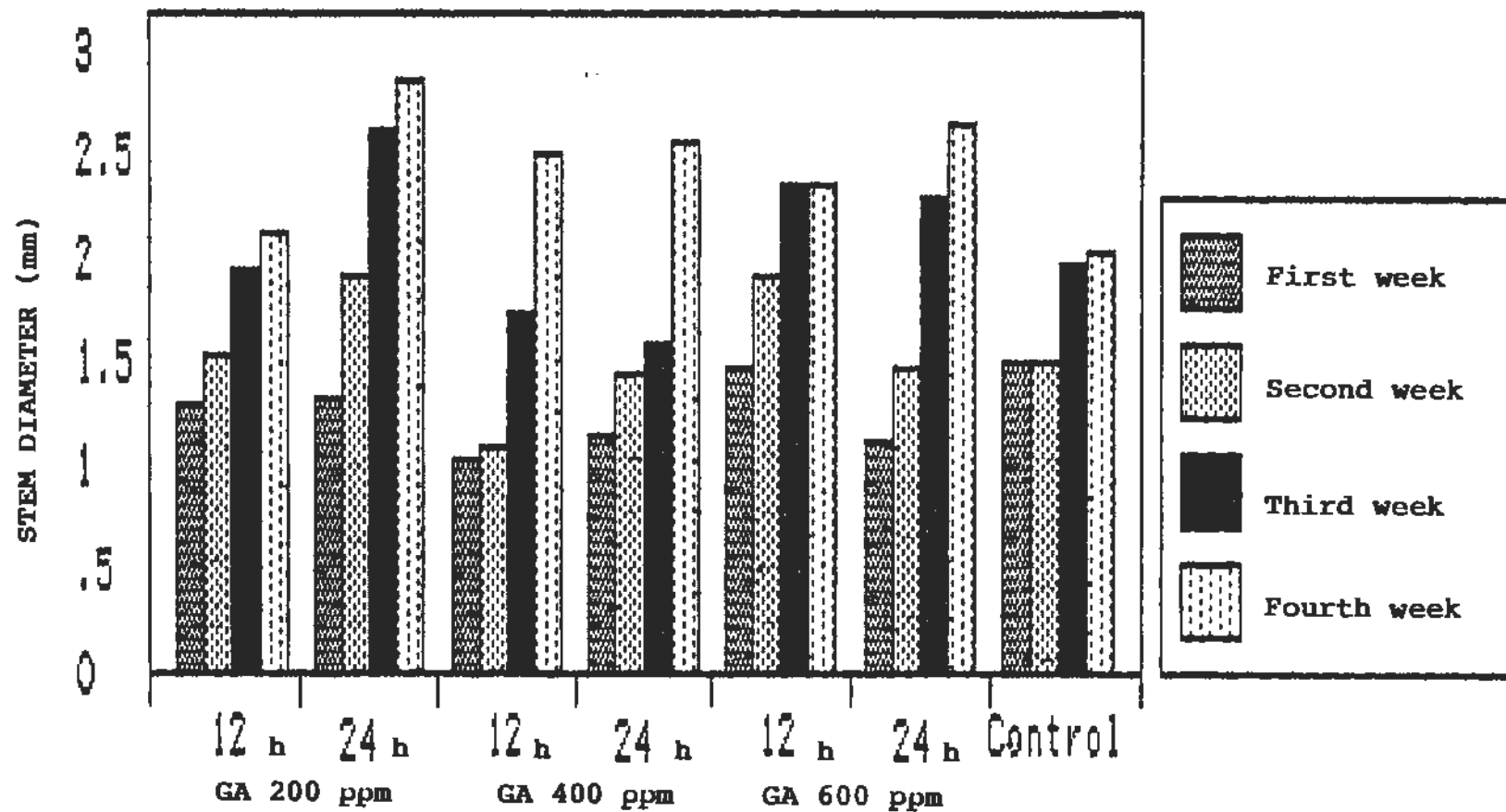


Fig.3.3: INFLUENCE OF ANNONA SEED SOAKING IN GIBBERELLIC ACID ON STEM DIAMETER

length among all treatments except soaking in GA 200 ppm for 24 h . Minimum root length was obtained from seeds soaked in GA 600 ppm for 24 h (6.13 cm).

4.3.7 Stem diameter (mm)

Data on stem diameter are presented in Table 3.3 and Fig.3.3. At the end of first week, there was no significant difference among all treatments tested. The maximum stem diameter was recorded in control (1.5 mm) and the minimum was recorded from the seeds soaked with 400 ppm for 12 h.

During second week, maximum stem diameter was recorded in seeds soaked in GA 200 ppm for 24 h as well as GA 600 ppm for 12 h (1.9 mm). It was followed by seeds soaked in GA 200 ppm for 12 h and GA 600 ppm for 24 h, whereas minimum stem diameter was recorded in seeds soaked in GA 400 ppm for 12 h (1.1 mm). At the third week, seeds soaked in GA 200 ppm for 24 h recorded maximum stem diameter (2.63) and it differed significantly from all other treatments. Minimum stem diameter was obtained with seeds soaked in GA 400 ppm for 24 h (1.6 mm). At the fourth week, seeds soaked in GA 200 ppm for 24 h recorded maximum stem diameter (2.86 mm) which was on par with GA 400 ppm for 12 h, 24 h, and GA 600 ppm for 24 h, whereas in control the stem diameter recorded was minimum.

Table 3.4: Effect of pre soaking of *Annona* seeds in gibberellic acid on number of leaves and leaf area of seedlings

Treatments	Number of leaves per plant				Leaf area per plant (cm ²)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
GA 200 ppm								
12 h	3.00	5.33	6.33	7.66	8.64	15.55	29.38	62.22
24 h	3.66	5.66	6.33	7.00	13.82	24.19	31.11	122.72
GA 400 ppm								
12 h	3.66	4.66	7.00	8.33	17.28	50.12	60.49	165.93
24 h	4.00	5.66	6.00	7.00	15.55	41.48	57.03	120.99
GA 600 ppm								
12 h	3.66	5.00	5.66	9.00	24.19	46.66	53.58	274.94
24 h	3.66	4.66	6.33	8.00	19.01	24.19	57.03	65.68
Control (dry seeds)	2.66	3.00	4.00	4.33	12.09	13.82	27.65	34.56
C.D. at 5%	N.S.	0.937	N.S.	0.593	N.S.	0.0226	0.0320	0.1572

4.3.8 Number of leaves per plant

No significant differences were observed in number of leaves per plant among all treatments tested during first week (Table 3.4). The maximum number of leaves was produced with seeds soaked in GA 400 ppm for 24 h (4.0) and minimum was produced in control (2.66). At the end of second week, seeds soaked in GA 400 ppm for 24 h and GA 200 ppm for 24 h recorded 5.66 leaves each. These two were on par with seeds soaked in GA 200 ppm for 12 h and GA 600 ppm for 12 h treatments. Whereas, minimum number of leaves were produced in control (3.0). At the end of third week it was found that there was no significant difference among different treatments. Seeds soaked in GA 400 ppm for 12 h (7.00) and control (4.00) recorded maximum and minimum leaves per plant respectively. At the end of fourth week, seeds soaked in GA 600 ppm for 12 h recorded significantly more leaves among all treatments. It was followed by seeds soaked in GA 400 ppm for 12 h, GA 600 ppm for 24 h and GA 200 ppm for 12 h treatments. Whereas, minimum number of leaves was produced in control (4.33).

4.3.9 Total leaf area per plant (cm²)

The data recorded on leaf area per plant are presented in Table 3.4.

Table 3.3: Effect of pre soaking of *Annona* seeds in gibberellic acid on stem diameter and leaf dry weight of seedlings

Treatments	Stem Diameter (mm)				Leaf dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
GA 200 ppm								
12 h	1.30	1.53	1.93	2.13	0.025	0.045	0.085	0.180
24 h	1.33	1.90	2.63	2.86	0.040	0.070	0.090	0.355
GA 400 ppm								
12 h	1.03	1.10	1.73	2.50	0.050	0.145	0.175	0.480
24 h	1.16	1.43	1.60	2.56	0.045	0.120	0.165	0.350
GA 600 ppm								
12 h	1.46	1.90	2.36	2.36	0.070	0.135	0.155	0.795
24 h	1.13	1.46	2.30	2.66	0.055	0.070	0.165	0.190
Control (dry seeds)	1.50	1.50	1.96	2.033	0.035	0.040	0.100	0.740
C.D. at 5%	N.S.	0.427	0.158	0.481	0.0184	0.0152	0.0358	0.361

At the end of first week, there was no significant variation among treatments. Maximum and minimum leaf area was recorded with seeds soaked in GA 600 ppm for 12 h (24.19 cm^2) and GA 200 ppm for 12 h (8.64 cm^2) respectively. At end of second week, seeds soaked in GA 400 ppm for 12 h recorded significantly more leaf area (50.12 cm^2) among all treatments tested. It was followed by soaking in GA 600 ppm for 12 h (46.66 cm^2) and GA 400 ppm for 24 h (41.48 cm^2), whereas in control, leaf area recorded was only 13.82 cm^2 . At the end of third week also, seeds soaked in GA 400 ppm for 12 h produced significantly more leaf area (60.49 cm^2) among all treatments. It was followed by seeds soaked in GA 400 ppm for 24 h, GA 600 ppm for 12 h and GA 200 ppm for 24 h (31.11 cm^2), whereas in control, minimum leaf area was recorded. At the end of fourth week, seeds soaked in GA 600 ppm for 12 h recorded significantly more leaf area (274.94 cm^2) among all treatments. It was followed by GA 400 ppm for 12 h (165.93 cm^2) and GA 200 ppm for 24 h (122.72 cm^2), whereas minimum leaf area was produced with control (34.56 cm^2).

4.3.10 Leaf dry weight (g)

The data pertaining to leaf dry weight are presented in Table 3.3.

At the end of first week, seeds soaked in GA 600 ppm for 12 h recorded maximum leaf dry weight (0.070 g). It was on par with soaking of seeds in GA 600 ppm for 24 h which was significantly superior to remaining treatments. Minimum dry weight was recorded with GA 200 ppm for 12 h treatment (0.025 g). At the end of second week, maximum leaf dry weight was recorded in seeds soaked in GA 400 ppm for 12 h (0.145 g). It was on par with GA 600 ppm for 24 h which was significantly superior to remaining treatments, whereas in control minimum leaf dry weight was recorded. At the end of third week also, seeds soaked with GA 400 ppm for 12 h gave maximum leaf dry weight (0.175 g). It was on par with soaking in GA 400 ppm for 24 h, GA 600 ppm for 24 h. Seeds soaked in GA 200 ppm for 24 h recorded minimum leaf dry weight (0.090 g). At the end of fourth week, soaking of seeds with GA 600 ppm for 12 h recorded maximum dry weight (0.795 g). It was on par with GA 400 ppm for 12 h and control. Seeds soaked in GA 200 ppm for 12 h recorded minimum dry weight (0.180 g).

4.3.11 Stem dry weight (g)

Data pertaining to stem dry weight are presented in Table 3.5.

Table 3.5: Effect of pre soaking of *Annona* seeds in gibberellic acid on stem and root dry weights of seedlings

Treatments	Stem dry weight (g)				Root dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
GA 200 ppm								
12 h	0.020	0.050	0.055	0.075	0.013	0.025	0.040	0.045
24 h	0.030	0.055	0.075	0.210	0.030	0.045	0.050	0.130
GA 400 ppm								
12 h	0.095	0.105	0.125	0.245	0.075	0.090	0.105	0.175
24 h	0.090	0.105	0.115	0.175	0.050	0.085	0.115	0.150
GA 600 ppm								
12 h	0.110	0.120	0.135	0.160	0.095	0.100	0.135	0.150
24 h	0.015	0.030	0.095	0.115	0.030	0.035	0.035	0.050
Control (dry seeds)	0.023	0.095	0.105	0.150	0.030	0.035	0.040	0.050
C.D. at 5%	0.0112	0.0122	0.0099	0.0130	0.0121	0.0078	0.0120	0.0159

At the end of first week, soaking of seeds in GA 600 ppm for 12 h recorded significantly maximum stem dry weight (0.110 g) among all other treatments. It was followed by soaking in GA 400 ppm for 12 h and 24 h, whereas minimum stem dry weight was recorded with soaking of seeds in GA 200 ppm for 12 h (0.020 g). At the end of second week also seeds soaked in GA 600 ppm for 12 h recorded significantly more stem dry weight among all treatments which was followed by GA 400 ppm for 12 h and 24 h and control. Seeds soaked in GA 200 ppm for 12 h recorded minimum stem dry weight (0.05 g). At the end of third week, soaking of seeds in GA 600 ppm for 12 h recorded significantly more stem dry weight and was followed by GA 400 ppm for 12 h, 24 h and control, whereas minimum dry weight was recorded with GA 200 ppm for 12 h (0.055 g). At the end of fourth week seeds soaked in GA 400 ppm for 12 h gave significantly highest stem dry weight among all treatments. It was followed by GA 200 ppm for 24 h, GA 400 ppm for 24 h, GA 600 ppm for 12 h and control, whereas seed soaking with GA 200 ppm for 12 h recorded minimum stem dry weight (0.075 g).

4.3.12 Root dry weight (g)

Data pertaining to root dry weight are presented in Table 3.5.

At the end of first week, seeds soaked in GA 600 ppm for 12 h recorded significantly maximum root dry weight among all other treatments. It was followed by GA 400 ppm treatment for periods of 12 h and 24 h, whereas minimum root dry weight was recorded with seeds soaked in GA 200 ppm for 12 h. At the end of second week, seeds soaked in 600 ppm for 12 h recorded significantly maximum root dry weight (0.1 g) among all treatments tested and was closely followed by soaking of seeds in GA 400 ppm for 12 h and 24 h. Minimum root dry weight was recorded in seeds treated with GA 200 ppm for 12 h (0.025 g). At the end of third week, GA 600 ppm soaked seeds for 12 h recorded significantly more root dry weight (0.135 g) among all treatments. It was followed by soaking of seeds in GA 400 ppm for 24 h which was on par with GA 400 ppm treatment for 12 h. Minimum root dry weight was recorded with GA 600 ppm for 24 h treatment (0.035 g). At the end of fourth week, seeds soaked in GA 400 ppm for 12 h recorded significantly highest root dry weight (0.175 g) and was followed by the treatments GA 400 ppm for 24 h, GA 600 ppm for 12 h and GA 200 ppm for 24 h. Minimum root dry weight was recorded in seeds soaked in GA 200 ppm for 12 h (0.045 g).

Table 3.6: Effect of pre-soaking of *Annona* seeds in gibberellic acid on relative growth rate of seedlings

Treatments	Relative growth rate		
	7-14 days	14-21 days	21-28 days
GA 200 ppm			
12 h	0.112	0.058	0.073
24 h	0.076	0.034	0.168
GA 400 ppm			
12 h	0.062	0.025	0.112
24 h	0.074	0.035	0.111
GA 600 ppm			
12 h	0.036	0.026	0.132
24 h	0.047	0.089	0.026
Control (dry seeds)	0.010	0.045	0.044
C.D. at 5%	0.00124	0.0382	0.00106

4.3.13 Relative growth rate

Relative growth rate was calculated and presented in Table 3.6.

Between seven and fourteen days, seeds soaked in GA 200 ppm for 12 h recorded highest relative growth rate (0.1120). It differed significantly among all treatments and was followed by GA 200 ppm for 24 h, GA 400 ppm for 24 h and 12 h treated seeds, whereas in control, minimum relative growth rate (0.01) was recorded. Between fourteen and twenty one days relative growth rate was maximum in seeds soaked in GA 600 ppm for 24 h (0.089). It was followed by soaking in GA 200 ppm for 12 h, control, GA 400 ppm for 24 h, whereas minimum relative growth rate was recorded when seeds soaked in GA 400 ppm for 12 h. Between twenty first and twenty eight day significantly maximum relative growth rate was recorded in seeds soaked in GA 200 ppm for 24 h. It was followed by soaking in GA 600 ppm for 12 h, GA 400 ppm for 12 h. Seeds soaked in GA 600 ppm for 24 h recorded minimum relative growth rate (0.026).

4.3.14 Leaf weight ratio

Leaf weight ratio was calculated and presented in Table 3.7.

Table 3.7: Effect of pre soaking of *Annona* seeds in gibberellic acid on leaf area ratio and leaf weight ratio of seedlings

Treatments	Leaf weight ratio				Leaf area ratio			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
GA 200 ppm								
12 h	0.455	0.375	0.472	0.600	157.09	129.58	163.22	207.40
24 h	0.400	0.412	0.419	0.511	138.20	142.29	144.697	176.57
GA 400 ppm								
12 h	0.227	0.426	0.432	0.533	78.54	147.41	149.35	184.36
24 h	0.243	0.387	0.418	0.519	84.05	133.80	144.37	179.24
GA 600 ppm								
12 h	0.255	0.380	0.365	0.743	87.96	131.43	126.07	590.17
24 h	0.614	0.560	0.559	0.535	211.22	193.52	193.32	185.01
Control (dry seeds)	0.449	0.250	0.364	0.333	155.11	86.37	125.68	115.20
C.D. at 5%	0.0077	0.0259	0.00106	0.00079	0.128	0.181	0.157	N.S.

At the end of first week, seeds soaked in GA 600 ppm for 24 recorded significantly more leaf weight ratio among all other treatments tested. It was followed by soaking in GA 200 ppm for 12 h, 24 h and GA 600 ppm for 12 h, whereas minimum leaf weight ratio was recorded with GA 400 ppm for 12 h (0.227). At the end of second week maximum leaf weight ratio was recorded with seeds soaked in GA 600 ppm 24 h which was significantly more among all treatments tested. This was followed by soaking in GA 400 ppm for 12 h, GA 200 ppm for 24 h and GA 600 ppm for 12 h whereas minimum leaf weight ratio (0.25) was obtained with control. At the end of third week, soaking of seeds in GA 600 ppm for 24h recorded significantly more leaf weight ratio followed by GA 200 ppm for 12 h GA 400 ppm for 12 h and 24 h treatments. Control seeds recorded minimum leaf weight ratio. At the end of fourth week seeds soaked in GA 600 ppm for 12 h recorded significantly highest leaf weight ratio (0.743) among all treatments followed by seeds soaked in GA 200 ppm for 12 h, GA 600 ppm for 24 h treatments. Minimum leaf weight ratio was recorded in control.

4.3.15 Leaf Area Ratio

The data on leaf area ratio are presented in Table 3.7.

At the end of first week of seedling growth, seeds soaked in GA 600 ppm for 24 h gave maximum leaf area ratio (211.22) and it significantly differed with all other treatments. It was followed by GA 200 ppm for 12 h, control, GA 200 ppm for 24 h treatments. Minimum leaf area ratio was recorded in seeds soaked in GA 400 ppm for 12 h (78.54). At the end of second week seeds soaked in GA 600 ppm for 24 h recorded significantly higher leaf area ratio (193.52) followed by seeds soaked in GA 400 ppm for 12 h, GA 200 ppm for 24 h and GA 400 ppm for 24 h treatments, whereas control recorded minimum leaf area ratio (86.37). At the end of third week, seeds soaked in GA 600 ppm for 24 h recorded significantly more leaf area ratio (193.32) following GA 200 ppm for 12 h, GA 400 ppm for 12 h, GA 200 ppm for 24 treatments, whereas control recorded minimum leaf area ratio. At the end of fourth week, there was no significant difference among all the treatments. Maximum (207.4) and minimum (115.2) leaf area ratio was recorded in seeds soaked in GA 200 ppm for 12 h and control respectively.

4.3.16 Correlations amongst germination and seedling attributes

The correlations worked out for various germination and seedling growth attributes are given in Table 3.8.

