EFFECT OF SEED TREATMENT ON GROWTH, SEED YIELD AND QUALITY IN OKRA (*Abelmoschus esculentus* L. Moench)

By

ADERSH S.

(2016-11-060)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA

2018

DECLARATION

I, hereby declare that the thesis entitled **"Effect of seed treatment on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench)"** is a bonafide record of research done by me during the course of research and that it has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara, **Adersh S.**

Date: **(2016-11-060)**

CERTIFICATE

Certified that this thesis entitled **"Effect of seed treatment on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench"** is a record of research work done independently by **Mr. Adersh S. (2016-11-060)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellanikkara,

Date:

Dr. Dijee Bastian

(Major advisor, Advisory committee)
Professor
Dept. of Seed Science and Technology
College of Horticulture
Vellanikkara, Thrissur

CERTIFICATE

We, the undersigned members of the advisory committee of **Mr. Adersh S. (2016-11-060)**, a candidate for the degree of **Master of Science in Agriculture** with major field in **Seed Science and Technology**, agree that this thesis entitled **"Effect of seed treatment on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench)"** may be submitted by **Mr. Adersh S. (2016-11-060),** in partial fulfillment of the requirement for the degree.

Dr. Dijee Bastian
(Chairperson)
Professor (Plant Breeding & Genetics)
Dept. of Seed Science & Technology
College of Horticulture, Vellanikkara

24/11/2018.

Dr. Rose Mary Francies
(Member)
Professor and Head
Dept. of Seed Science & Technology
College of Horticulture, Vellanikkara

24/11/18

Dr. Biju S.
(Member)
Assistant professor (Plant Breeding & Genetics)
Dept. of Plant Breeding & Genetics
College of Horticulture, Vellanikkara

24/11/18

Dr. Anita Cherian, K.
(Member)
Professor and Head (Plant Pathology)
Dept. of Plant Pathology
College of Horticulture, Vellanikkara

24/11/18

(External Examiner)

Dr. K. RAJA, Ph.D.,
Assistant Professor (Seed Science & Technology)
Department of Nano Science & Technology
Tamil Nadu Agricultural University
Coimbatore - 641 003.

ACKNOWLEDGEMENT

At this moment of accomplishment my heart is overwhelmed with gratitude and I wish if these words could convey the subtle feelings.

At the outset, I bow my head to the ***Almighty*** *for his showers and equipping me with utmost strength, knowledge and patience, to combat all the hurdles that came on the way to persevere and complete it successfully. I wish to avail this opportunity and evoke on record the ineffable personal indebtedness, deep sense of gratitude and sincere thanks for the kindness of my magnanimous chairperson,* ***Dr. Dijee Bastian,*** *, Professor, Department of Seed Science and Technology, College of Horticulture, Vellanikkara, for her explicit instructions, meticulous guidance, unfailing patience, incessant inspiration, sustained encouragement, expert counselling, critical suggestions, affectionate advices and unaccountable help rendered throughout my study and the tenure of this investigation and will be remembered forever.*

I would like to express my extreme indebtedness and obligation to ***Dr. Rose Mary Francies****, Professor and Head, Department of Seed Science and Technology, College of Horticulture, Vellanikkara, member of my Advisory committee for her meticulous support, care, affectionate advices, valuable suggestions and critical scrutiny of the manuscript which has helped a lot for the improvement of the thesis.*

I express my heartiest gratitude to ***Dr. Nirmala Devi. S.****, Professor (Hort.), AICRP on VC, Department of Olericulture, College of Horticulture, Vellanikkara, Member of my Advisory committee for her unwavering encouragement valuable guidance, timely suggestions and help rendered in the conduct of the research work.*

I wish to extend my wholehearted gratitude to ***Dr.Anita Cherian K.,*** *Professor and Head, Department of plant pathology, College of horticulture, Vellanikkara, Member of my Advisory committee for her immense help rendered during the conduct of the experiment and timely suggestions during the preparation of the manuscript.*