Table 3.8: Correlation coefficients amongst germination and seedling attributes in gibberellic acid treated Annona seeds

Seedling attributes	Seedling vigour index	Coefficient of velocity of germination	Stem diameter	Plant height	Root length	Number of leaves per plant	Leaf area per plant	Germination percentage
Days for initiation of germination	-0.21601	-0.92443**	-0.54607**	-0.91708**	-0.28088	-0.86439**	-0.50202**	-0.59610**
Seedling vigour index		0.25438	0.13817	0.23271	0.12558	0.11262	0.15289	0.32888*
Coefficient of velocity of germination			0.60434**	0.90417**	0.26485	0.81101**	0.42939**	0.57994**
Stem diameter				0.52732**	0.36019*	0.30327	0.16639	0.48706**
Plant height					0.42384**	0.84584**	0.53460**	0.69212**
Root length						0.39893*	0.64402**	0.33463*
Number of leaves per plant							0.67696**	0.46247**
Leaf area per plant								0.4524**

** Significant at 1% level

* Significant at 5% level

The final germination percentage had a negative correlation with days taken for commencement of germination (-0.5961). But the relationship was strongly positive with vigour, velocity of germination, stem diameter, height, root length, number of leaves and leaf area. Number of days taken for initiation of germination was negatively correlated with velocity of germination, stem diameter, height, number of leaves and leaf area. Velocity of germination had a strong positive relationship with stem diameter, height, number of leaves and leaf area. Stem diameter was positively correlated with height and root length of seedling, whereas height was strongly positively related to root length and number of leaves and leaf area. Root length also positively correlated with number of leaves and leaf area whereas number of leaves and leaf area were positively correlated with each other.

EXPERIMENT IV

4.4 STUDIES ON THE EFFECT OF THIOUREA ON ANNONA SEED GERMINATION AND SUBSEQUENT SEEDLING GROWTH

This experiment was planned with five treatments viz; soaking of seeds in thiourea 0.5 per cent for 12 h and 24 h separately, soaking of seeds in thiourea 1.0 per cent for 12 h and 24 h separately and

Table 4.1: Effect of thiourea on germination of *Annona* seeds

Treatments	Germination (%)	No. of days taken for initiation of germination	Coefficient of velocity of germination	Seedling vigour Index
Thiourea 0.5%				
12 h	37.00	17.00	5.06	1102.25
24 h	62.00	17.40	5.02	1863.72
Thiourea 1%				
12 h	56.00	16.00	4.77	1231.45
24 h	26.00	17.20	4.72	667.16
Control (dry seeds)	16.00	31.60	3.28	276.16
C.D. at 5%	21.83	1.17	0.401	532.62

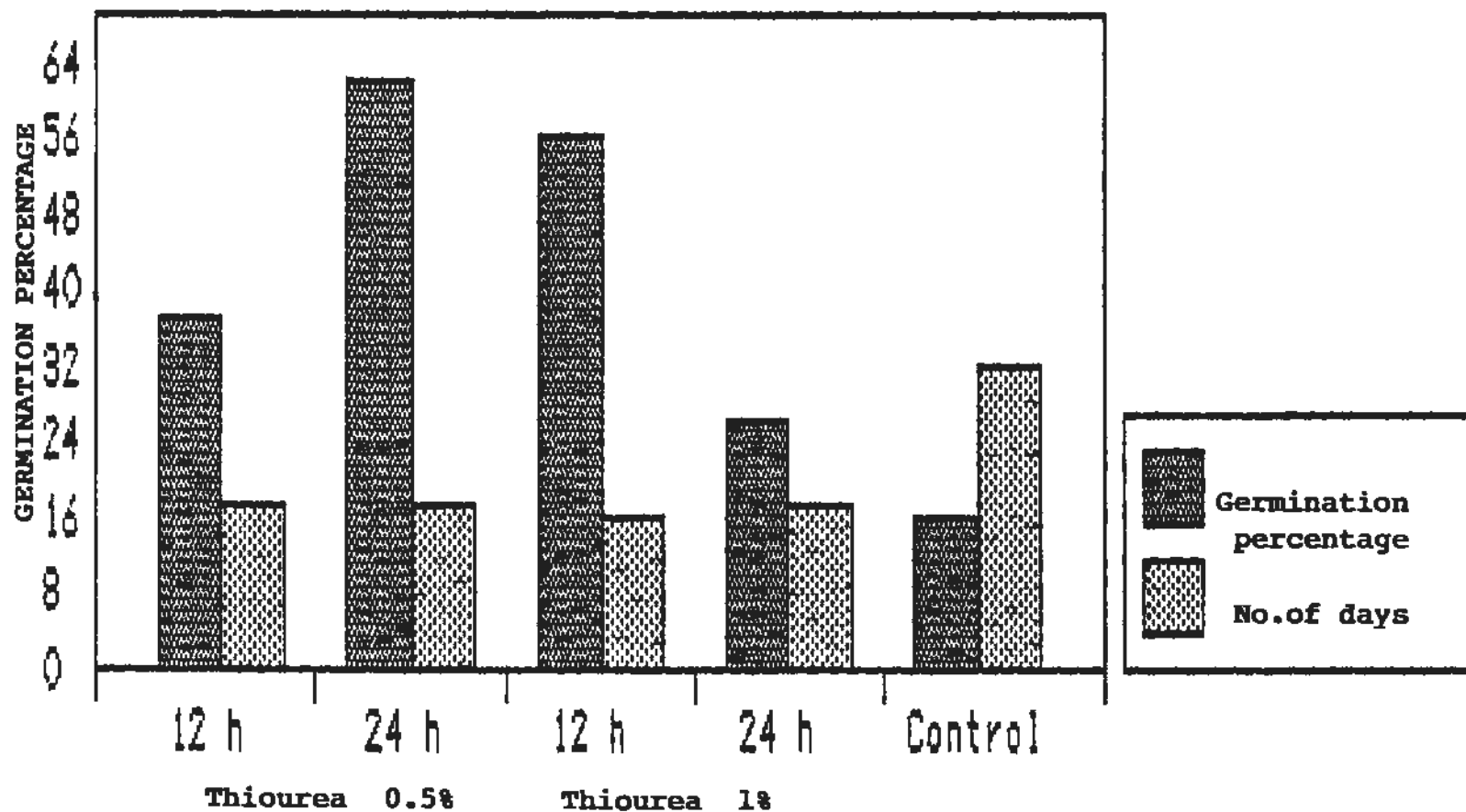


Fig. 4.1 Influence of Annona seed soaking in thiourea on germination

dry seeds as control. The following parameters were recorded under field conditions.

4.4.1 Germination percentage

The data recorded on germination percentage are presented in Table 4.1 and Fig.4.1.

Seeds soaked in thiourea 0.5% solution for 24 h recorded maximum germination percentage (62.0%) among all treatments. It was on par with seeds soaked in thiourea 1% for 12 h (56.0%), which was significantly superior to seeds soaked in thiourea 1% for 24 h (26.0%) and control. Seeds soaked in thiourea 0.5% for 12 h recorded only 37 per cent of germination, while in control only 16 per cent of germination was occurred.

4.4.2 Number of days taken for initiation of germination

Seeds soaked in thiourea 1% for 12 h took significantly minimum days (16.0) for initiation of germination among all treatments (Table 4.1 and Fig.4.1). It was followed by seeds soaked in thiourea 0.5% for 12 h (17.00) which was on par with thiourea 1% for 24 h (17.20) and thiourea 0.5% for 24 h (17.40) treated seeds. The control seeds took 31.6 days to initiate the germination.

4.4.3 Coefficient of velocity of germination

Highest velocity of germination was recorded in seeds soaked in thiourea 0.5% for 12 h (5.06) which was on par with seeds soaked in thiourea 0.5% for 24 h (5.02). Velocity of germination in seeds soaked in thiourea 1% for 12 h and 24 h was 4.77 and 4.72 respectively (Table 4.1), while in control, lowest velocity of germination (3.28) was recorded.

4.4.4 Seedling vigour index

Data on seedling vigour index are presented in Table 4.1.

Seeds soaked in thiourea 0.5% for 24 h recorded significantly highest seedling vigour among all treatments tested. It was followed by seeds soaked in thiourea 1% for 12 h (1231.45) which was on par with thiourea 0.5% for 12 h treatment (1102.25) seeds soaked in thiourea 1% for 24 h recorded only 667.16 seedling vigour, whereas in control minimum seedling vigour was recorded.

4.4.5 Plant height (cm)

Data pertaining to plant height recorded at weekly intervals are presented in Table 4.2 and Fig.4.2.

Table 4.2: Effect of pre-soaking of *Annona* seeds in thiourea on plant height and root lengths of seedlings

Treatments	Plant height (cm)				Root length (cm)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Thiourea 0.5%								
12 h	8.70	10.03	16.76	21.66	1.93	5.86	6.43	8.13
24 h	12.50	14.20	16.10	21.70	2.03	4.80	7.50	7.36
Thiourea 1%								
12 h	11.70	13.96	17.86	21.50	2.63	2.66	6.10	7.16
24 h	7.80	9.76	14.18	17.93	1.73	4.60	7.30	7.73
Control (dry seeds)	8.10	8.96	9.70	11.00	2.83	4.63	5.63	6.26
C.D. at 5%	1.56	2.68	1.67	1.78	N.S.	N.S.	N.S.	N.S.

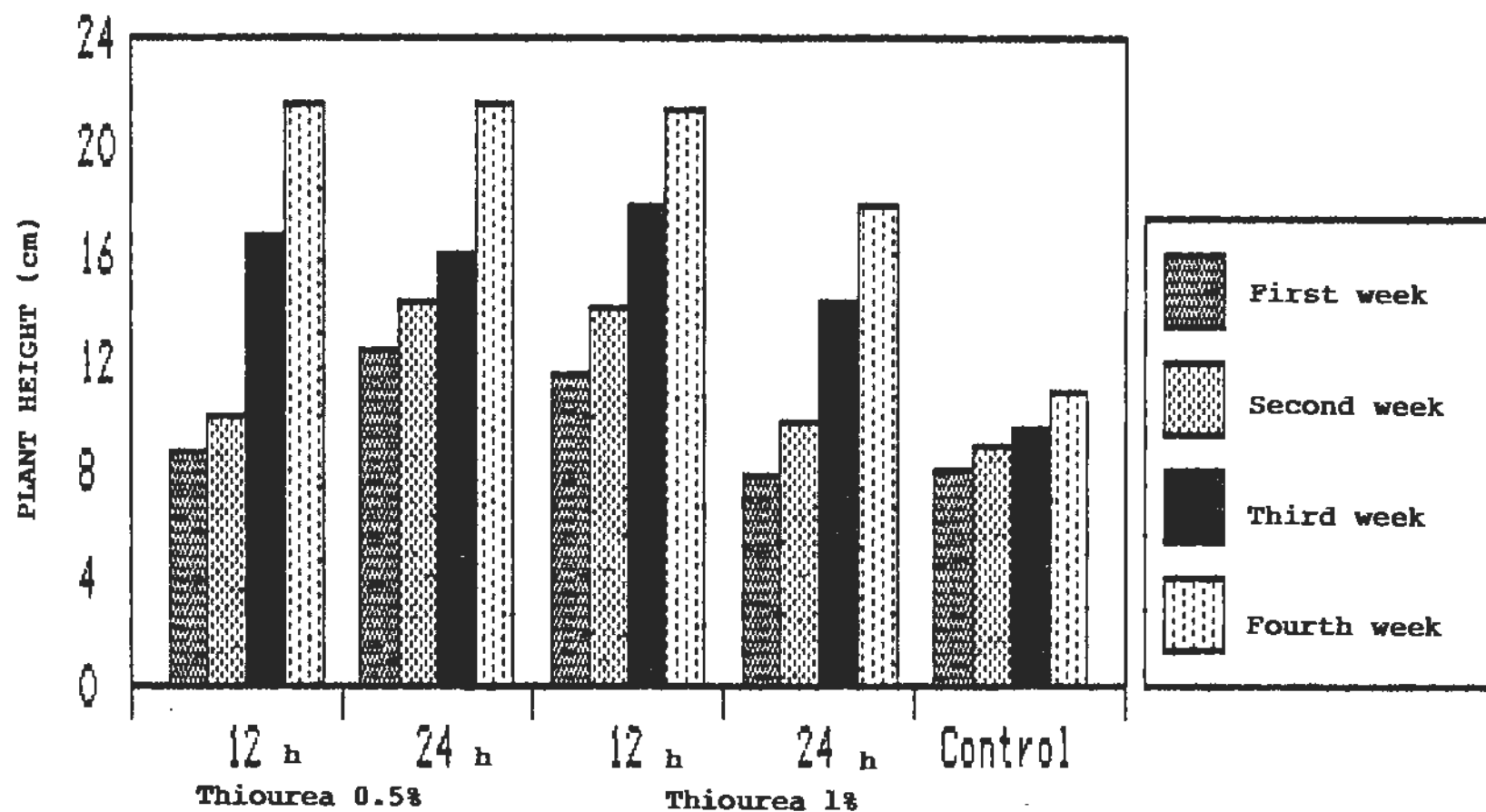


Fig.4.2: INFLUENCE OF ANNONA SEED SOAKING IN THIOUREA ON PLANT HEIGHT

At the end of first week, seeds soaked in thiourea 0.5% for 24 h recorded maximum plant height (12.5 cm) among all treatments. It was on par with the thiourea 1% for 12 h treatment which was significantly superior to remaining treatments, whereas in control minimum plant height was recorded. At the end of second week thiourea 0.5 per cent for 24 h recorded maximum plant height (14.2 cm) among all treatments. It was on par with seeds soaked in thiourea 1 per cent for 12 h (13.96 cm) which was significantly superior to all other remaining treatments. At the end of third week, seeds soaked in thiourea 1 per cent for 12 h recorded maximum plant height (17.86 cm) and it was followed by thiourea 0.5 per cent for 12 and 24 h soaked seeds, whereas minimum plant height was obtained with control (9.7 cm). At the end of fourth week seeds soaked in thiourea 0.5% solution for 24 h recorded maximum plant height (21.7 cm) which was on par with thiourea 0.5% for 12 h and thiourea 1 per cent for 12 h treatments. Minimum plant height (11.00 cm) was recorded in control.

4.4.6 Root length (cm)

Data on root length of seedlings at weekly intervals are presented in Table 4.2.

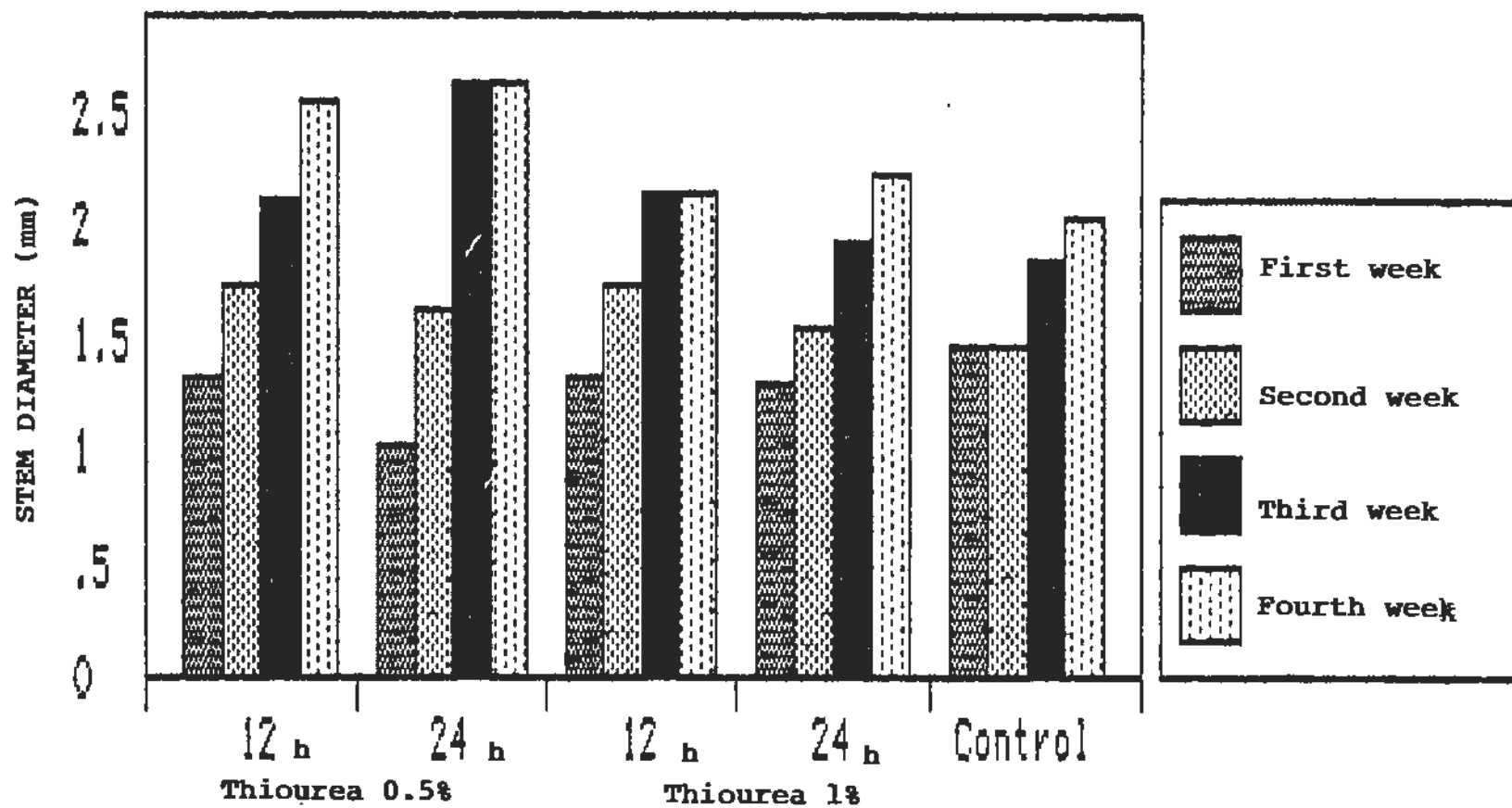


Fig.4.3: INFLUENCE OF ANNONA SEED SOAKING IN THIOUREA ON STEM DIAMETER

There was no significant difference in root length of seedlings at all the week intervals i.e. from first week to fourth week. At end of first week maximum root length was recorded in control (2.83 cm) and minimum with seeds soaked in thiourea 1% solution for 24 h (1.73 cm). At the end of second week, maximum and minimum root length was recorded with seeds soaked in thiourea 0.5 per cent for 12 h (5.86 cm) and thiourea 1 per cent for 12 h (2.66 cm) respectively. At the third week seeds soaked in thiourea 0.5 per cent for 24 h recorded maximum root length (7.5 cm) and minimum was recorded in control (5.63 cm), whereas at the end of fourth week, maximum root length was recorded with seeds soaked in thiourea 0.5% for 12 h (8.13 cm) and minimum was recorded in control (6.26 cm).

4.4.7 Stem diameter (mm)

Data on stem diameter of seedlings recorded at weekly intervals are presented in Table 4.4 and 4.3.

At the end of first week, it was found that there was no significant difference among all treatments. Maximum stem diameter was recorded in control (1.46 mm) and minimum with seeds soaked in thiourea 0.5% solution for 24 h (1.03 mm). In the second week also, there was no significant difference

Table 4.3: Effect of pre-soaking of *Annona* seeds in thiourea on number of leaves and leaf area of seedlings

Treatments	Number of leaves per plant				Leaf area per plant (cm ²)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Thiourea 0.5%								
12 h	4.33	5.66	6.00	8.00	12.44	17.28	45.93	89.88
24 h	4.00	5.66	6.66	8.66	32.84	39.75	69.13	93.33
Thiourea 1%								
12 h	3.33	5.66	6.33	8.33	24.19	27.65	50.12	81.23
24 h	3.33	4.00	5.66	6.66	5.18	6.91	41.48	69.13
Control (dry seeds)	2.66	3.00	4.00	4.33	13.82	15.55	27.65	34.56
C.D. at 5%	N.S.	1.19	1.13	1.00	N.S.	N.S.	0.041	0.058

among all treatments tested. Seeds soaked in thiourea 1 per cent for 12 h recorded highest stem diameter (1.73 mm), whereas minimum was recorded in control (1.46 mm). At the end of third week, seeds soaked in thiourea 0.5 per cent solution for 24 h recorded maximum stem diameter (2.63 mm) which was superior to all treatments. It was followed by thiourea 0.5 per cent for 12 h treatment, whereas minimum stem diameter was recorded in control (1.83 mm). At the end of fourth week thiourea 0.5% soaked seeds for 24 h recorded maximum stem diameter (2.63 mm) which was on par with seeds soaked in thio urea 0.5 per cent for 12 h, whereas minimum stem diameter (2.03 mm) was recorded in control.

4.4.8 Number of leaves per plant

Data on number of leaves observed at weekly intervals per plant are presented in Table 4.3.

Maximum number of leaves were recorded in seeds soaked in thiourea 0.5 per cent for 12 h (4.33) at the end of first week and minimum leaves were recorded in control. There was no significant difference among all the treatments during first week. At the end of second week, soaking of seeds in thiourea 0.5 per cent solution for 24 h and 12 h as well as thiourea 1 per cent for 12 h treatments recorded

maximum number of leaves per plant (5.66) and were significantly superior to all other treatments while minimum number of leaves were recorded in control.

At the end of third week, seeds soaked in thiourea 0.5 per cent for 24 h recorded maximum number of leaves and it was on par with seeds soaked in thiourea 0.5 per cent for 12 h and seeds soaked in thiourea 1 per cent for 12 h treatments, whereas minimum number of leaves was recorded in control. At the end of fourth week, maximum number of leaves was recorded with seeds treated with thiourea 0.5 per cent for 24 h (8.66). It was on par with thiourea 1 per cent for 12 h and thiourea 0.5 per cent for 12 h treatments. Minimum number of leaves (4.33) were recorded with control.

4.4.9 Leaf area per plant (cm^2)

It was found that there was no significant difference among all treatments tested in the first and second weeks (Table 4.3). Maximum leaf area was recorded in seeds soaked with thiourea 0.5 per cent for 24 h (32.84 cm^2). Minimum leaf area was produced in seeds soaked in thiourea 1 per cent solution for 24 h (5.18 cm^2). At the end of second week, seeds soaked in thiourea 0.5 per cent for 24 h recorded highest leaf area, whereas thiourea 1 per cent for 24 h recorded minimum leaf area. At the age of third week, soaking

Table 4.4: Effect of pre-soaking of *Annona* seeds in thiourea on stem diameter and leaf dry weight of seedlings

Treatments	Stem Diameter (mm)				Leaf dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Thiourea 0.5%								
12 h	1.33	1.73	2.10	2.53	0.036	0.050	0.133	0.260
24 h	1.03	1.63	2.63	2.63	0.095	0.115	0.2	0.270
Thiourea 1%								
12 h	1.33	1.73	2.13	2.13	0.070	0.080	0.145	0.235
24 h	1.30	1.53	1.93	2.23	0.015	0.020	0.120	0.200
Control (dry seeds)	1.46	1.46	1.83	2.03	0.040	0.045	0.080	0.100
C.D. at 5%	N.S.	N.S.	0.48	0.40	0.012	0.015	0.045	0.052

of seeds in thiourea 0.5 per cent solution for 24 h recorded significantly more leaf area (69.13 cm^2) among all treatments. It was followed by seeds soaked in thiourea 1 per cent for 12 h and thiourea 0.5 per cent for 24 h treatments. Whereas in control, minimum leaf area (27.65 cm^2) was recorded. At the age of fourth week also thiourea 0.5 per cent for 24 h recorded significantly highest leaf area (93.33 cm^2), followed by thiourea 0.5 per cent for 12 h thiourea 1 per cent for 12 h and 24 h treatments. Minimum leaf area was recorded in control (34.56 cm^2).

4.4.10 Leaf dry weight (g)

The data on leaf dry weight at weekly intervals of seedling growth are presented in Table 4.4.

At the age of first week, seeds soaked in thio urea 0.5 per cent for 24 h recorded significantly maximum leaf dry weight among all treatments. It was followed by seeds soaked in thiourea 1 per cent for 12 h, control and thiourea 0.5 per cent for 12 h treatments, whereas minimum leaf dry weight was recorded in seeds soaked in thiourea 1 per cent for 24 h (0.015 g). At the age of second week significantly maximum leaf dry weight (0.115 g) was recorded in seeds soaked in thio urea 0.5 per cent solution for 24 h among all other treatments, whereas minimum leaf dry

weight (0.020 g) was recorded with seeds soaked in thiourea 1 per cent for 24 h. At the end of third week, seeds soaked in thiourea 0.5 per cent solution for 24 recorded significantly more leaf dry weight. It was followed by thiourea 1 per cent for 12 h, thiourea 0.5 per cent for 12 h and thiourea 1 per cent for 24 h treatments, whereas leaf dry weight was minimum (0.089 g) in control. At the end of fourth week also, seeds soaked in thiourea 0.5 per cent for 24 h recorded significantly maximum leaf dry weight followed by seeds soaked in thiourea 0.5 per cent for 12 h; thiourea 1 per cent for 12 h and 24 h treatments. Control recorded the minimum (0.1 g) leaf dry weight.

4.4.11 Stem dry weight (g)

Data on stem dry weight at weekly intervals of seedling growth are presented in Table 4.5.

At end of first week seeds soaked in thiourea 0.5% solution for 24 h recorded significantly more stem dry weight among all treatments tested. It was followed by thiourea 1 per cent for 12 h, 24 h and thio urea 0.5 per cent for 12 h. In control, minimum stem dry weight was recorded (0.025 g). Among all treatments tested control recorded maximum stem dry weight at the end of second week (0.095 g), third week (0.15 g) and fourth week (0.15 g) of seedling growth. Minimum

Table 4.5: Effect of pre-soaking of *Annona* seeds in thiourea on stem and root dry weights of seedlings

Treatments	Stem dry weight (g)				Root dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Thiourea 0.5%								
12 h	0.026	0.03	0.063	0.123	0.020	0.036	0.046	0.106
24 h	0.080	0.06	0.1	0.130	0.015	0.025	0.060	0.065
Thiourea 1%								
12 h	0.055	0.065	0.075	0.105	0.075	0.085	0.090	0.100
24 h	0.040	0.05	0.085	0.115	0.025	0.035	0.040	0.058
Control (dry seeds)	0.025	0.095	0.150	0.150	0.020	0.025	0.040	0.045
C.D. at 5%	0.013	0.041	0.023	0.0076	0.0113	0.002	0.0033	0.0094

stem dry weights were obtained in seeds soaked in thiourea 0.5% for 12 (0.03 g), thiourea 0.5% for 12 h (0.063 g) and thiourea 1% for 12 h (0.105 g) in second, third and fourth weeks of seedling growth respectively.

4.4.12 Root dry weight (g)

Data pertaining to root dry weight of seedlings are presented in Table 4.5.

At the end of first week, seeds soaked in thiourea 1 per cent solution for 12 h recorded significantly more dry weight of roots among all treatments (0.075 g) followed by thiourea 1 per cent for 24 h, thiourea 0.5 per cent for 12 h soaked seeds, whereas seeds soaked in thiourea 0.5 per cent for 24 h recorded minimum root dry weight (0.015 g). At the end of second week also, thiourea 1 per cent treated seeds for 12 h recorded maximum root dry weight which was significantly superior to thiourea 0.5 per cent for 12 h and thiourea 1 per cent for 24 h treatments. Minimum root dry weight was recorded in control (0.025 g). At the end of third week, seeds soaked in thiourea 1 per cent solution for 12 h recorded significantly maximum root dry weight, whereas minimum dry weight was recorded in control and thiourea 0.5 per cent treated seeds for 24 h (0.040 g). At the end of fourth week, seeds soaked in thiourea 0.5 per cent for 12 h recorded signifi-

Table 4.6: Effect of pre-soaking of *Annona* seeds in thiourea on relative growth rate of seedlings

Treatments	Relative growth rate		
	7-14 days	14-21 days	21-28 days
Thiourea 0.5%			
12 h	0.050	0.105	0.1
24 h	0.014	0.070	0.037
Thiourea 1%			
12 h	0.020	0.043	0.050
24 h	0.039	0.121	0.059
Control (dry seeds)	0.095	0.070	0.013
C.D. at 5%	0.000068	0.00087	0.000105

cantly maximum root dry weight (0.106 g) followed by seeds soaked in thiourea 1 per cent for 12 h, thiourea 0.5 per cent for 24 h treatments. In control minimum root dry weight was recorded (0.045 g).

4.4.13 Relative Growth Rate

Relative growth rate was calculated and presented in Table 4.6.

Between seven and fourteen days, relative growth rate was maximum (0.095) in control. It was significantly superior to all other treatments. It was followed by seeds soaked in thiourea 0.5 per cent solution for 12 h (0.050), thiourea 1 per cent for 24 h (0.039) and for 12 hours. Minimum relative growth rate was obtained in seeds treated with thiourea 0.5 per cent solution for 24 h (0.014). Between fourteen and twenty one days of seedlings growth, relative growth rate was maximum in thiourea 1 per cent soaking for 24 h (0.121). It was significantly superior to seeds soaked in thiourea 0.5 per cent for 12 h and 24 h, whereas minimum was recorded seeds soaked in thiourea 1 per cent for 12 h (0.043). Between twenty first and twenty eight days of seedling growth, relative growth rate was significantly maximum in thiourea 0.5 per cent soaked seeds for 12 h (0.1). It was followed by thiourea 0.5 per cent for 24 h (0.059) and 12 h (0.05),

whereas minimum relative growth rate was recorded in control (0.013).

4.4.14 Leaf Weight Ratio

Data on leaf weight ratio are presented in Table 4.7.

At the end of first week, 0.5 per cent thiourea soaked seeds for 24 h recorded maximum (0.475) leaf weight ratio. It was on par with control which was in turn significantly superior to remaining treatments. Minimum leaf weight ratio (0.188) was recorded in thiourea 1% for 24 h. At the end of second week, seeds soaked in thiourea 0.5% solution for 24 h recorded significantly more leaf weight ratio among all treatments. It was followed by thiourea 0.5% for 12 h (0.431), thiourea 1% for 12 h (0.348) and control (0.273), whereas minimum leaf weight ratio was recorded in seeds soaked in thiourea 1% for 24 h (0.19). At the end of the third week, thiourea 0.5% soaked seeds for 24 h recorded significantly highest leaf weight ratio. It was followed by thio urea 0.5% for 12 h, thiourea 1% for 24 h and 12 h treatments, whereas minimum leaf weight ratio was recorded in control. At the end of fourth week also, thiourea 0.5% soaked seeds for 24 h recorded significantly highest

Table 4.7: Effect of pre-soaking of *Annona* seeds in thiourea on leaf weight ratio and leaf area ratio of seedlings

Treatments	Leaf Weight Ratio				Leaf Area Ratio			
	Ist week	IInd week	IIIRD week	IVth week	Ist week	IInd week	IIIRD week	IVth week
Thiourea 0.5%								
12 h	0.439	0.431	0.550	0.532	151.70	148.93	189.92	183.80
24 h	0.475	0.523	0.556	0.581	164.20	180.68	192.02	200.50
Thiourea 1%								
12 h	0.350	0.348	0.468	0.534	120.91	120.21	161.67	184.61
24 h	0.188	0.190	0.490	0.541	64.81	65.80	169.30	186.83
Control (dry seeds)	0.471	0.273	0.339	0.339	162.58	94.242	102.40	117.15
C.D. at 5%	0.0092	0.0017	0.00048	0.0019	0.124	0.279	0.216	0.432

leaf weight ratio (0.581) and the minimum was recorded in control.

4.4.15 Leaf Area Ratio

The data on leaf area ratio calculated at weekly intervals are presented in Table 4.7.

Maximum leaf area ratio was recorded with seeds soaked in thiourea 0.5% solution for 24 h (164.2). This was followed by control, thiourea 0.5% soaked seeds for 12 h and thiourea 1% soaked seeds for 12 h, whereas minimum was recorded in soaking of seeds in thiourea 1% for 24 h (64.81). At the end of second week, seeds soaked in thiourea 0.5% solution for 24 h recorded significantly highest leaf area ratio. It was followed by seeds soaked in thiourea 0.5% for 12 h and thiourea 1% for 24 h treatments. At the end of third week thiourea 0.5% soaked seeds for 24 h recorded significantly more leaf area ratio. It was followed by seeds soaked in thiourea 0.5% for 12 h, thiourea 1% for 24 h and 12 h treatments, whereas minimum leaf area ratio was recorded in control. At the end of fourth week also thiourea (0.5%) soaked seeds for 24 h recorded significantly highest (200.5) leaf area ratio among all treatments. It was followed by seeds soaked in thiourea 1% for 24 h (186.83), 12 h (184.61) and thiourea 0.5% soaked seeds for 12 h (183.8), whereas

Table 4.8: Correlation coefficients amongst germination and seedling attributes in thiourea treated *Annona* seeds

Seedling attributes	Seedling vigour index	Coefficient of velocity of germination	Stem diameter	Plant height	Root length	Number of leaves per plant	Leaf area per plant	Germination percentage
Days for initiation of germination	-0.56270**	-0.88657**	-0.48807*	-0.81686**	-0.65117**	-0.87836**	-0.90227**	0.51131**
Seedling vigour index		0.60192**	0.51850**	0.65261**	0.30061	0.78669**	0.74165**	0.9555**
Coefficient of velocity of germination			0.59663**	0.85027**	0.47454*	0.87774**	0.89497**	0.51784**
Stem diameter				0.63911**	0.41360**	0.61288**	0.70837**	0.32476
Plant height					0.59663**	0.85777**	0.91993**	0.51820**
Root length						0.44074*	0.61436**	0.17488
Number of leaves per plant							0.95875**	0.73774**
Leaf area per plant								0.63274**

** Significant at 1% level

* Significant at 5% level

minimum leaf area ratio was recorded in control (117.15).

4.4.16 Correlations amongst germination and seedling growth attributes

The correlation coefficients calculated for various germination and seedling growth attributes are given in Table 4.8.

The final germination percentage had a strong inverse relationship with number of days taken for commencement of germination and positive relation with vigour, velocity of germination, height, number of leaves and leaf area. The number of days taken for initiation was negatively correlated with seedling vigour, velocity of germination, stem diameter, height, root length of seedlings, number of leaves and leaf area. Seedling vigour was positively correlated with velocity of germination, stem diameter, height, number of leaves and leaf area of seedling. Velocity of germination was positively related to stem diameter, height, root length, number of leaves and leaf area, whereas stem diameter, plant height, root length, number of leaves and leaf area had positive relation with each other amongst themselves.

EXPERIMENT V

4.5 STUDIES ON THE INFLUENCE OF POTASSIUM NITRATE (KNO_3) ON ANNONA SEED GERMINATION AND SUBSEQUENT SEEDLING GROWTH

In this experiment a total number of five treatments were tested on *Annona* seed germination and seedling growth. Seed soaking in 0.5 per cent KNO_3 for 12 h, or 24 h; 1 per cent KNO_3 for 12 h or 24 h and dry seed as control were the five treatments. The parameters recorded under field conditions are presented.

4.5.1 Germination percentage

The data recorded on germination percentage are presented in Table 5.1 and Fig.5.1.

The maximum germination was recorded with the seeds soaked in KNO_3 1% solution for 24 h (64.0 per cent). It was on par with soaking seeds in KNO_3 0.5% solution for 24 h (58.0 per cent) and 12 h (54.0 per cent) and KNO_3 1% solution for 12 h (52.0 per cent), whereas in control only 13 per cent of germination was recorded.

Table 5.1: Effect of potassium nitrate on the germination of *Annona* seeds

Treatments	Germination (%)	No. of days taken for initiation of germination	Coefficient of velocity of germination	Seedling vigour Index
KNO ₃ 0.5%				
12 h	54.0	17.0	5.08	1673.48
24 h	58.0	17.0	5.22	1847.88
 KNO ₃ 1%				
12 h	52.0	17.0	5.04	1707.18
24 h	64.0	16.2	5.17	1689.60
Control (dry seeds)	13.0	30.0	3.30	224.77
C.D. at 5%	16.03	2.01	0.368	489.36

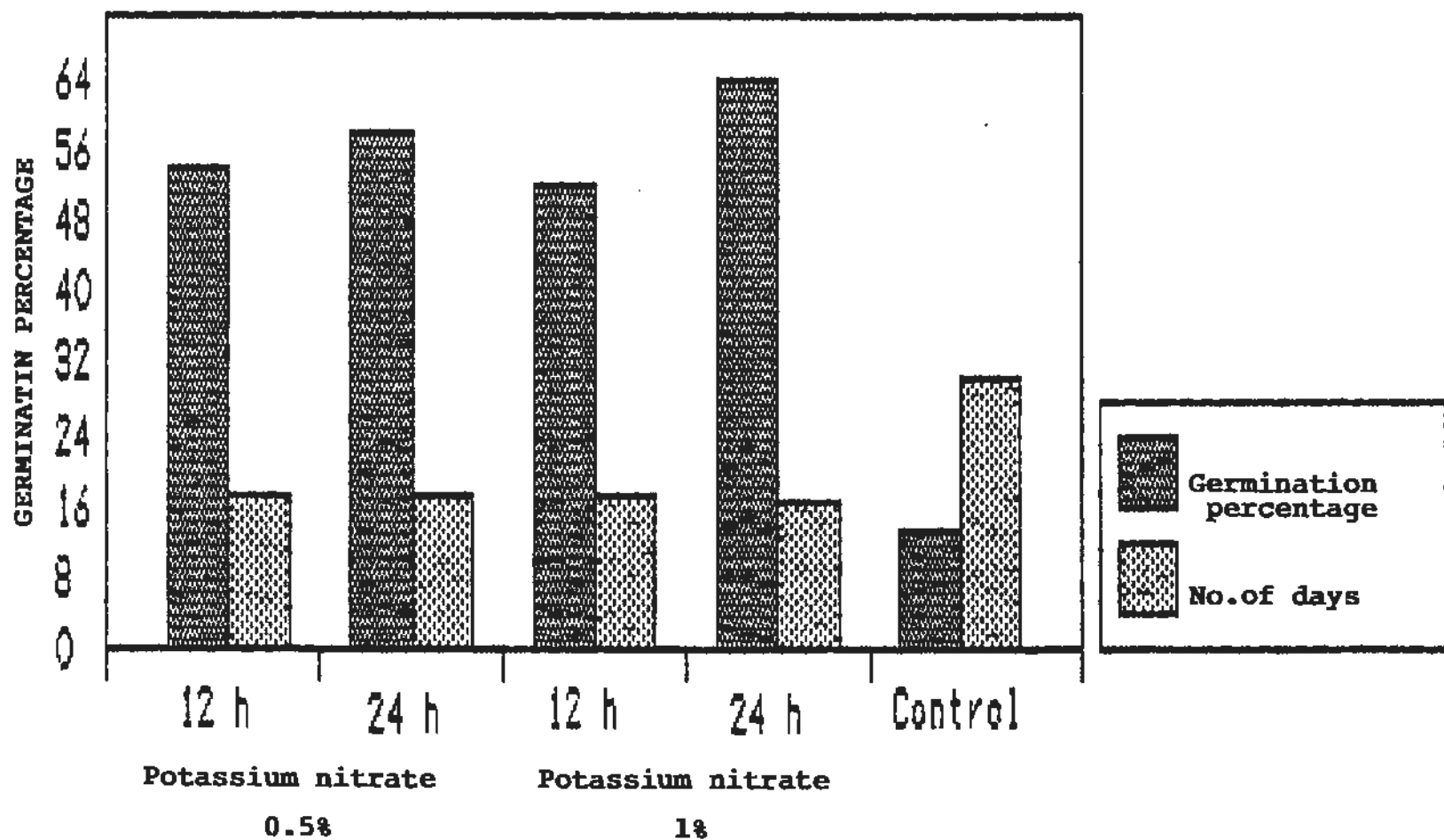


Fig. 5.1 Influence of Annona seed soaking in potassium nitrate on germination

4.5.2 Number of days taken for initiation of germination

The data on number of days taken for initiation of germination are presented in Table 5.1 and Fig.5.1.