I take this opportunity to express my heartfelt gratitude to ***Dr. Jiji Joseph****, Professor, Department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara,* ***Dr. S. Beena,*** *Professor, Department of Plant Pathology, College of Horticulture, Vellanikkara,* ***Dr. Jayashree Sankar,*** *Professor and Head, Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara for their boundless help accorded during the laboratory work.*

I am grateful to ***Dr. A. T. Francies****, Librarian, College of Horticulture for his support during the period of course and research work. I appreciate all other staff members of the library and acknowledge the facilities provided by the Library of College of Horticulture which assisted me in the preparation of the manuscript.*

I thankfully remember the services rendered by all the staff members of Student's computer club, College Library, Office of COH. I am thankful to Kerala Agricultural University for the technical and financial assistance for persuasion of my study and research work.

I am extremely thankful to the field labourers, Department of Seed Science and Technology, for their sincere help and cooperation during the conduct of field experiments.

I sincerely acknowledge the kind concern and continuous support, which I have received from the non-teaching staff members ***Indira chechi, Naveenettan, Hitha chechi, Smitha chechi, Jeena chechi, Babuettan Amal ikka, Amal Vijay.***

This journey would have never accomplished without my dear friends ***Reshma, Athmaja, Abid, Amal, Amjath, Anto, Bennett, Chakravarthy, Fazeedh, Jithin, Murthala, Nagendra, Rakesh, Rejinettan, Unniettan, Juby Baby, Swathy Sugathan, Leema Antony, Anju M Job, Megha, Lakshmi Muralikrishna ,Gayathri Sajikumar, Akhil Sarath R, Vishnu M.S, Moonis P.P, Nithinettan, Arjun V.P, Siddique Hassan, Susmi Raju and Nithya.N*** *with their infinite affection, warm concern, constant encouragement and moral support.*

I would also like to extend my huge warm thanks to my seniors ***Nishiditha, Nikhil Narayanan, Nagendra, Ashwin Varghese, Akhil Thomas*** *for their constant encouragement and my juniors* ***Athulya, Gayathri, Agina, Rosna,*** *for their valuable support*

I can barely find words to express all the wisdom, love and support given to me for that I am eternally grateful to my parents, family members and my dear brother for their unconditional love, fidelity, endurance and encouragement.

They have been selfless in giving me the best of everything and I express my deep gratitude for their love, personal sacrifice and constant prayers without which this work would not have been completed.

A word of apology to those I have not mentioned in person and a note of thanks to everyone who helped for the successful completion of this endeavor

Adersh S.

CONTENTS

Chapter	Title	Page no.
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-22
III	MATERIALS AND METHODS	23-35
IV	RESULTS	36-74
V	DISCUSSION	75-90
VI	SUMMARY	91-94
	REFERENCES	I-IX
	APPENDICES	
	ABSTRACT	

LIST OF TABLES

Table No.	Title	Page no.
1	**Details of treatments**	24-25
2	**Analysis of variance for vegetative, fruit and seed yield attributes in okra**	37
3	**Effect of seed treatments with growth regulators on growth in okra**	40
4	**Effect of seed treatment with growth regulators on fruit, seed yield parameter in okra**	42
5	**Initial seed quality parameters of okra seeds before harvest**	45-46
6	**Effect of seed treatment with plant growth regulators on germination (%) during storage in okra**	48-49
7	**Effect of seed treatment with plant growth regulators on seedling shoot length (cm) during storage in okra**	51-52
8	**Effect of seed treatment with plant growth regulators on seedling root length(cm) during storage in okra**	54-55
9	**Effect of seed treatment with plant growth regulators on seedling dry weight (g) during storage in okra**	56-57
10	**Effect of seed treatment with plant growth regulators on EC of leachate (µS/cm) during storage period in okra**	59-60
11	**Effect of seed treatment with plant growth regulators on mean germination time (MGT) during storage period in okra**	61-62