Seeds soaked in KNO_3 0.5% solution for 12 h as well as 24 h required 17 days for initiation of germination. Soaking of seeds in KNO_3 1% solution for 24 h needed minimum number of days (16.2), whereas in control maximum number of days (30.0) was required for initiation of germination.

4.5.3 Coefficient of velocity of germination

Data relating to velocity of germination are presented in Table 5.1.

The highest velocity of germination (5.22) was recorded when seeds were soaked in KNO_3 0.5% for 24 h. It was on par with treatments like soaking in KNO_3 1% solution for 12 h, 24 h and KNO_3 0.5% for 12 h, whereas minimum velocity was recorded in control (3.30).

4.5.4 Seedling vigour index

Data on seedling vigour index are presented in Table 5.1.

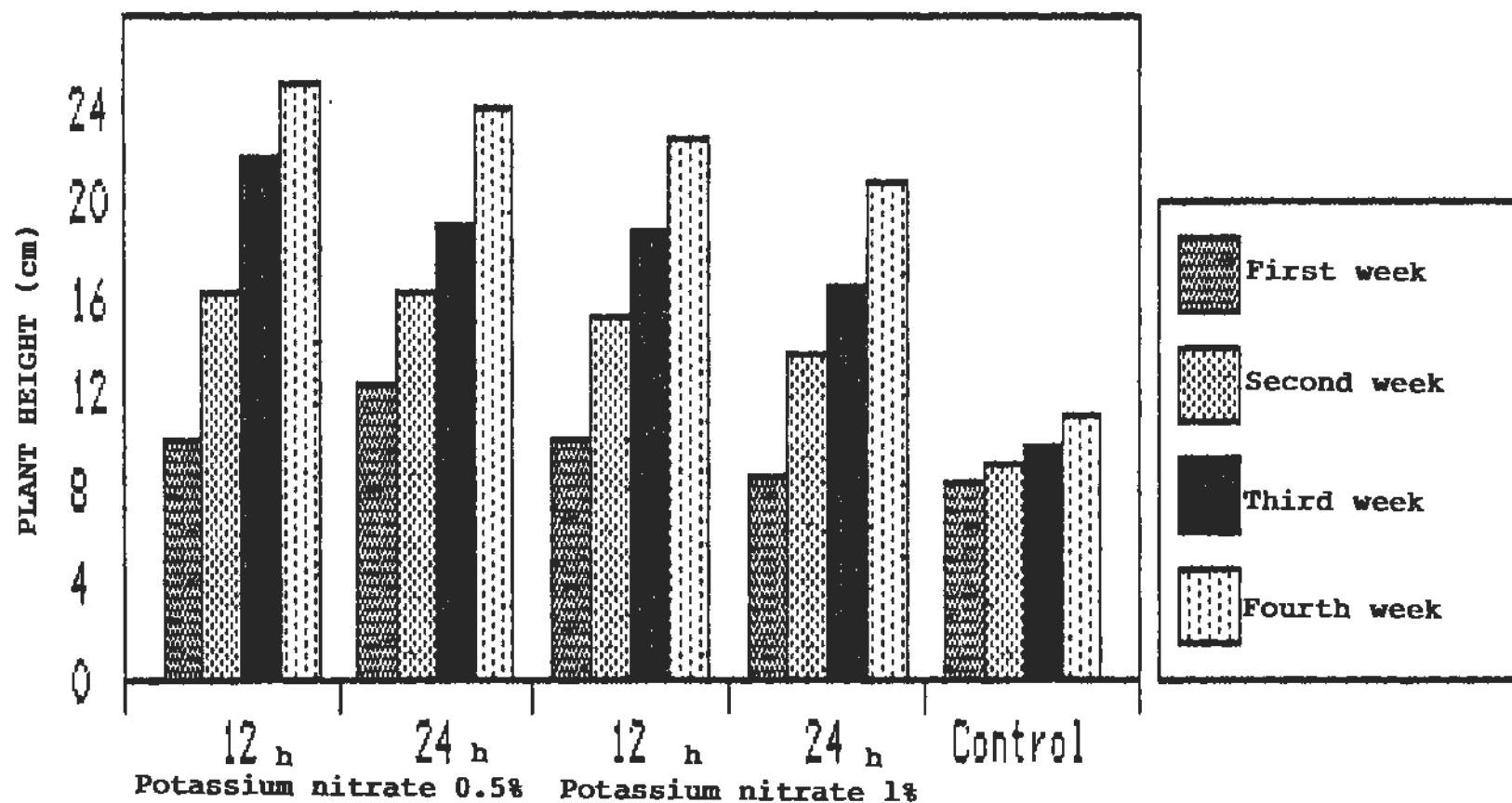


Fig.5.2: INFLUENCE OF ANNONA SEED SOAKING IN POTASSIUM NITRATE ON PLANT HEIGHT

Table 5.2: Effect of pre-soaking of Annona seeds in potassium nitrate on plant height and root length of seedlings

Treatments	Plant height (cm)				Root length (cm)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
KNO ₃ 0.5%								
12 h	10.03	16.16	21.83	24.96	2.80	3.20	4.66	6.03
24 h	12.33	16.13	19.03	23.76	5.36	5.38	8.03	8.10
KNO ₃ 1%								
12 h	10.10	15.16	18.70	22.63	4.90	5.20	7.36	10.23
24 h	8.46	13.60	16.46	20.70	2.83	4.40	5.66	5.70
Control (dry seeds)	8.10	9.10	9.73	11.16	2.46	5.26	5.83	6.13
C.D. at 5%	1.18	1.33	1.08	2.05	1.53	NS	1.75	2.30

Seeds soaked in KNO_3 0.5% solution for 24 h recorded maximum seedling vigour (1847.88) than other treatments. Except control, the remaining treatments were on par with each other in respect of seedling vigour. The minimum seedling vigour (489.36) was recorded in control.

4.5.5 Plant height (cm)

The data on seedling heights recorded at weekly intervals are presented in Table 5.2 and Fig.5.2.

At end of the first week soaking of seeds in KNO_3 0.5% solution for 24 h recorded maximum plant height (12.33 cm) which was significantly superior to all other treatments. Soaking in KNO_3 1% solution for 12 h (10.10 cm) was on par with soaking of seed in KNO_3 0.5% solution for 12 h (10.03 cm), whereas minimum height (8.10 cm) was observed in control. At the age of two weeks, seeds soaked in KNO_3 0.5% solution for 12 h recorded maximum plant height (16.16 cm) which was on par with soaking in KNO_3 0.5% for 24 h and KNO_3 1% for 12 h. Untreated seeds recorded minimum plant height. At the end of third week, seeds soaked in KNO_3 0.5% solution for 12 h recorded maximum plant height (21.03 cm) which was significantly superior to all other treatments tested. In control, only 9.73 cm height was

recorded. At the four weeks old age, seeds soaked in KNO_3 0.5% solution for 12 h recorded maximum plant height (24.96 cm) which was on par with treatments like soaking in KNO_3 0.5% for 24 h and KNO_3 1% for 12 h. Untreated seeds recorded minimum (11.16 cm) plant height.

4.5.6 Root length (cm)

Data recorded at weekly intervals on root length are presented in Table 5.2.

At the end of first week, seeds soaked in KNO_3 0.5% solution for 24 h recorded maximum root length (5.36 cm). It was on par with soaking of seeds in KNO_3 1% solution for 12 h. In control, minimum root length (2.46 cm) was recorded. At the age of two weeks, maximum root length was recorded in seeds soaked in KNO_3 0.5% solution for 24 h (5.38 cm) and minimum (3.2 cm) in seeds soaked in KNO_3 0.5% for 12 h. It was found that there was no significant difference in root length among all treatments when the seedlings were two weeks old. At the end of third week, seeds soaked in KNO_3 0.5% solution for 24 h recorded maximum root length (8.03 cm) which was on par with seeds soaked in KNO_3 1% solution for 12 h, whereas minimum root length was recorded with seeds soaked in KNO_3 0.5% for 12 h (4.66 cm). At the age of four weeks, seeds soaked in

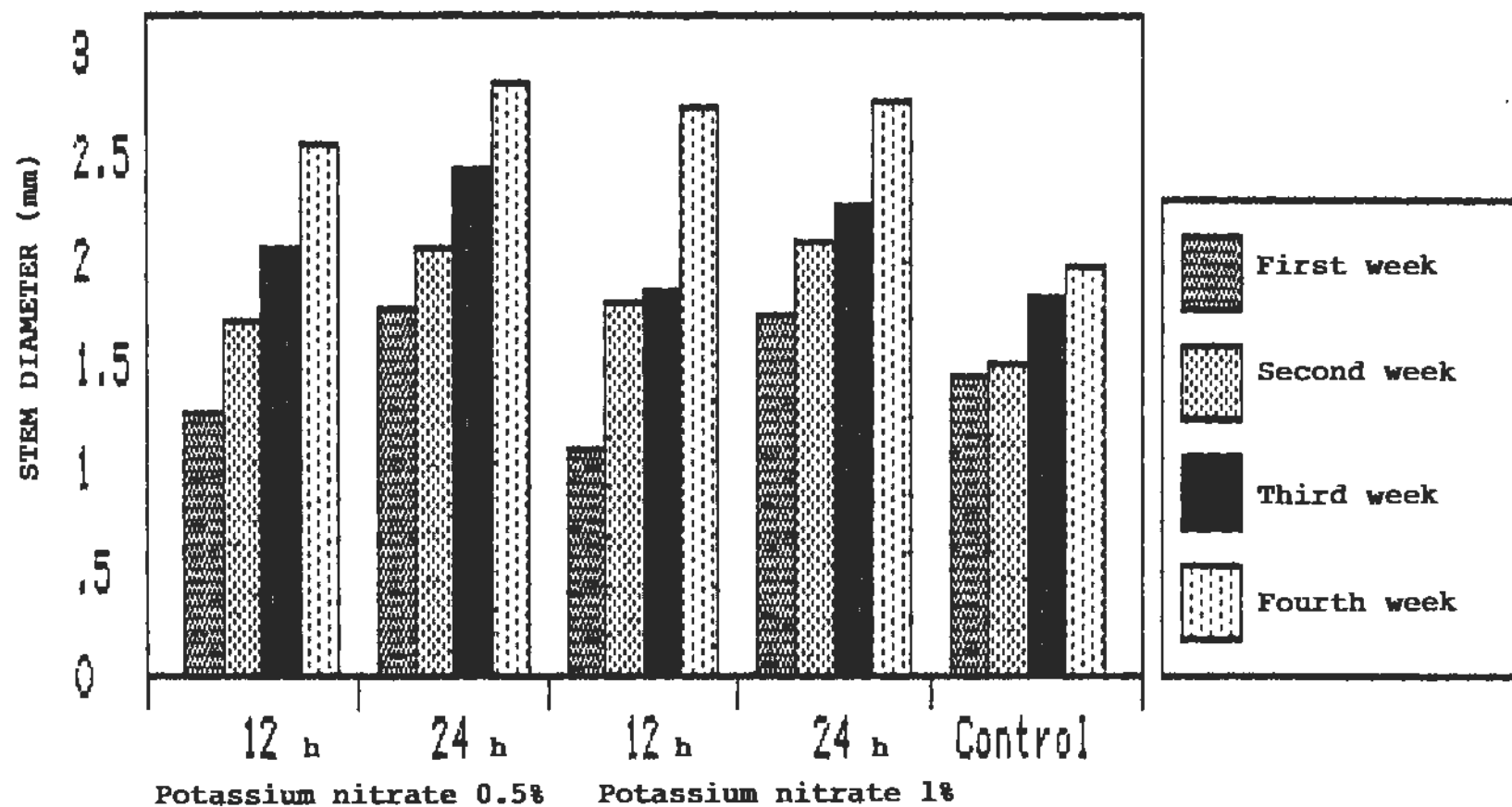


Fig.5.3: INFLUENCE OF ANNONA SEED SOAKING IN POTASSIUM NITRATE ON STEM DIAMETER

KNO_3 1% solution for 12 h recorded maximum root length (10.23 cm). It was significantly superior to all other treatments except soaking in KNO_3 0.5% solution for 24 h. Minimum root length (5.7 cm) was recorded with seeds soaked in KNO_3 1% solution for 24 h.

4.5.7 Stem diameter (mm)

The data on stem diameter of seedlings recorded at weekly intervals are presented in Table 5.4 and Fig.5.3.

At the age of one week, seeds soaked in KNO_3 0.5% solution for 24 h had higher stem diameter (1.76 cm). It was on par with seeds soaked in KNO_3 1% for 24 h (1.73 cm), whereas in control diameter of stem was 1.43 mm. Minimum stem diameter (1.1 mm) was recorded in seeds soaked in KNO_3 solution for 12 h. At the end of second week, there was no significant difference among all treatments. Maximum and minimum diameter were recorded with seeds soaked in KNO_3 for 24 h (2.1 mm) and control (1.5 mm) respectively. At the age of third week, seeds soaked in KNO_3 0.5% solution for 24 h recorded maximum stem diameter (2.43 mm) which was significantly superior to all other treatments, except KNO_3 1% for 24 h. Minimum diameter was recorded in control. At the age of fourth week, seeds soaked in KNO_3 0.5% solution for 24 h recorded maximum (2.96 mm)

Table 5.3: Effect of pre-soaking of *Annona* seeds in potassium nitrate on number of leaves and leaf area of seedlings

Treatments	Number of leaves per plant				Leaf area per plant (cm ²)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
KNO₃ 0.5%								
12 h	3.66	5.00	6.33	7.66	31.11	41.48	58.69	82.96
24 h	4.00	6.00	6.33	8.00	50.12	55.31	62.22	91.60
KNO₃ 1%								
12 h	4.00	4.66	5.66	8.33	15.55	31.11	65.67	98.52
24 h	4.00	6.00	6.33	7.33	36.29	51.85	72.59	77.78
Control (dry seeds)	2.66	3.00	4.00	4.33	13.82	15.55	27.65	51.84
C.D. at 5%	N.S.	1.59	1.28	1.05	0.046	0.065	0.11	N.S.

diameter which was on par with all other treatments except control (1.96 cm).

4.5.8 Number of leaves per plant

The data recorded on number of leaves per plant are presented in Table 5.3.

It was found that there was no significant difference among all treatments tested. At the end of first week, maximum and minimum number of leaves were recorded with soaking of seeds in KNO_3 0.5% solution for 24 h (4) and control (2.66) respectively. At the age of second week, both KNO_3 0.5% solution soaked seeds for 24 h and KNO_3 1% solution soaked seeds for 24 h recorded maximum number of leaves (6.0), whereas in control minimum number of leaves (3.0) was recorded. At the end of third week seeds treated with KNO_3 1% solution for 24 h, KNO_3 0.5% solution for 12 h as well as 24 h recorded maximum number of leaves (6.33), while in control minimum number of leaves was obtained (4.00). At the end of fourth week, seeds soaked in KNO_3 1% solution for 12 h recorded maximum number of leaves (8.33) which was on par with treatments like KNO_3 0.5% for 12 h, 24 h and KNO_3 1% for 24 h, whereas minimum number of leaves (4.33) was recorded in control.

Table 5.4: Effect of pre-soaking of *Annona* seeds in potassium nitrate on stem diameter and leaf dry weight of seedlings

Treatments	Stem diameter (mm)				Leaf dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
KNO_3 0.5%								
12 h	1.27	1.70	2.06	2.56	0.09	0.120	0.170	0.250
24 h	1.76	2.06	2.43	2.86	0.145	0.160	0.180	0.265
KNO_3 1%								
12 h	1.10	1.80	1.86	2.73	0.045	0.090	0.190	0.285
24 h	1.73	2.10	2.26	2.76	0.105	0.150	0.210	0.225
Control (dry seeds)	1.43	1.50	1.83	1.96	0.040	0.045	0.080	0.150
C.D. at 5%	0.36	N.S.	0.222	0.367	0.0094	0.0176	0.0168	0.0126

4.5.9 Leaf area per plant (cm^2)

Data on leaf area per plant are presented in Table 5.3.

At the first week, seeds soaked in KNO_3 0.5% solution for 24 h (50.12 cm^2) recorded significantly more leaf area when compared to other treatments. It was followed by treatments like KNO_3 1% solution for 24 h, KNO_3 0.5% solution for 12 h. Minimum leaf area (13.82 cm^2) was recorded in control. At the age of second week, seeds soaked in KNO_3 0.5% solution for 24 h recorded significantly more leaf area than other treatments. It was followed by seeds soaked in KNO_3 1% solution for 24 h and KNO_3 0.5% solution for 12 h, whereas minimum leaf area was recorded in control. At the end of third week, soaking of seeds in KNO_3 1% solution for 24 h (72.59 cm^2) recorded significantly highest leaf area. This was followed by treatments like KNO_3 1% for 12 h, KNO_3 0.5% solution for 24 h. In control leaf area recorded was 27.65 cm^2 only. At the age of fourth week, seeds soaked in KNO_3 1% solution for 12 h recorded maximum leaf area (98.52 cm^2) and minimum (51.84 cm^2) was recorded in control.

4.5.10 Leaf dry weight (g)

The data on leaf dry weight recorded at weekly intervals are presented in Table 5.4.

At the age of first week, maximum leaf dry weight (0.145 g) was recorded with soaking of seeds in KNO_3 0.5% solution for 24 h which was significantly superior to all other treatments. It was closely followed by soaking in KNO_3 1% solution for 24 h (0.105 g), whereas minimum dry weight (0.040 g) was recorded in control. At the age of second week, soaking of seeds in KNO_3 0.5% solution for 24 h recorded maximum leaf dry weight (0.16 g). It was on par with seeds soaked in KNO_3 1% solution for 24 h, whereas minimum dry weight was recorded in control (0.045 g). At the end of third week, KNO_3 1% soaked seeds for 24 h recorded maximum dry weight (0.21 g) which was significantly superior to all other treatments and was followed by soaking in KNO_3 1% for 12 h, KNO_3 0.5% for 24 h and 12 h. In control, minimum dry weight (0.08 g) was recorded. At the end of fourth week, maximum leaf dry weight was recorded with soaking of seeds in KNO_3 1% solution for 12 h (0.285 g). It was significantly superior to all other treatments tested and was followed by treatments like KNO_3 0.5% for 24 h and 12 h, while in control, the dry weight recorded was 0.15 g only.

4.5.11 Stem dry weight (g)

The data recorded at weekly intervals on stem dry weight are presented in Table 5.5.

Table 5.5: Effect of pre-soaking of *Annona* seeds in potassium nitrate on stem and root dry weights of seedlings

Treatments	Stem dry weight (g)				Root dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
KNO_3 0.5%								
12 h	0.085	0.105	0.110	0.120	0.050	0.075	0.097	0.150
24 h	0.090	0.115	0.120	0.155	0.040	0.070	0.125	0.155
KNO_3 1%								
12 h	0.030	0.045	0.080	0.095	0.050	0.065	0.070	0.077
24 h	0.085	0.100	0.135	0.160	0.080	0.095	0.118	0.125
Control (dry seeds)	0.025	0.095	0.100	0.100	0.010	0.025	0.040	0.050
C.D. at 5%	0.0105	0.0041	0.0171	0.0125	N.S.	0.0067	0.0053	0.0024

At the age of first week, soaking in KNO_3 0.5% solution for 24 h recorded more stem dry weight (0.09 g) and it was on par with seeds soaked in KNO_3 0.5% for 12 h and KNO_3 1% solution for 24 h, whereas minimum dry weight (0.025 g) was recorded in control. At the second week, seeds soaked in KNO_3 0.5% solution for 24 h gave significantly more stem dry weight (0.115 g) among all treatments, whereas soaking with KNO_3 0.5% for 12 h and KNO_3 1% for 24 h resulted in 0.105 g and 0.1 g of dry weights respectively. Soaking of seeds in KNO_3 1% solution for 12 h resulted in minimum dry weight (0.045 g). At the age of third week, maximum dry weight was observed with seeds soaked in KNO_3 1% solution for 24 h (0.135 g). It was on par with soaking in KNO_3 0.5% for 24 h. Minimum dry weight was recorded in control (0.1 g). At the age of fourth week, maximum stem dry weight was recorded with soaking of seeds in KNO_3 1% for 24 h (0.16 g) and was on par with seeds soaked in KNO_3 0.5% solution for 24 h, while in control, lowest stem dry weight (0.1 g) was recorded.

4.5.12 Root dry weight (g)

The data on root dry weight are presented in Table 5.5.

Table 5.6: Effect of pre-soaking of *Annona* seeds in potassium nitrate on relative growth rate

Treatments	Relative growth rate		
	7-14 days	14-21 days	21-28 days
KNO_3 0.5%			
12 h	0.041	0.032	0.044
24 h	0.032	0.030	0.043
KNO_3 1%			
12 h	0.067	0.076	0.042
24 h	0.045	0.033	0.044
Control (dry seeds)	0.117	0.037	0.043
C.D. at 5%	0.00015	0.00015	0.00082

At the first week, there was no significant difference among all treatments tested for root dry weight. Maximum root dry weight was recorded with seeds soaked in KNO_3 1% solution for 24 h (0.08 g), whereas minimum dry weight (0.01 g) was recorded in control. At the age of second week, seeds soaked in KNO_3 1% solution for 24 h recorded maximum dry weight (0.095 g). It was significantly superior to all other treatments, whereas minimum dry weight was recorded in control (0.025 g). At the end of third week, significantly maximum dry weight (0.125 g) was recorded with seeds soaked in KNO_3 0.5% solution for 24 h. It was followed by KNO_3 1% for 24 h and KNO_3 0.5% for 12 h treatments, whereas minimum dry weight was recorded in control. At the age of fourth week, seeds soaked in KNO_3 0.5% solution for 24 h recorded significantly more dry weight (0.155 g). It was closely followed by seeds soaked in KNO_3 0.5% solution for 12 h. Minimum dry weight (0.05 g) was recorded in control.

4.5.13 Relative Growth Rate

The data worked out on relative growth rate are presented in Table 5.6.

Between seven and fourteen days, maximum relative growth rate (0.117) was recorded in control followed by soaking of seeds in KNO_3 1% for 12 h, 24 h

and KNO_3 0.5% for 12 h treatments. Minimum relative growth rate (0.032) was obtained with seeds soaked in KNO_3 0.5% solution for 24 h. Between fourteen and twenty one days maximum relative growth rate (0.076) was recorded with soaking of seeds in KNO_3 1% for 12 h. It was significantly superior to all other treatments, whereas minimum relative growth rate was recorded in control. Between twenty one and twenty eight days, seeds soaked in KNO_3 1% solution for 24 h as well as seeds soaked in KNO_3 solution for 12 h recorded maximum relative growth rate (0.044), however, minimum relative growth rate was recorded in KNO_3 1% soaked seeds for 12 h (0.042).

4.5.14 Leaf Weight Ratio

The data on leaf weight ratio are presented in Table 5.7.

At the end of first week, maximum leaf weight ratio was recorded in control (0.533). Seeds soaked in KNO_3 0.5% solution for 24 h recorded a leaf weight ratio of 0.527, whereas minimum leaf weight ratio was recorded in seeds soaked in KNO_3 1% solution for 12 h (0.36). At the age of second week, seeds soaked in KNO_3 0.5% solution for 24 h recorded maximum leaf weight ratio (0.464) which was on par with seeds soaked in KNO_3 per cent solution for 12 h (0.45). In control

Table 5.7: Effect of pre-soaking of *Annona* seeds in potassium nitrate on leaf weight ratio and leaf area ratio of seedlings

Treatments	Leaf weight ratio				Leaf area ratio			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
KNO_3 0.5%								
12 h	0.400	0.400	0.453	0.471	138.26	138.26	156.69	162.66
24 h	0.527	0.464	0.424	0.461	182.25	160.318	146.40	159.30
KNO_3 1%								
12 h	0.360	0.450	0.559	0.626	124.40	155.55	193.17	216.52
24 h	0.389	0.405	0.452	0.461	134.50	140.13	156.10	152.50
Control (dry seeds)	0.533	0.265	0.366	0.500	184.26	91.47	125.68	172.83
C.D. at 5%	0.0082	0.024	0.003	0.0167	N.S.	0.3902	0.2631	0.2631

minimum (0.265) leaf weight ratio was recorded. At the age of third week, seeds soaked in KNO_3 1% solution for 12 h recorded significantly more leaf weight Ratio (0.559) among all treatments tested. Other treatments except control were on par with each other with respect of leaf weight ratio. The control recorded minimum leaf weight ratio (0.366). At the end of fourth week, significantly maximum leaf weight ratio (0.626) was recorded. The other treatments except control were on par with each other. Minimum leaf weight ratio (0.461) was recorded with seeds soaked in KNO_3 1% solution for 24 h.

4.5.15 Leaf Area Ratio

The data recorded on leaf area ratio are presented in Table 5.7.

At the end of first week, it was found that there was no significant difference among all treatments tested. Maximum and minimum leaf area ratios were recorded with control (184.26) and seeds soaked in KNO_3 1% solution for 12 h (124.4) respectively. At the age of second week, seeds soaked in KNO_3 0.5% solution for 24 h recorded significantly more leaf area ratio (60.318) among all treatments and was followed by soaking of seeds in KNO_3 1% solution for 12 h (155.55) and 24 h (140.13) as well as KNO_3

Table 5.8: Correlation coefficients amongst germination and seedling attributes in potassium nitrate treated *Annona* seeds

Seedling attributes	Seedling vigour index	Coefficient of velocity of germination	Stem diameter	Plant height	Root length	Number of leaves per plant	Leaf area per plant	Germination percentage
Days for initiation of germination	-0.87851**	-0.91141**	-0.84752**	-0.92133**	-0.28381	-0.93465**	-0.85314**	-0.85182**
Seedling vigour index		0.76257**	0.71216**	0.85265**	0.28009	0.87081**	0.80129**	0.97642**
Coefficient of velocity of germination			0.88683**	0.89759**	0.21055	0.90139**	0.83871**	0.72827**
Stem diameter				0.78698**	0.36376	0.81690**	0.82315**	0.67923**
Plant height					0.31270	0.93908**	0.88120**	0.77499**
Root length						0.44570*	0.64109**	0.13456
Number of leaves per plant							0.94995**	0.79502**
Leaf area per plant								0.68816**

** Significant at 1% level

* Significant at 5% level

0.5% solution for 12 h (138.26). Minimum leaf area ratio (91.47) was recorded in control. At the third week, all the treatments differed significantly with each other. Maximum leaf area ratio (193.17) was recorded with soaking of seeds in KNO_3 1% solution for 12 h and minimum LAR was (125.68) recorded in control. At the fourth week also, seeds soaked in KNO_3 1% solution for 12 h recorded significantly more leaf area ratio (216.52) and was followed by the seeds in control, soaking in KNO_3 0.5% solution for 12 h and 24 h treatments. Leaf area ratio was minimum (152.5) with seeds soaked in KNO_3 1% for 24 h.

4.5.16 Correlations amongst germination and seedling growth attributes

The correlation coefficients calculated for various germination and seedling growth attributes are given in Table 5.8.

The germination percentage had a positive correlation with seedling vigour, velocity of germination, stem diameter, height, number of leaves and leaf area, but the relationship was negative with number of days taken for commencement of germination which in turn negatively correlated with seedling vigour, velocity of germination, stem diameter, seedling height, number of leaves and leaf area. Seedling

vigour had a strong positive relation with velocity of germination, stem diameter, height of seedling, number of leaves and leaf area. Velocity of germination had a strong positive relationship with stem diameter, plant height, number of leaves and leaf area. Stem diameter also had a positive relation with plant height, number of leaves and leaf area, whereas plant height, number of leaves, leaf area correlated positively with each other.

EXPERIMENT VI

4.6 STUDIES ON THE INFLUENCE OF PRE SOWING TREATMENT WITH COMBINATION OF DIFFERENT CHEMICALS ON ANNONA SEED GERMINATION AND SUBSEQUENT SEEDLING GROWTH

In this experiment 14 treatments with different combinations of chemicals were tried on Annona seeds. Out of 14 treatments, only 11 treatments were evaluated further for their effect on subsequent seedling growth since those three treatments did not produce sufficient plant samples for evaluation due to poor germination. The following parameters were recorded under field conditions.

Table 6.1: Effect of pre-soaking of Annona seeds in different combinations of chemicals on germination

Treatments	Germination (%)	No. of days taken for initiation of germination	Coefficient of velocity of germination	Seedling vigour Index
Water for 24 h + H_2SO_4 4 min.	5.00	35.2	2.85	99.09
Water for 24 h + GA 200 ppm for 24 h	45.00	16.2	6.01	1261.35
Water for 24 h + GA 400 ppm for 12 h	58.00	15.0	5.46	1735.94
Water for 24 h + KNO_3 1% for 12 h	54.00	17.0	6.03	1823.05
Water for 24 h + KNO_3 1% for 24 h	33.00	16.0	5.23	849.09
GA 200 ppm for 24 h + H_2SO_4 for 4 min.	9.00	30.0	3.32	180.00
GA 200 ppm for 24 h + KNO_3 1% for 12 h	39.00	15.0	5.94	1010.87
GA 200 ppm for 24 h + KNO_3 1% for 24 h	51.00	17.0	5.55	1408.62
GA 400 ppm for 12 h + H_2SO_4 for 4 min.	10.00	16.4	3.65	213.00
GA 400 ppm for 12 h + KNO_3 1% for 12 h	43.00	16.2	5.91	1225.07
GA 400 ppm for 12 h + KNO_3 1% for 24 h	44.00	16.0	5.84	1222.76
KNO_3 1% for 12 h + conc H_2SO_4 for 4 min.	34.00	19.4	5.58	855.44
KNO_3 1% for 24 h + conc H_2SO_4 for 4 min.	36.00	18.0	5.57	921.25
Control	17.00	30.0	3.34	292.910
C.D. at 5%	15.69	1.42	0.830	449.83

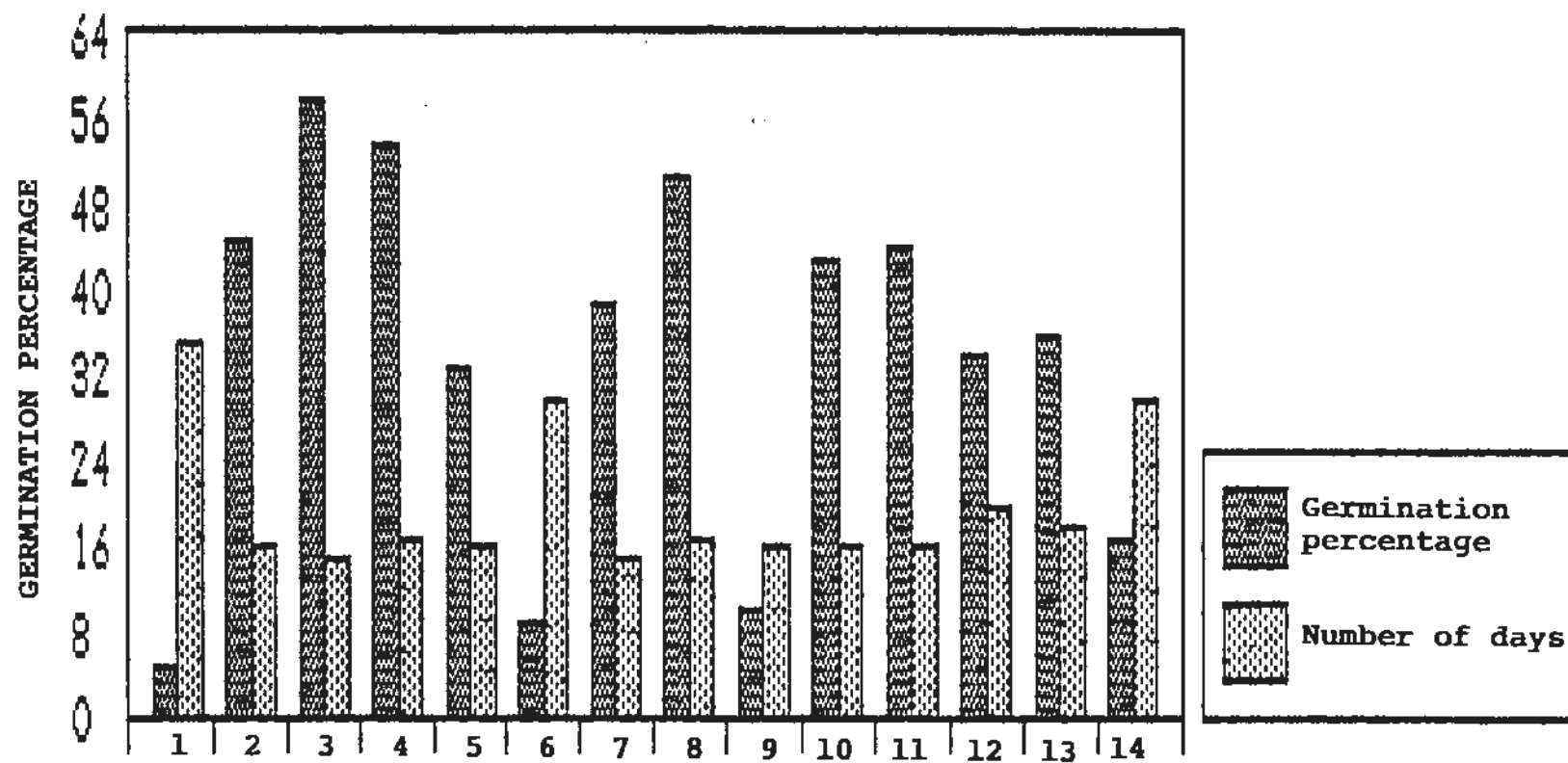


Fig.6.1: INFLUENCE OF ANNONA SEED SOAKING IN DIFFERENT COMBINATIONS OF CHEMICALS ON GERMINATION

4.6.1 Germination percentage

Data recorded on germination percentage are presented in Table 6.1 and Fig.6.1.

Seeds soaked in water for 24 h + GA 400 ppm for 12 h recorded maximum germination (58.00 per cent) among all treatments tested. It was on par with seeds soaked in water for 24 h + potassium nitrate 1% solution for 12 h (54.00 per cent), GA 200 ppm for 24 h + KNO_3 1% for 24 h (51.00 per cent), water for 24 h + GA 200 ppm for 24 h (45.00 per cent), GA 400 ppm for 24 h + KNO_3 1% for 24 h (44.00 per cent) and GA 400 ppm for 24 h + KNO_3 1% solution for 12 h (43.00 per cent) treatments, whereas soaking in water for 24 h + concentrated H_2SO_4 for 4 minutes recorded only 5 per cent of germination. In control, 17 per cent of seeds were germinated. Seeds soaked in GA 200 ppm for 24 h + concentrated H_2SO_4 for 4 minutes and seeds soaked in GA 400 ppm for 24 h + concentrated H_2SO_4 for 4 minutes recorded 9 per cent and 10 per cent of germination respectively.

4.6.2 Number of Days Taken for Initiation of Germination

Minimum number of days was required for initiation of germination (Table 6.1 and Fig.6.1) in seeds soaked in water for 24 h + GA 400 ppm for 12 h

(15.0) as well as seeds soaked in GA 200 ppm for 24 h + KNO_3 1% solution for 12 h (15.0). It was on par with seeds soaked in water for 24 h + GA 200 ppm for 24 h, water for 24 h + KNO_3 1% for 24 h (16.0), GA 400 ppm for 12 h + H_2SO_4 for 4 minutes (16.4), GA 400 ppm for 12 h + KNO_3 1% for 12 h (16.2) and GA 400 ppm for 12 h + KNO_3 1% for 24 h (16.0) treatments, whereas remaining treatments needed significantly more number of days for initiation of germination. Seeds soaked in water for 24 h + concentrated H_2SO_4 for 4 minutes took maximum number of days (35.2) for initiation of germination.

4.6.3 Coefficient of velocity of germination

The data pertaining to velocity of germination are presented in Table 6.1.

Maximum velocity of germination was recorded in seeds soaked in water for 24 h + Potassium nitrate (KNO_3) 1% solution for 12 h (6.03). It was on par with seeds soaked in water for 24 h + GA 200 ppm for 24 h, GA 200 ppm for 24 h + KNO_3 1% for 12 h, GA 400 ppm for 12 h + KNO_3 1% for 12 h, GA 400 ppm for 12 h + KNO_3 1% for 24 h and KNO_3 1% for 12 h + concentrated H_2SO_4 for 4 min treatments. Lowest velocity of germination (2.85) was recorded in seeds soaked in water for 24 h + H_2SO_4 for 4 minutes.