12	**Effect of seed treatment with plant growth regulator on time taken for 50% germination during storage in okra**	64-65
13	**Effect of seed treatment with plant growth regulators on vigour index I during storage in okra**	66-67
14	**Effect of seed treatment with plant growth regulators on seedling vigour index II during storage in okra**	68-69
15	**Seed moisture (%) at the start and end of storage period**	71-72
16	**Effect of seed treatment with plant growth regulators on seed micro flora (%) during storage in okra**	73-74
17	**Scoring and Ranking of growth regulators based on growth, yield and quality in okra**	89-90

LIST OF FIGURES

Figure No.	Title	Between pages
1	**Effect of seed treatment with plant growth regulators on plant height (cm) in okra**	76-77
2	**Effect of seed treatment with plant growth regulators on fruit yield per plant in okra**	79-80
3	**Effect of seed treatment with plant growth regulators on seed yield per plant (g) in okra**	80-81
4	**Effect of seed treatment with growth regulators on seed longevity**	82-83
5	**Effect of seed treatment with plant growth regulators on EC of leachate (µS/cm) during storage period in okra**	84-85
6	**Effect of seed treatment with plant growth regulators on mean germination time (MGT) during storage period in okra seeds**	85-86
7	**Effect of seed treatment with plant growth regulators on vigour index I during storage in okra**	86-87
8	**Effect of seed treatment with plant growth regulators on seedling vigour index II during storage in okra**	86-87
9	**Effect of seed treatment with plant growth regulators on seed micro flora (%) during storage in okra**	87-88

LIST OF PLATES

Plate No.	Title	Between pages
1	**Land preparation**	25-26
2	**General view of experimental plot during sowing**	25-26
3	**General view of experimental plot at seedling stage**	25-26
4	**Flowering stage**	25-26
5	**Field view at fruit development stage**	25-26
6	**Field view at maturity stage**	25-26
7	**Field view at harvesting stage**	25-26
8	**Overall view of observations taken during field experiment.**	26-27
9	**Conduct of germination test in okra**	29-30
10	**Seeds soaked for conducting electrical conductivity test**	29-30
11	**Seed micro flora study**	70-71

LIST OFAPPENDICES

Appendix No.	Title	Page No.
I	**Monthly meteorological data from May 2017 to July 2018**	
II	**Benefit Cost Ratio for the best seed treatments with growth regulators in okra**	

LIST OF ABBREVIATIONS AND SYMBOLS USED

Symbols	Abbreviations
AOSA	Association of Official Seed Analysts
^{0} C	Degree Celsius
ccc	Cycocel
CD	Critical difference
cm	Centimetre
cv.	Cultivar
EC	Electrical conductivity
et al.	And others
Fig.	Figure
g	Gram
GA_3	Gibberellic acid
h	Hour
ha	Hectare
IAA	Indole -3- acetic acid
KAU	Kerala Agricultural University
kg	Kilogram
m	Metre
MAS	Months after storage
MH	Maleic hydrazide
µS/m	Micro Siemens per metre
MSCS	Minimum Seed Certification Standards
ml	Milli litre
MT	Metric Tons
NAA	Naphthalene acetic acid
NS	Non- Significant
ppm	Parts per million
%	Per cent
CRD	Completely Randomized Design
sp. or spp.	Species (Singular and Plural)
Th	Thiourea

Introduction

1. INTRODUCTION

Good quality seed is not only highly desirable but also a statutory requirement for successful crop production. The expected returns from any improved variety cannot be realized unless quality seeds of such variety are made available in adequate quantities to farmers at the right time and at optimum price. The overarching goal of crop establishment is to achieve rapid and uniform germination, followed by rapid and uniform seedling emergence (Covell *et al.*, 1986). Seeds are particularly vulnerable to stresses encountered between sowing and seedling establishment (Carter and Chesson,1996). Since the area under cultivation has almost reached a saturation point in current years, it is imperative to enhance the production and productivity per unit area. The role of seed in agriculture is of prime importance in developing countries like India where the population and GDP (Gross Domestic Product) considerably depends on agriculture sector (Tyagi, 2012).