Table 6.2: Effect of pre-soaking of *Annona* seeds in different combinations of chemicals on plant height and root length of seedlings

Treatments	Plant height (cm)				Root length (cm)			
	Ist week	IInd week	IIInd week	IVth week	Ist week	IInd week	IIInd week	IVth week
Water for 24 h + GA 200 ppm for 24 h	10.10	15.16	18.70	22.63	1.46	2.73	4.80	5.43
Water for 24 h + GA 400 ppm for 12 h	9.06	14.03	16.50	25.30	2.40	2.56	3.86	4.63
Water for 24 h + KNO_3 1% for 12 h	9.90	14.06	18.60	25.06	5.40	7.80	8.13	8.70
Water for 24 h + KNO_3 1% for 24 h	7.03	14.96	18.30	19.20	4.33	5.96	6.06	6.53
GA 200 ppm for 24 h + KNO_3 1% for 12 h	11.50	13.73	17.93	18.80	4.43	5.76	5.96	7.13
GA 200 ppm for 24 h + KNO_3 1% for 24 h	10.30	12.96	18.63	19.66	4.66	7.43	7.90	7.96
GA 400 ppm for 12 h + KNO_3 1% for 12 h	9.50	12.16	17.13	18.73	3.73	4.90	9.43	9.76
GA 400 ppm for 12 h + KNO_3 1% for 24 h	8.06	14.46	18.80	20.43	4.30	6.33	6.90	7.36
KNO_3 1% for 12 h + conc H_2SO_4 for 4 min.	9.56	16.06	17.06	19.00	3.46	4.16	6.03	6.16
KNO_3 1% for 24 h + conc H_2SO_4 for 4 min.	7.43	15.66	17.06	20.76	2.90	3.46	4.00	4.83
Control (dry seeds)	8.133	9.03	9.70	11.10	2.46	5.23	6.06	6.13
C.D. at 5%	2.25	1.90	1.76	2.33	N.S.	2.68	2.87	1.84

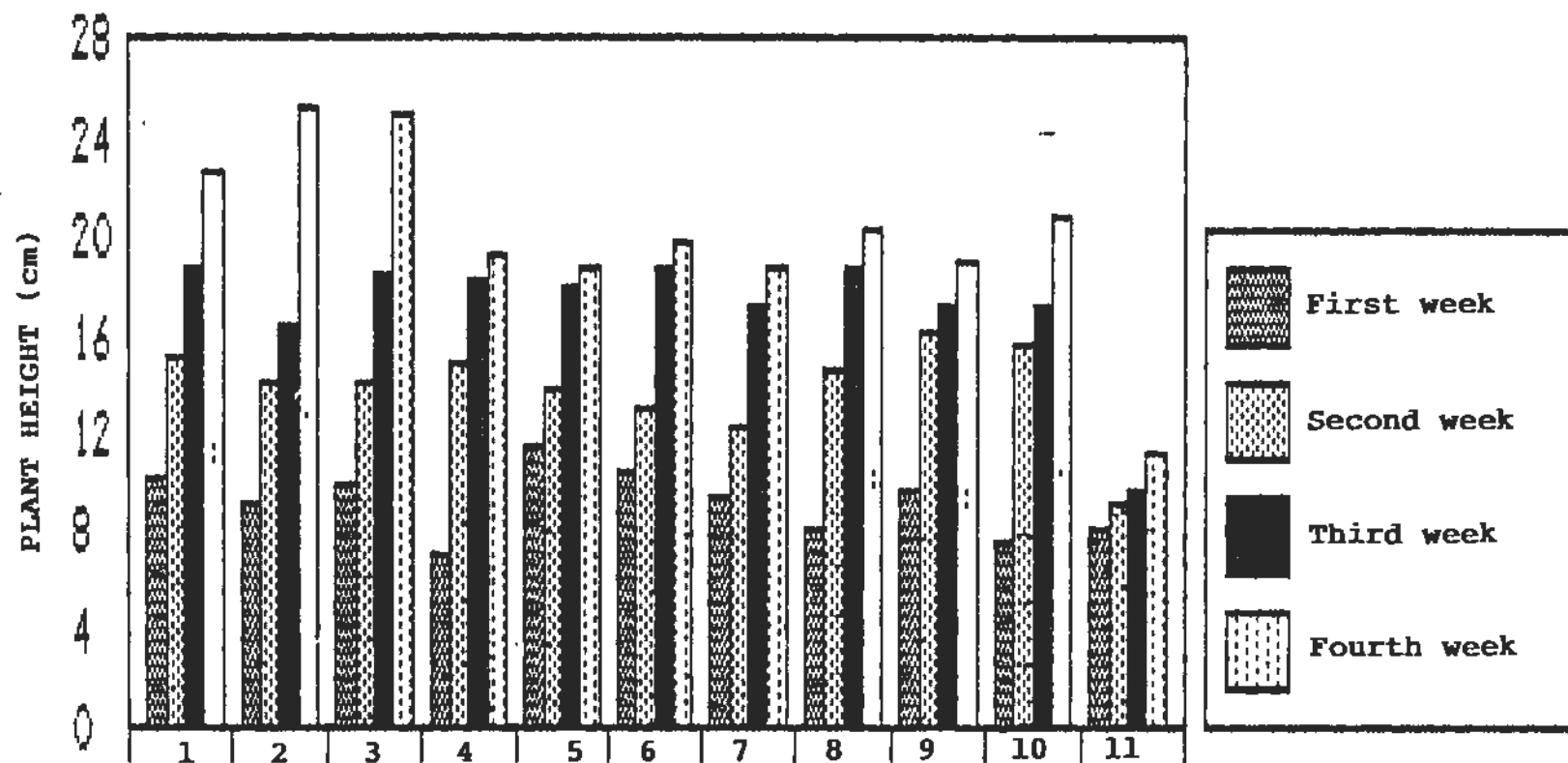


Fig.6.2: INFLUENCE OF ANNONA SEED SOAKING IN DIFFERENT COMBINATIONS. OF CHEMICALS ON PLANT HEIGHT

4.6.4 Seedling vigour index

Seeds soaked in water for 24 h + KNO_3 1% for 12 h recorded highest seedling vigour (1,823.05) which was significantly superior to all other treatments except seeds soaked in water for 24 h + GA 200 ppm for 24 h, water for 24 h + GA 400 ppm for 12 h and GA 200 ppm for 24 h + KNO_3 1% for 24 h treatments (Table 6.1). Seeds soaked in water for 24 h + concentrated H_2SO_4 for 4 minutes, GA 200 ppm for 24 h + concentrated H_2SO_4 for 4 minutes recorded seedling vigour of only 99.00, 180.00 and 213.00 respectively.

4.6.5 Plant height (cm)

The data recorded on plant height at weekly intervals are presented in Table 6.2 and Fig.6.2.

Maximum plant height was recorded with seeds soaked in GA 200 ppm for 24 h + KNO_3 1% for 12 h. It was on par with seeds soaked in water for 24 h GA 200 ppm for 24 h (10.1 cm), GA 200 ppm for 24 h + KNO_3 1% solution for 24 (10.3 cm), KNO_3 1% solution for 12 h + Concentrated H_2SO_4 for 4 minutes (9.56) and GA 400 ppm for 12 h + KNO_3 1% for 12 h (9.5 cm). Whereas, minimum plant height was recorded with seeds soaked in water for 24 h + KNO_3 1% for 24 h (7.03 cm). At the end of second week, seeds soaked in KNO_3 1% solution for 12 h + concentrated H_2SO_4 for 4 minutes (16.06 cm) recorded

maximum plant height followed by KNO_3 1% for 24 h + concentration H_2SO_4 for 4 minutes, water soaking for 24 h + GA 200 ppm for 24 h, water soaking for 24 h + KNO_3 1% for 24 h, and GA 400 ppm for 12 h + KNO_3 for 24 h soaked seeds, whereas minimum plant height was recorded with control (9.03 cm). At the end of third week, seeds soaked in GA 400 ppm for 12 h + KNO_3 1% solution for 24 h recorded maximum plant height (18.8 cm). It was on par with seeds soaked in water for 24 h + GA 200 ppm for 24 h, water for 24 h + KNO_3 1% for 12 h, and water for 24 h + KNO_3 1% for 24 h treatments, whereas minimum plant height was recorded in control (9.7 cm). At the end of fourth week, seeds soaked in water for 24 h + GA 400 ppm for 12 h recorded significantly maximum plant height (25.3 cm) among all treatments except seeds soaked in water for 24 h + KNO_3 1% solution for 12 h. In control minimum plant height (11.1 cm) was recorded.

4.6.6 Root length (cm)

The data pertaining to root length recorded at weekly intervals are presented in Table 6.2.

It was found that there was no significant difference among all treatments at the end of first week. Maximum and minimum root lengths were recorded with seeds soaked in water for 24 h + KNO_3 1% solution

for 12 h (5.4 cm) and seeds soaked in water for 24 h + GA 200 ppm solution for 24 h (1.46 cm) respectively. At the end of second week, seeds soaked in water for 24 h plus KNO_3 1% solution for 12 h recorded maximum root length (7.8 cm) and it was on par with seeds soaked in GA 200 ppm for 24 h + KNO_3 1% solution for 24 h, GA 400 ppm for 12 h + KNO_3 1% solution for 24 h, water soaked for 24 h + KNO_3 1% solution for 24 h and GA 200 ppm for 24 h + KNO_3 1% solution for 12 treatments. Minimum root length (2.56 cm) was recorded in water soaking for 24 h + GA 400 ppm for 12 h. At the end of third week, highest root length (9.43 cm) was observed with seeds soaked in GA 400 ppm for 12 h + KNO_3 1% solution for 12 h and was followed by soaking in water for 24 h + KNO_3 1% solution for 12 h, GA 200 ppm for 24 h + KNO_3 1% solution for 24 h and GA 400 ppm for 12 h + KNO_3 1% solution for 24 h treatments. Minimum root length was recorded with water soaking for 24 h + GA 400 ppm for 12 h treatment. At the end of fourth week, seeds soaked in GA 400 ppm solution for 12 h + KNO_3 1% solution for 12 h recorded more root length (9.76 cm) and it was significantly superior to all other treatments tested except soaking in water for 24 h + KNO_3 1% solution for 12 h treatment (8.7 cm). Seed soaking in water for 24 h + GA 400 ppm for 12 h recorded the minimum (4.63 cm) root length.

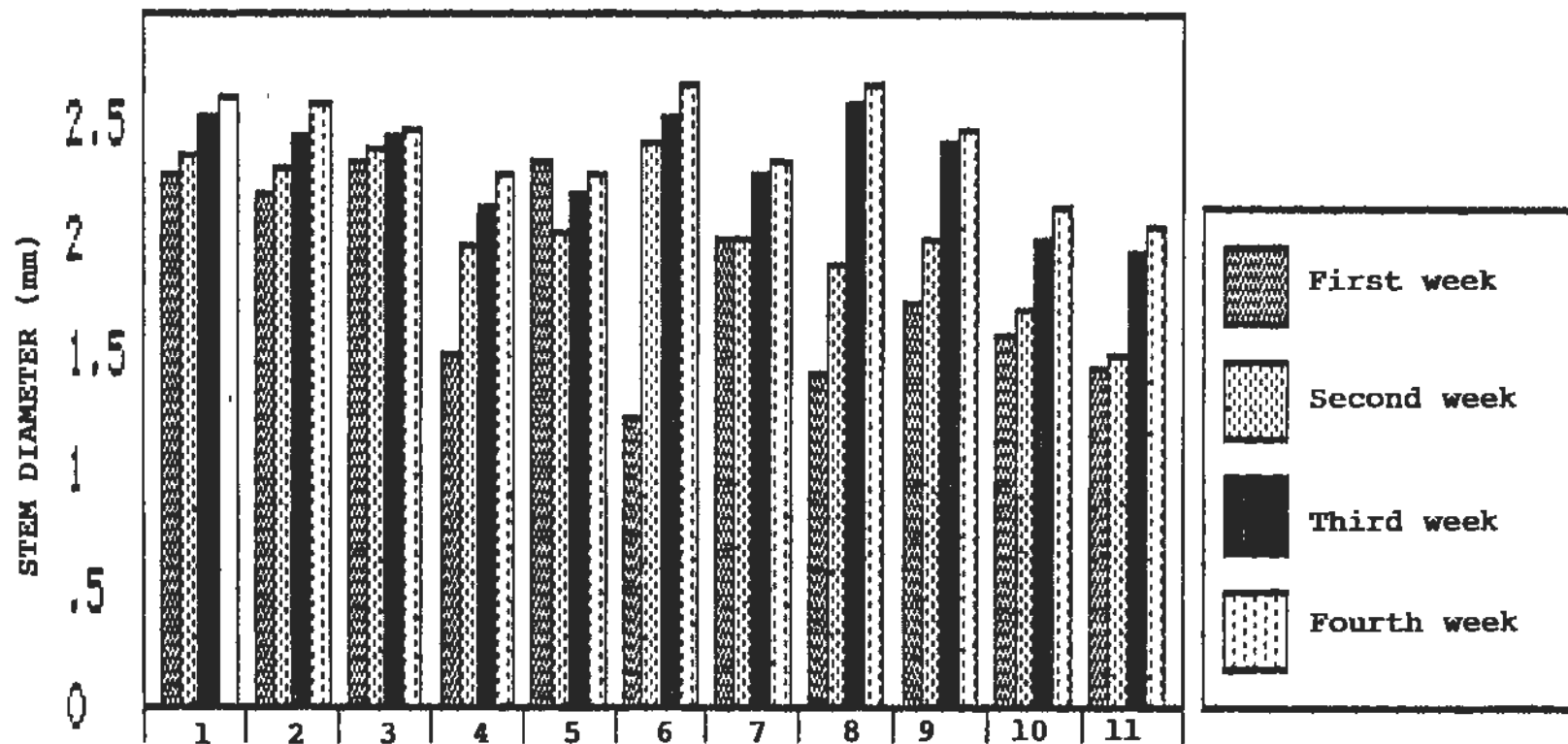


Fig.6.3: INFLUENCE OF ANNONA SEED SOAKING IN DIFFERENT COMBINATIONS OF CHEMICALS ON STEM DIAMETER

4.6.7 Stem diameter (mm)

Data on stem diameter recorded at weekly intervals are presented in Table 6.4 and Fig.6.3.

At the end of first week, seeds soaked in water for 24 h + KNO_3 1% solution for 12 h recorded maximum stem diameter (2.33 mm). It was on par with soaking in water for 24 h + GA 200 ppm for 24 h, water soaking for 24 h + GA 400 ppm for 12 h, GA 200 ppm for 24 h + KNO_3 1% for 24 h and GA 400 ppm for 12 h + KNO_3 1% for 12 h treatments. Minimum stem diameter was recorded from seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 24 h (1.43 mm). At the end of second week, seeds soaked in GA 200 ppm solution for 24 h + KNO_3 1% for 24 h recorded maximum (2.4 mm) stem diameter. It was on par and followed by the treatments like water soaking for 24 h + KNO_3 1% for 12 h, water soaking for 24 h + GA 00 ppm for 24 h, water soaking for 24 h + GA 400 ppm for 12 h and GA 400 ppm for 12 h + KNO_3 1% for 12 h, whereas minimum stem diameter (1.5 mm) occurred in control. At the end of third week, soaking of seeds in GA 400 ppm solution for 12 h + KNO_3 1% solution for 24 h produced significantly more stem diameter among all treatments except soaking in KNO_3 1% solution for 24 h + concentrated H_2SO_4 for 4 minutes. Minimum stem diameter was recorded in control. At the end of fourth week, however, there was no significant difference

Table 6.3: Effect of pre-soaking of Annona seeds in different combinations of chemicals on number of leaves and leaf area of seedlings

Treatments	Number of leaves per plant				Leaf area per plant (cm ²)			
	Ist week	IInd week	IIInd week	IVth week	Ist week	IInd week	IIInd week	IVth week
Water for 24 h + GA 200 ppm for 24 h	3.66	4.66	5.00	6.66	22.47	39.75	56.17	77.78
Water for 24 h + GA 400 ppm for 12 h	3.00	4.33	4.33	6.33	23.17	52.54	70.00	107.17
Water for 24 h + KNO ₃ 1% for 12 h	3.33	5.33	5.66	7.33	5.18	25.92	53.57	62.22
Water for 24 h + KNO ₃ 1% for 24 h	3.00	5.00	6.00	7.00	15.92	31.13	60.49	65.68
GA 200 ppm for 24 h + KNO ₃ 1% for 12 h	3.33	5.33	6.00	7.00	12.44	25.23	41.48	45.97
GA 200 ppm for 24 h + KNO ₃ 1% for 24 h	4.33	6.00	6.00	7.33	7.94	40.11	51.85	58.76
GA 400 ppm for 12 h + KNO ₃ 1% for 12 h	2.66	4.66	6.33	5.33	32.84	41.48	57.38	91.60
GA 400 ppm for 12 h + KNO ₃ 1% for 24 h	2.33	5.66	6.00	7.00	4.83	19.01	40.43	67.41
KNO ₃ 1% for 12 h + conc H ₂ SO ₄ for 4 min.	3.00	5.66	5.66	7.66	17.28	22.81	44.94	50.12
KNO ₃ 1% for 24 h + conc H ₂ SO ₄ for 4 min.	4.00	5.66	6.00	6.00	12.33	19.01	30.24	55.31
Control (dry seeds)	2.667	3.00	4.00	4.33	13.82	15.55	25.92	34.56
C.O. at 5%	N.S.	1.26	1.27	1.28	0.425	0.063	0.477	0.1

among all treatments. Maximum and minimum stem diameter were recorded with seeds soaked in GA 200 ppm for 24 h + KNO_3 1% solution for 24 h and control respectively.

4.6.8 Number of leaves per plant

The data on number of leaves per plant recorded at weekly intervals are presented in Table 6.3.

There was no significant difference among different treatments at the end of first week. Maximum number of leaves (4.33) was recorded with seeds soaked in GA 200 ppm solution for 24 followed by KNO_3 1% solution for 24 h and minimum number of leaves were recorded in control. At the end of second week, seeds soaked in GA 200 ppm solution for 24 h + KNO_3 1% solution for 24 h recorded more number of leaves (6.0) which was on par with all other treatments except water soaking for 24 h + GA 400 ppm for 12 h treatment. In control minimum number (3.0) of leaves was recorded. At the end of third week, seeds soaked in GA 400 ppm solution for 12 h + KNO_3 1% solution for 12 h recorded more number of leaves. It was on par with all other treatments except water soaking for 24 h + GA 200 ppm for 24 h and water soaking for 24 h + GA 400 ppm for 12 h treatments, whereas minimum number of leaves were

recorded in control. At the end of fourth week, more number of leaves were produced in seeds soaked in KNO_3 1% solution for 12 h followed by soaking in concentrated H_2SO_4 for 4 minutes (7.66) which was on par with all other treatments except KNO_3 1% for 24 h + concentrated H_2SO_4 for 4 minutes, GA 400 ppm for 12 h + KNO_3 1% for 12 h and water soaking for 24 h + GA 400 ppm for 12 h treatments. The control recorded minimum number of leaves per plant.

4.6.9 Leaf area per plant (cm^2)

Data on leaf area recorded at weekly intervals are presented in Table 6.3.

At the end of first week, leaf area was maximum (32.84 cm^2) in seeds soaked in GA 400 ppm solution for 12 h followed by KNO_3 solution for 12 h. It was significantly superior to all other treatments. Seeds soaked in water for 12 h + KNO_3 1% for 24 h, and GA 200 ppm for 24 h + KNO_3 1% for 24 h recorded minimum leaf area of 5.18 cm^2 and 7.94 cm^2 respectively. At the end of second week, maximum leaf area was recorded with seeds soaked in water for 24 h + GA 400 ppm solution for 12 h (52.54 cm^2) which significantly differed with rest of the treatments, whereas control recorded minimum (15.55 cm^2) leaf area. At the end of third week, seeds soaked in water for 24 h + GA 400 ppm

Table 6.4: Effect of pre-soaking of *Annona* seeds in different combinations of chemicals on stem diameter and leaf dry weight of seedlings

Treatments	Stem Diameter (mm)				Leaf dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Water for 24 h + GA 200 ppm for 24 h	2.26	2.36	2.53	2.60	0.065	0.115	0.162	0.225
Water for 24 h + GA 400 ppm for 12 h	2.20	2.30	2.43	2.56	0.067	0.152	0.202	0.310
Water for 24 h + KNO_3 1% for 12 h	2.33	2.38	2.44	2.46	0.015	0.075	0.155	0.180
Water for 24 h + KNO_3 1% for 24 h	1.50	1.96	2.13	2.26	0.045	0.090	0.175	0.190
GA 200 ppm for 24 h + KNO_3 1% for 12 h	2.33	2.03	2.20	2.26	0.036	0.073	0.120	0.133
GA 200 ppm for 24 h + KNO_3 1% for 24 h	1.23	2.40	2.53	2.66	0.023	0.116	0.150	0.170
GA 400 ppm for 12 h + KNO_3 1% for 12 h	2.0	2.00	2.26	2.33	0.095	0.120	0.166	0.265
GA 400 ppm for 12 h + KNO_3 1% for 24 h	1.43	1.90	2.56	2.66	0.014	0.053	0.111	0.195
KNO_3 1% for 12 h + conc H_2SO_4 for 4 min.	1.73	2.00	2.40	2.46	0.050	0.066	0.130	0.145
KNO_3 1% for 24 h + conc H_2SO_4 for 4 min.	1.60	1.70	2.00	2.13	0.035	0.055	0.087	0.160
Control (dry seeds)	1.46	1.50	1.93	2.06	0.045	0.045	0.075	0.1
C.D. at 5%	0.620	0.356	0.404	N.S.	0.00772	0.00695	0.0115	0.0284

solution for 12 h recorded significantly highest leaf area (70 cm^2), whereas minimum (25.92 cm^2) leaf area was produced in control. At the end of fourth week also, seeds soaked in water for 24 h + GA 400 ppm solution for 12 h recorded maximum (107.17 cm^2) leaf area. It was closely followed by GA 400 ppm for 12 h + KNO_3 1% for 12 h, water soaking for 24 h + GA 200 ppm for 24 h, GA 400 ppm for 12 h + KNO_3 1% for 24 h and water soaking for 24 h + KNO_3 1% solution for 12 h treatments, whereas control recorded lowest (34.56 cm^2) leaf area.

4.6.10 Leaf dry weight (g)

Data on leaf dry weight recorded at weekly intervals are presented in Table 6.4.

At the end of first week, seeds soaked in GA 400 ppm solution for 12 h + KNO_3 1% solution for 12 h recorded significantly more (0.095 g) leaf dry weight. It was followed by water soaking for 24 h + GA 400 ppm for 12 h and water soaking for 24 h + GA 200 ppm for 24 h treatments. Other treatments recorded very low dry weight. Least dry weight was recorded with seeds soaked in GA 400 ppm solution for 12 h + KNO_3 1% for 24 h (0.014 g). At the end of second week, water soaking for 24 h + GA 400 ppm for 12 h recorded significantly highest leaf dry weight among all treatments. It was

closely followed by GA 200 ppm soaking for 24 h + KNO_3 1% for 24 h, GA 400 ppm soaking for 12 h + KNO_3 1% for 12 h and water soaking for 24 h + GA 200 ppm for 24 h treatments. Remaining treatments recorded very low dry weights. At the end of third week, seeds soaked in water for 24 h + GA 400 ppm solution for 12 h recorded maximum (0.202 g) leaf dry weight. It was followed by treatments like water soaking for 24 h + KNO_3 for 24 h, GA 400 ppm for 12 h + KNO_3 1% for 12 h, water soaking for 24 h + GA 200 ppm for 24 h, whereas others recorded significantly lesser dry weight. Minimum dry weight (0.075 g) was obtained in control. At the end of fourth week, seeds soaked in water for 24 h + GA 400 ppm for 12 h recorded significantly maximum (0.31 g) dry weight. Other treatments next to maximum were GA 400 ppm for 12 h + KNO_3 1% for 12 h, water soaking for 24 h + GA 200 ppm for 24 h, GA 400 ppm for 12 h + KNO_3 1% for 24 h, whereas minimum dry weight (0.1 g) was recorded in control.

4.6.11 Stem dry weight (g)

Data on stem dry weight recorded at weekly intervals are presented in Table 6.5.

No significant difference was found among all treatments at the end of first week, whereas maximum (0.1 g) and minimum (0.015 g) stem dry weights were

Table 6.5: Effect of pre-soaking of Annona seeds in different combinations of chemicals on stem and root dry weights of seedlings

Treatments	Stem dry weight (g)				Root dry weight (g)			
	Ist week	IIInd week	IIIrd week	IVth week	Ist week	IIInd week	IIIrd week	IVth week
Water for 24 h + GA 200 ppm for 24 h	0.026	0.055	0.071	0.102	0.010	0.022	0.035	0.065
Water for 24 h + GA 400 ppm for 12 h	0.046	0.082	0.097	0.152	0.042	0.055	0.067	0.130
Water for 24 h + KNO_3 1% for 12 h	0.030	0.035	0.075	0.105	0.015	0.040	0.075	0.1
Water for 24 h + KNO_3 1% for 24 h	0.035	0.050	0.085	0.1	0.041	0.045	0.080	0.120
GA 200 ppm for 24 h + KNO_3 1% for 12 h	0.046	0.070	0.075	0.080	0.046	0.05	0.055	0.066
GA 200 ppm for 24 h + KNO_3 1% for 24 h	0.016	0.063	0.1	0.113	0.023	0.056	0.063	0.086
GA 400 ppm for 12 h + KNO_3 1% for 12 h	0.085	0.095	0.098	0.106	0.095	0.1	0.125	0.145
GA 400 ppm for 12 h + KNO_3 1% for 24 h	0.026	0.028	0.040	0.073	0.010	0.015	0.023	0.036
KNO_3 1% for 12 h + conc H_2SO_4 for 4 min.	0.1	0.105	0.150	0.170	0.020	0.026	0.090	0.115
KNO_3 1% for 24 h + conc H_2SO_4 for 4 min.	0.015	0.047	0.055	0.075	0.010	0.026	0.055	0.095
Control (dry seeds)	0.023	0.090	0.150	0.150	0.015	0.025	0.029	0.050
C.D. at 5%	N.S.	0.0098	0.0272	0.0115	0.0401	0.0056	0.0351	0.00514

recorded with seeds soaked in KNO_3 1% solution for 12 h + concentrated H_2SO_4 for 4 min and with seeds soaked in KNO_3 1% solution for 24 h + concentrated H_2SO_4 for 4 min. At the end of second week, seeds soaked in KNO_3 1% solution for 12 h + concentrated H_2SO_4 for 4 min recorded significantly highest dry weight. It was next to seeds soaked in GA 400 ppm for 12 h + KNO_3 1% solution for 12 h. Minimum stem dry weight was recorded in GA 400 ppm for 12 h + KNO_3 1% for 24 h treatment. At the end of third week also, maximum (0.15 g) stem dry weight was recorded with seeds soaked in KNO_3 solution for 12 h + concentrated H_2SO_4 for 4 min. In control also similar result was observed. All other treatments recorded very low dry weight. The minimum (0.04 g) stem dry weight was observed with seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 24 h treatment. At the end of fourth week, seeds soaked with KNO_3 1% solution for 12 h + concentrated H_2SO_4 for 4 min recorded maximum (0.17 g) stem dry weight. It was followed by water soaking for 24 h + GA 400 ppm for 12 h, control, GA 200 ppm for 24 h + KNO_3 1% for 24 h treatments. Seeds soaked in GA 400 ppm for 12 h + KNO_3 1% solution for 24 h however recorded minimum (0.073 g) stem dry weight.

4.6.12 Root dry weight (g)

Data on root dry weight recorded at weekly intervals are presented in Table 6.5.

At the end of first week, maximum (0.095 g) root dry weight was recorded with seeds soaked in GA 400 ppm for 12 h + KNO_3 1% solution for 12 h. In other treatments, the root dry weight recorded was very low when compared to above treatment. Minimum dry weight was recorded in seeds soaked in KNO_3 1% solution for 24 h + con H_2SO_4 for 4 min. At the end of second week, significantly maximum (0.01 g) root dry weight was observed with seeds soaked in GA 400 ppm for 12 h + KNO_3 solution for 12 h. Root dry weight was very low in other treatments when compared to the treatment which produced maximum root dry weight. Soaking in GA 400 ppm for 12 h + KNO_3 solution for 24 h recorded lowest (0.015 g) root dry weight. At the end of third week, seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 12 h recorded significantly highest (0.125 g) root dry weight among all treatments tested except seeds soaked in KNO_3 1% solution for 12 h + concentrated H_2SO_4 for 4 min. In control root dry weight was 0.029 g and the minimum dry weight (0.023 g) was recorded with GA 400 ppm for 12 h + KNO_3 1% solution for 24 h. At the end of fourth week, root dry weight (0.145 g) was significantly more in GA 400 ppm soaked for 12 h + KNO_3 1%

Table 6.6: Effect of pre-soaking of *Annona* seeds in different combinations of chemicals on relative growth rate

Treatments	Relative growth rate		
	7-14 days	14-21 days	21-28 days
Water for 24 h + GA 200 ppm for 24 h	0.091	0.047	0.054
Water for 24 h + GA 400 ppm for 12 h	0.076	0.035	0.067
Water for 24 h + KNO_3 1% for 12 h	0.131	0.101	0.003
Water for 24 h + KNO_3 1% for 24 h	0.061	0.087	0.027
GA 200 ppm for 24 h + KNO_3 1% for 12 h	0.059	0.037	0.016
GA 200 ppm for 24 h + KNO_3 1% for 24 h	0.19	0.041	0.024
GA 400 ppm for 12 h + KNO_3 1% for 12 h	0.019	0.034	0.037
GA 400 ppm for 12 h + KNO_3 1% for 24 h	0.079	0.107	0.075
KNO_3 1% for 12 h + conc H_2SO_4 for 4 min.	0.021	0.090	0.020
KNO_3 1% for 24 h + conc H_2SO_4 for 4 min.	0.108	0.063	0.073
Control (dry seeds)	0.112	0.049	0.041
C.D. at 5%	0.00015	0.000076	0.000066

soaked for 12 h treatment (0.145 g). It was almost next to seeds soaked in water for 24 h + GA 400 ppm for 12 h (0.130 g), whereas minimum (0.036 g) was recorded in GA 400 ppm for 12 h + KNO_3 1% for 24 h.

4.6.13 Relative Growth Rate

Relative growth was calculated and presented in Table 6.6.

Between seven and fourteen days, relative growth rates differed significantly among all treatments tested. Seeds soaked in GA 200 ppm for 24 h + KNO_3 1% for 24 h recorded maximum relative growth rate (0.19) and minimum was recorded with seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 12 h. Between fourteen and twenty one days, seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 24 h recorded significantly more relative growth rate, whereas lowest relative growth rate was recorded with seeds soaked in water for 24 h + GA 400 ppm for 12 h. Between twenty one and twenty eight days, seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 24 h recorded significantly more relative growth rate (0.075) and minimum was recorded with water soaked for 24 h + KNO_3 1% for 12 h (0.003) treatment.

4.6.14 Leaf weight ratio

Leaf weight ratios computed at weekly intervals are presented in Table 6.7.

At the end of first week, seeds soaked in water for 24 h + GA 200 ppm for 24 h recorded significantly highest leaf weight ratio (0.64) among all treatments. It was followed by seeds soaked in KNO_3 1% solution for 24 h + concentrated H_2SO_4 for 4 min (0.583), control (0.548), water soaking for 24 h + GA 400 ppm for 12 h (0.393) and water soaking for 24 h + KNO_3 1% solution for 24 h treatments. Minimum leaf weight ratio (0.25) was recorded in seeds soaked in water for 24 h + KNO_3 1% solution for 12 h. At the end of second week, leaf weight ratio (0.647) was maximum in seeds soaked in GA 400 ppm for 12 h + KNO_3 1% solution for 24 h. It was significantly superior to all other treatments and was followed by treatments like water soaking for 24 h + GA 200 ppm for 24 h, water soaking for 24 h + GA 400 ppm for 12 h and water soaked for 24 h + KNO_3 1% solution for 12 h. However, lowest (0.281) leaf weight ratio was recorded in control. At the end of third week, seeds soaked in GA 400 ppm for 12 h + KNO_3 1% solution for 24 h recorded significantly highest leaf weight ratio. It was followed by treatments like water soaking for 24 h + GA 200 ppm for 24 h, water soaking for 24 h + GA 400

Table 6.7: Effect of pre-soaking of *Annona* seeds in different combinations of chemicals on leaf weight ratio and leaf area ratio of seedlings

Treatments	Leaf weight ratio				Leaf area ratio			
	Ist week	IInd week	IIInd week	IVth week	Ist week	IInd week	IIInd week	IVth week
Water for 24 h + GA 200 ppm for 24 h	0.64	0.597	0.606	0.573	195.39	206.49	209.35	198.16
Water for 24 h + GA 400 ppm for 12 h	0.393	0.525	0.546	0.523	135.80	181.48	188.78	180.86
Water for 24 h + KNO_3 1% for 12 h	0.25	0.5	0.508	0.468	86.41	172.80	175.67	161.61
Water for 24 h + KNO_3 1% for 24 h	0.372	0.486	0.515	0.463	128.51	168.16	177.91	160.19
GA 200 ppm for 24 h + KNO_3 1% for 12 h	0.281	0.378	0.481	0.477	97.18	130.72	165.88	164.76
GA 200 ppm for 24 h + KNO_3 1% for 24 h	0.371	0.494	0.479	0.461	128.22	170.63	165.65	159.24
GA 400 ppm for 12 h + KNO_3 1% for 12 h	0.345	0.381	0.416	0.513	119.35	131.68	143.806	177.51
GA 400 ppm for 12 h + KNO_3 1% for 24 h	0.265	0.647	0.649	0.641	91.71	223.64	224.38	221.74
KNO_3 1% for 12 h + conc H_2SO_4 for 4 min.	0.294	0.335	0.351	0.341	101.64	115.78	121.45	117.86
KNO_3 1% for 24 h + conc H_2SO_4 for 4 min.	0.583	0.431	0.443	0.485	201.50	149.09	153.11	167.60
Control (dry seeds)	0.548	0.281	0.333	0.333	189.31	97.18	115.20	115.43
C.D. at 5%	0.00102	0.00549	0.00049	0.00065	0.325	0.325	0.180	0.270

ppm for 12 h and water soaking for 24 h + KNO_3 1% solution for 24 h, whereas in control lowest leaf weight ratio (0.333) was recorded. At the end of fourth week, seeds soaked in GA 400 ppm solution for 12 h + KNO_3 solution for 24 h recorded significantly higher leaf weight ratio and was followed by soaking in water for 24 h + GA 200 ppm solution for 24 h, water for 24 h + GA 400 ppm for 12 h and GA 400 ppm solution for 12 h + KNO_3 1% solution for 24 h treatments. The lowest leaf weight ratio (0.333) was recorded in control.

4.6.15 Leaf area ratio

The data computed at weekly intervals on leaf area ratio are presented in Table 6.7.

At the end of first week, seeds soaked in KNO_3 1% solution for 24 h + concentrated H_2SO_4 for 4 min recorded significantly highest (201.5) leaf area ratio. It was followed by seeds soaked in water for 24 h + GA 200 ppm solution for 24 h, control, water soaking for 24 h + GA 400 ppm solution for 12 h, water soaking for 24 h + KNO_3 1% solution for 24 h and GA 200 ppm solution for 24 h + KNO_3 1% solution for 24 h treatments. Minimum leaf area ratio (86.41) was obtained in seeds soaked in water for 24 h + KNO_3 1% for 12 h. At the end of second week, leaf area ratio

was maximum in GA 400 ppm for 12 h + KNO_3 soaking for 24 h. This was significantly superior to all other treatments and followed by soaking in water for 24 h + GA 200 ppm for 24 h, water soaking for 24 h + GA 400 ppm for 12 h and water soaking for 24 h + KNO_3 1% for 12 h treatments, whereas minimum leaf area ratio was recorded in control. At the end of third week, seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 24 h recorded significantly highest leaf area ratio (224.38) followed by water soaking for 24 h + GA 200 ppm for 24 h, water soaking for 24 h + GA 400 ppm for 12 h, water soaking for 24 h + KNO_3 1% for 24 h and water soaking for 24 h + KNO_3 1% for 12 h treatments. Minimum leaf area ratio (115.2) was recorded in control. At the end of fourth week, seeds soaked in GA 400 ppm for 12 h + KNO_3 1% for 24 h recorded significantly more (221.74) leaf area ratio. It was followed by water soaking for 24 h + GA 200 ppm for 24 h, water soaking for 24 h + GA 400 ppm for 12 h and soaking in GA 400 ppm for 12 h + KNO_3 1% for 12 h treatments. Minimum leaf area ratio (115.43) was recorded in control.

4.6.16 Correlations amongst germination and seedling growth attributes

The correlations worked out for various germination and seedling growth attributes are presented in Table 6.8.

Table 6.8: Correlation coefficients amongst germination and seedling attributed in the Annona seeds treated with different combinations of chemicals

Seedling attributes	Seedling vigour index	Coefficient of velocity of germination	Stem diameter	Plant height	Root length	Number of leaves per plant	Leaf area per plant	Germination percentage
Days for initiation of germination	-0.37538**	-0.56544**	-0.37108**	-0.66039**	-0.12005	-0.64541**	-0.46338**	-0.3169*
Seedling vigour index		0.58670**	0.39891**	0.72976**	0.18798	0.52207**	0.61356**	0.9794**
Coefficient of velocity of germination			0.41656**	0.64479**	0.16649	0.65925**	0.49070**	0.5708**
Stem diameter				0.42380**	0.03305	0.32505*	0.34964*	0.38996**
Plant height					-0.01582	0.58411**	0.68253**	0.64052**
Root length						0.36208**	0.07089	0.1379
Number of leaves per plant							0.41271**	0.4877**
Leaf area per plant								0.5684**

** Significant at 1% level

* Significant at 5% level

The final germination percentage was negatively correlated with number of days taken for initiation of germination but had a positive relationship with attributes like seedling vigour, velocity of germination, stem diameter, plant height, number of leaves and leaf area, whereas number of days taken for commencement of germination had a negative relationship with seedling vigour, velocity of germination, plant diameter, height, number of leaves, and leaf area. Seedling vigour, however, had a strongly positive relationship with velocity of germination, stem diameter, height, number of leaves and leaf area. Velocity of germination was correlated positively with stem diameter, plant height, number of leaves and leaf area. The plant height, stem diameter, number of leaves and leaf area were correlated positively with each other. Root length had a positive relationship with number of leaves per plant.

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CHAPTER V

DISCUSSION

DISCUSSION

The salient findings emanating from various experiments on certain aspects of *Annona* seed germination and subsequent growth of seedlings are discussed in this chapter.

5.1 IMPROVEMENT OF *ANNONA* SEED GERMINATION BY GROWTH REGULATORS, CHEMICALS, WATER TREATMENT AND ACID SCARIFICATION

There are several instances, where different kinds of chemicals and growth regulators applied exogenously to dormant seeds cause them to germinate. Treating the seeds with concentrated acids for shorter periods, as well as soaking of seeds in water for different periods were also found to accelerate the germination in different horticultural crops. Some of these chemicals have potential value in agriculture and horticulture to accelerate germination or break dormancy of seeds (Heydeker and Coolbear, 1977; Gray and Steckel, 1977). Though, many chemicals, growth regulators, water treatment and acid scarification were reported to be effective in breaking the dormancy in various crop plants, not many of them were utilized for improving *Annona* seed germination by earlier workers. At best, their studies were only confined to the use of gibberellic acid.

Seeds were soaked in gibberellic acid, thiourea and potassium nitrate at each concentration for 12 h and 24 h. In case of water treatment, soaking periods were 12 h, 24 h, 36 h, or 48 h and acid scarification was done for 2 min, 4 min, or 6 min. From these experiments information has been generated about the effectiveness of different treatments and their optimum periods which could be used practically for improving the *Annona* seed germination and subsequent seedling growth.

It is evident from the field experiments conducted on *Annona* cv. Balanagar seeds, that soaking of seeds in water for 24 h was the best treatment for improving the germination (Table 1.1 and Fig 1.1). Seed soaking in gibberellic acid 400 ppm for 12 h was next to water soaking for 24 h in improving germination (Table 3.1 and Fig 3.1) followed by water soaking for 36 h, potassium nitrate 1 per cent for 24 h, gibberellic acid 200 ppm for 24 h and thiourea 0.5 per cent for 24 h treatments. Earlier, Campbell and Popenoe (1968) reported that gibberellic acid at 350 ppm can give the greatest increase in germination.

This maximum germination in water soaked seeds may be due to (i) imbibition of sufficient water during soaking period (ii) leaching out the germination inhibitors present in seed (iii) the activation of all

enzymatic processes due to the presence of sufficient moisture during soaking period. As a result, the pre-soaked seeds had sufficient available nutrients and activated embryo at the time of seeding, which caused them to germinate quickly, where as enhancement of germination with gibberellic acid may be due to stimulation of enzymatic reactions within the seed.

But number of days taken for initiation of germination was higher in case of seeds soaked in water for 24 h (Table 1.1 and Fig 1.1) and gibberellic acid 400 ppm for 12 h (Table 3.1 and Fig 3.1). Seeds treated with water for 24 h + gibberellic acid 400 ppm for 12 h and gibberellic acid 200 ppm for 24 h + potassium nitrate 1 per cent for 12 h started germination earlier (Table 6.1 and Fig 6.1). Whereas, acid scarified seeds as well as seeds scarified in combination with other chemicals or seeds treated with growth regulators initiated germination a bit earlier. But in control, initiation of germination was too late when compared to treated or scarified seeds.

Velocity of germination was highest in seeds treated with water for 24 h + potassium nitrate 1 per cent for 12 h followed by water for 24 h + gibberellic acid 200 ppm for 24 h; gibberellic acid 200 ppm for 24 h + potassium nitrate 1 per cent for 24 h and gibberellic acid 400 ppm for 12 h + potassium nitrate 1 per

cent for 12 h (Table 6.1). Velocity of germination was low in the case of scarified seeds, where as, seeds treated with potassium nitrate, thiourea, gibberellic acid and water fell in between above said treatments and scarified seeds. But velocity of germination was lower in control when compared to scarified seeds.

Seeds treated with gibberellic acid 400 ppm for 12 h recorded highest seedling vigour (Table 3.1). Seedlings obtained from gibberellic acid 200 ppm soaked seeds for 24 h were next to gibberellic acid 400 ppm for 12 h treatment followed by water soaked seeds for 24 h, thiourea 0.5 per cent for 24 h and potassium nitrate 0.5 per cent for 24 h. Seedling vigour was also less in the case of scarified seeds. In control, seedling vigour was however, still less when compared to scarified seeds.

As observed, water soaked seeds had higher percentage of germination. But number of days taken to germinate was more. In the case of seeds treated with gibberellic acid 400 ppm for 12 h also same trend occurred. The treatments which gave early germination viz., seeds treated with water for 24 h followed by gibberellic acid 400 ppm for 12 h, gibberellic acid 200 ppm for 24 h followed by potassium nitrate 1 per cent for 12 h treatments did not record sufficient germination percentage (Table 6.1) when compared to water or

gibberellic acid soaked seeds. Seeds treated with water for 24 h + potassium nitrate 1 per cent for 12 h and water for 24 h + gibberellic acid 200 ppm for 24 h recorded highest velocity of 6.03 and 6.01 respectively, whereas seeds soaked in water for 24 h and gibberellic acid 400 ppm solution for 12 h recorded 5.01 and 4.98 velocity of germination respectively and also number of days taken for initiation of germination were more. Hastening of germination occurred with combination of different treatments like water soaking for 24 h + gibberellic acid 400 ppm for 12 h. The additive effect of water followed by gibberellic acid treatment may involve in breaking the dormancy in two ways i.e., water soaking makes hard seed coat soft thereby water will be imbibed into inner tissue, and gibberellic acid will activate the dormant embryo. By these two simultaneous effects seeds will germinate earlier (Dehgan and Johnson, 1983), whereas lesser germination of seeds with combination of different pre-sowing treatments like water, gibberellic acid 400 ppm, potassium nitrate 1 per cent may be toxic to many of the seeds and ultimately resulted in low germination.

5.2 EFFECTS OF DIFFERENT CHEMICALS, GROWTH REGULATOR, WATER TREATMENT AND ACID SCARIFICATION ON THE GROWTH OF ANNONA SEEDLINGS

Several experiments were conducted primarily to obtain information on germination behaviour of Annona seeds. Seedlings produced out of the seeds soaked in gibberellic acid 400 ppm solution for 12 h had a maximum plant height by four weeks age (Table 3.2 and Fig.3.2) and it was maximum at fourth week among all six experiments in comparison to several other treatments. It was followed by seeds treated with distilled water for 24 h + gibberellic acid 400 ppm solution for 12 h (Table 6.2 and Fig.6.2) as well as potassium nitrate 0.5 per cent solution soaked seeds for 12 h in respect of seedling height. Whereas in control, height varied from 11.00 to 11.16 cm in all the experiments. The stimulation of plant height with gibberellic acid has been attributed to cell division, cell elongation and cell multiplication in the cambium tissues (Guseva and Flory, 1969).

Seedlings resulting from seeds soaked in gibberellic acid 200 ppm solution for 24 h as well as potassium nitrate 0.5 per cent solution for 24 h had a maximum stem diameter (Table 3.3 and Fig.3.3) followed by seeds soaked in potassium nitrate 1 per cent

solution for 12 h as well as 24 h (Table 5.4 and Fig.5.3). Seedlings that emerged from gibberellic acid 400 ppm for 12 h pre sowing treatment had a considerable diameter (Table 3.3 and Fig.3.3) when compared to control.

Seedlings resulted from seeds treated with gibberellic acid 400 ppm solution for 12 h had a maximum plant height (25.33 cm), longer root length (12.23 cm) (Table 3.2), more stem dry matter (0.245 g) and root dry matter production (0.175 g) (Table 3.5). Whereas, gibberellic acid 600 ppm for 12 h recorded maximum number of leaves (9.0) as well as leaf area (274.94 cm²) (Table 3.4) and gibberellic acid 200 ppm for 24 h treated seeds resulted in maximum stem diameter (2.86 mm) (Table 3.3). This shows that gibberellic acid has effect on above said parameters. This increase in dry weights, number of leaves, leaf area, plant height, root length, stem diameter of seedlings may be due to the increase in over all assimilation and redistribution of materials within the plant.

Seedlings resulted out of the seeds soaked in gibberellic acid 400 ppm for 12 h produced longer root growth as well as more root dry weight (Table 3.2 and 3.5) followed by potassium nitrate 1 per cent for 12 h. On the contrary, to the increased shoot growth, gibberellic acid treatment either generally reduced the root

growth or it was unaffected. This is in agreement with the findings of Yabuta and Hayashi (1939), Sumiki (1952) and Brian et al. (1955). However, increased root growth was noticed in case of Eugenia jambolana and Pongamia glabra. There is also an evidence that stimulation of root growth has been recorded by GA seed treatments in Pseudotsuga menziesu (Richardson, 1958).

Custard apple seedling, to be used as root stock, requires considerable thickness of stem as well as height. The required height and thickness of stem should be obtained within a short period. For this purpose, treating of seeds with gibberellic acid had resulted in seedlings with maximum length, diameter of stem and drymatter when compared to control i.e., without any soaking treatment.

Well developed root system is also very important in a way that it assures optimum water absorption. Since water is the major limiting factor for plant growth in arid areas, perennial plants like Annona must have an extensive root system extending over few meters. Apart from absorption of water root system to some extent determines the productivity of the established plants. If dry conditions occur shortly after sowing, survival of young seedlings may depend on the young root system, growing sufficiently

with adequate laterals developing at a depth from which sufficient nutrients and water can be absorbed in the subsequent period (Russel, 1977).

The number of leaves produced per plant as affected by different chemicals, growth regulator, water and acid scarification, were more when compared to control at first week as well as fourth week of seedling growth. Seedlings which resulted from seeds treated with gibberellic acid 600 ppm for 12 h had more number of leaves per plant (Table 3.4), followed by thiourea 0.5 per cent for 24 h as well as 1 per cent for 12 h, gibberellic acid 400 ppm for 12 h and potassium nitrate 1 per cent for 12 h treated seeds, whereas direct sowing (control) without any pre sowing treatment resulted in lesser number of leaves when compared to treated seeds in all experiments.

Leaf area per plant was also more in seedlings obtained from seeds treated with gibberellic acid 600 ppm for 12 h followed by gibberellic acid 400 ppm for 12 h (Table 3.4). Eventhough, gibberellic acid 400 ppm for 12 h treatment produced lesser number of leaves when compared to potassium nitrate and thiourea treated seeds, it recorded more leaf area. This shows that gibberellic acid influences leaf expansion than number of leaves, which is more important physiologically. Leaf dry weight was also more in seedlings obtained

from seeds soaked in gibberellic acid, followed by chemicals like potassium nitrate, thiourea, water soaked seeds, whereas with acid scarification, leaf dry matter was reduced considerably. Also, some of chemical combinations reduced leaf dry matter.

Similar report was made by Randhawa and Pal (1968) in respect of number of leaves, leaf area and leaf dry matter per plant in grape. For improving photosynthetic activity of seedling, more leaf area is required which in turn increases dry matter content of leaf which was achieved with gibberellic acid treatment.

Leaf dry weight as well as total plant dry weight will determine the leaf weight ratio. In present experiments leaf weight ratio varied in different ways. With gibberellic acid at all concentrations, as well as soaking periods, the leaf weight ratio increased as age of seedling increased except with gibberellic acid 200 ppm for 12 h treatment (Table 3.7). Thiourea in both concentrations with soaking period of 24 h increased leaf weight ratio, as age of seedling increased. Similar was also with potassium nitrate 1 per cent at both soaking periods. Scarification for 6 min and also gibberellic acid 400 ppm for 12 h + potassium nitrate 1 per cent for 12 h treated seeds recorded same effect as mentioned above. The

other treatments in different experiments did not follow any pattern. In general, at first week leaf weight ratio was more; in second week it was less, again it increased in third and fourth weeks. This was due to the fact that leaf dry weight as well as total plant dry weight did not change uniformly as the age of seedling advanced.

Leaf area ratio also varied in different ways as age advanced. The leaf dry weight changed in accordance with the changes in leaf area. The leaf dry weight in relation to total plant dry weight did not constantly change as the age of seedling advanced. The leaf area in relation to total plant dry weight also followed the same pattern. This may be due to improved assimilation but the redistribution of dry matter into different plant parts was not proper. Gibberellic acid and potassium nitrate had increased leaf area ratio as the age of seedlings advanced.

5.3 VARIOUS INDICES FOR GERMINATION AND THEIR INTER-RELATIONSHIP

The expression of vigour is the ability of seeds to do well under wide range of conditions which depends upon the environment in which it is sown. Seed vigour has many components which can be quantified and many tests are employed to demonstrate manifestations

of vigour. In the present investigations, different germination attributes like days taken for initiation of germination, velocity of germination were taken into account along with seedling characters like plant height, stem diameter, seedling vigour, number of leaves, leaf area and root length to examine the best possible parameters to assess the germination behaviour of *Annona* seeds.

The number of days taken for the start of germination had a negative correlation with final germination in all six experiments. Similarly it had a negative correlation with seedling vigour, velocity of germination, plant height, stem diameter, leaf area and number of leaves. Velocity of germination had a positive relationship with seedling vigour in five out of six experiments and both the number of days as well as velocity of germination in turn were positively related with final germination percentage, plant height, number of leaves and leaf area in almost all experiments, whereas, the stem diameter, was positively correlated in nearly 50 per cent of experiments with final germination percentage, plant height, number of leaves and leaf area. Plant height also had a positive

correlation with seedling vigour and velocity of germination in five experiments out of six. But it was negatively correlated with the number of days to start germination in all experiments.

It appears that number of days taken for commencement of germination and velocity of germination are good indices for final germination which in turn are positive indices for seedling vigour and plant height.

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CHAPTER VI

SUMMARY

SUMMARY

Studies were conducted at the college of Agriculture, Rajendranagar with an objective of standardising the pre-sowing seed treatments to *Annona squamosa* L. cv. Balanagar to improve germination and subsequent seedling growth with different chemicals, growth regulators, distilled water and acid scarification. The results obtained from various experiments are summarised below:

1. Maximum germination percentage was recorded with seeds soaked in water for 24 h (71%) followed by gibberellic acid 400 ppm for 12 h (69%), soaking in water for 36 h (67%), gibberellic acid 200 ppm for 24 h (64%) and potassium nitrate 1 per cent for 24 h (64%).
2. Seeds soaked in water for 24 h + gibberellic acid 400 ppm for 12 h took 15 days for commencement of germination, whereas water soaked seeds for 48 h, gibberellic acid 600 ppm solution treated seeds for 12 and 24 h, seeds soaked in thiourea 1 per cent for 12 h and seeds soaked in water for 24 h + potassium nitrate 1 per cent for 12 h took 16 days to initiate germination.

3. Highest velocity of germination was recorded with seeds soaked in water for 24 h + potassium nitrate 1 per cent for 12 h (6.03) followed by water for 24 h + gibberellic acid 200 ppm for 24 h (6.01), gibberellic acid 200 ppm for 24 h + potassium nitrate 1 per cent for 12 h (5.94), gibberellic acid 400 ppm for 12 h + potassium nitrate 1 per cent for 12 h (5.91) and gibberellic acid 400 ppm for 12 h + potassium nitrate 1 per cent for 24 h (5.84) soaking treatments, whereas lowest velocity of germination (2.85) was observed with seeds soaked in water for 24 h + scarification for 4 minutes.
4. Seedling vigour was maximum (2403.50) with seed soaking in gibberellic acid 400 ppm solution for 12 h followed by gibberellic acid 200 ppm for 24 h (2173.50), water for 24 h (1988.00), thiourea 0.5 per cent for 24 h (1863.72) and potassium nitrate 0.5 per cent for 24 h (1847.88), while seed soaking in water for 24 h + scarification for 4 min recorded minimum (99.09) vigour.
5. Seed soaking in gibberellic acid 400 ppm solution for 12 h recorded maximum plant height (25.33 cm) followed by seed soaking in water

for 24 h + gibberellic acid 400 ppm for 12 h (25.30 cm), water for 24 h + potassium nitrate 1 per cent for 12 h (25.06 cm), potassium nitrate 0.5 per cent for 12 h (24.96 cm) and 24 h (23.76). Minimum height was observed with control i.e., without any treatment.

6. Root length was maximum (12.23 cm) in seedlings obtained from seeds soaked in gibberellic acid 400 ppm for 12 h followed by potassium nitrate 1 per cent for 12 h (10.23 cm) and gibberellic acid 600 ppm for 2 h (10.06 cm) treatment, whereas minimum root length (5.43 cm) was observed with seeds soaked in water for 24 h + gibberellic acid 200 ppm for 24 h treatment.
7. Stem diameter was maximum (2.86 mm) in seedlings obtained from seeds soaked in gibberellic acid 200 ppm for 24 h as well as potassium nitrate 0.5 per cent for 24 h (2.86 mm) followed by potassium nitrate 1 per cent for 12 h and 24 h. Seedlings resulted from scarified seeds for 6 min had a minimum (1.83 mm) stem diameter.
8. Leaves present on seedling emerged from seeds soaked in gibberellic acid 600 ppm for 12 h

were more (9.00) followed by thiourea 0.5 per cent for 24 h (8.66), thiourea 1 per cent for 12 h (8.33), gibberellic acid 400 ppm for 12 h (8.33) treatments. Less number of leaves (4.33) was observed on seedlings emerged from dry seeds i.e., control.

9. Total leaf area per seedling was more (274.94 cm^2) when seeds were soaked in gibberellic acid 600 ppm for 12 h, followed by gibberellic acid 400 ppm for 12 h (165.93 cm^2) and gibberellic acid 200 ppm for 24 h (122.72 cm^2) treatments. Leaf area was minimum (34.56 cm^2) in control.
10. Leaf dry weight per seedling was more (0.795 g) with seeds soaked in gibberellic acid 600 ppm for 12 h followed by gibberellic acid 400 ppm for 12 h (0.480 g) and gibberellic acid 200 ppm for 24 h (0.355 g) treatments, whereas minimum (0.1 g) leaf dry weight per plant was observed in control.
11. Stem dry weight per seedling was highest (0.245 g) when seeds were soaked in gibberellic acid 400 ppm for 12 h, followed by gibberellic acid 200 ppm for 24 h (0.210 g) and gibberellic acid 400 ppm for 24 h

(0.175 g). Seedlings obtained from seeds soaked in gibberellic acid 400 ppm for 12 h + potassium nitrate 1 per cent for 24 recorded lesser (0.073 g) stem dry weight.

12. Root dry weight per seedling was highest (0.175 g) with seeds soaked in gibberellic acid 400 ppm for 12 h followed by potassium nitrate 0.5 per cent for 24 h (0.155 g), and gibberellic acid 400 ppm for 24 h (0.150 g) treatments. Lowest dry weight (0.036 g) was recorded from seedlings obtained from seeds soaked in gibberellic acid 400 ppm for 12 h + potassium nitrate 1 per cent for 24 h.
13. Leaf weight ratio was highest (0.743) with seeds soaked in gibberellic acid 600 ppm for 12 h followed by potassium nitrate 1 per cent for 12 h (0.626), gibberellic acid 200 ppm for 12 h (0.6) and gibberellic acid 600 ppm for 24 h (0.535) treatments. Minimum leaf weight ratio was observed in control.
14. Leaf area ratio was highest (590.17) with seeds soaked in gibberellic acid 600 ppm for 12 h followed by gibberellic acid 400 ppm for 12 h + potassium nitrate 1 percent for 24 h (221.74), potassium nitrate 1 per cent for 12

h (216.52) and thiourea 0.5 per cent for 24 h (200.50) seed treatments, whereas scarified seeds for 4 min recorded lowest (110.15) leaf area ratio.

Water soaking for 24 h though gave 71 per cent of germination, was not superior in aspects like plant height, root length, stem diameter, number of leaves, leaf area and dry matter production, whereas pre-sowing treatments like gibberellic acid 200 ppm was superior in stem diameter and gibberellic acid 600 ppm in number of leaves, leaf area and leaf dry matter production. Seeds treated with gibberellic acid 400 ppm gave 69 per cent of germination and the difference was negligible when compared to water treatment and gibberellic acid 400 ppm itself was superior in plant vigour, plant height, root length, stem and root dry matter production. It was also considerably superior in leaf area and number of leaves when compared to all other treatments except gibberellic acid 600 ppm which was very poor in germination percentage, plant height, root length and dry matter production. Pre-sowing treatment with gibberellic acid 400 ppm for 12 h could be suggested for improving *Annona* seed germination and subsequent seedling growth.

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APPENDICES

Appendix 1: Meteorological data during the period of investigation (October 1989 to February 1990)

Period	Standard week	Temperature oC		Relative humidity		Sunshine (hours)	Total rainfall
		Maxi- mum	Mini- mum	7.14 hrs.	14.14 hrs.		
01/10-07/10	40	30.1	21.0	86	47	9.3	13.8
08/10-14/10	41	32.8	19.0	81	40	10.0	0.0
15/10-21/10	42	32.9	17.4	71	36	10.0	0.0
22/10-28/10	43	31.4	16.2	9	37	10.3	0.0
29/10-04/11	44	31.0	16.5	74	37	9.6	0.0
05/11-11/11	45	29.7	15.4	74	35.1	8.1	1.8
12/11-18/11	46	29.0	17.8	77	39	6.4	0.0
19/11-25/11	47	30.1	12.2	69	34	10.4	0.0
26/11-02/12	48	29.7	12.4	78	33	10.5	0.0
03/12-09/12	49	28.7	11.5	73	29	10.5	0.0
10/12-16/12	50	27.4	10.9	75	36	10.1	0.0
17/12-23/12	51	27.7	11.5	79	32	10.0	0.0
24/12-31/12	52	28.6	17.5	77	46	6.2	2.6
01/01-07/01	1	27.4	14.6	87	43	7.4	0.0
08/01-14/01	2	28.7	12.0	70	32	9.1	0.0
15/01-21/01	3	31.0	8.7	60	22	11.2	0.0
22/01-28/01	4	31.4	10.5	70	25	11.3	0.0
29/01-04/02	5	32.4	12.6	66	22	10.8	0.0
05/02-11/02	6	27.5	14.6	69	22	11.2	0.0
12/02-18/02	7	32.8	17.8	79	25	10.7	0.0
19/02-25/02	8	32.8	15.0	77	24	10.7	0.0
26/02-04/03	9	33.9	17.8	64	23	11.2	0.0