Okra is one of the important summer and rainy season vegetable crop grown extensively throughout India. India ranks first in the world with 5,784 thousand tonnes (72% of the total world production) of okra. In India, Andhra Pradesh is the leading okra producing state with a production of around 1184.2 thousand tons from an area of 78.90 thousand hectare, and a productivity of 15 tons/ha. (Anon., 2017). Okra is a heavy yielder and highly remunerative crop but sometimes grower suffer with recurring economic loss due to poor plant vigour, low pod setting and small pod size (Sanodiya, 2016). Poor seed germination, the delayed and erratic emergence of seedlings are serious issues in okra, which eventually creates problems with fertilizer utilization, post emergence weed control, and uniform harvesting (Singh *et al.,* 2013). The hard seed coat of okra interferes with water uptake and is a major physiological constraint to uniform stand establishment and performance (Marsh,1993). The commercial seed yield in okra depends on the fruit length and number of fruits produced per plant (Baruah and Paul, 1997).

In recent years, scientists have paid attention to the idea of regulating plant growth as an important factor in improving the germination, growth, yield and quality through the application of plant growth regulators (Bhagure and Tambe, 2013).

Plant growth regulators are organic substances, which are produced in trace amounts naturally in plants. They are known as chemical messengers because they are produced in one part of plant and effect on another part. Exogenous application of plant growth regulators improved the yield, production and fruit quality of horticultural crops (Gadade *et al.*, 2017). They are known to act right from seed germination to senescence either by enhancing growth or by reducing the plant height, flowering, fruit development, fruit ripening and seed yield. Therefore, through proper application of exogenous plant growth regulators at appropriate time it is quite possible that all physiological processes undergone in plants can be manipulated to man's benefit.

Seed treatment with plant growth regulator is one of the most effective tools for improving rate of germination, vigourous growth, early flowering, fruit setting, seed development and high yield. Incorporation of plant growth regulators during pre-soaking, priming and other treatments have improved seed performance in many vegetables crops. Typical responses to priming are faster and closer spread of times to emergence over all seedbed environments and wider temperature range of emergence, leading to better crop stands, thereby leading to improved yield and harvest quality, especially under suboptimal and stress condition growing conditions in the field (Halmer, 2004).

. Application of plant growth regulator has to be planned sensibly in terms of optimal concentration, stage of application, species specificity and seasons (Sanodiya, 2016). The same growth regulator at different concentrations and different time period could bring about different results. So, the selection of growth regulators, their adequate concentration and their time and method of application are most essential.

Vijaykumar *et al.* (1988) studied the effect of seed treatment with CCC at 100 and 200 ppm on seed quality parameters in okra and reported that 100 ppm treatment gave a germination per cent of 95, which was found superior over control. Seeds of okra variety MDU-1 treated with 50 ppm GA_3 had exhibited a high germination (85.8%), number of fruits per plant (12.5), yield per plant (166.8 g), harvest index and the highest fruit yield (15.7 t/ha) whereas, the yield from untreated plot was 8.07 t/ha (Vijayaraghavan, 2000).

Although extensive studies have been conducted to enhance the growth, yield and seed quality in okra *viz.*, nutritional management, cultural practices, methods of sowing, time of sowing, crop protection measures and others studies involving use of plant growth regulators in seed treatment are very few and far apart.

In this context, the present investigation is entitled 'Effect of seed treatments on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench)', has been undertaken with the following objectives:-

1. To determine the effect of growth regulators on seedling emergence and growth parameters
2. To study the effect of growth regulators on seed yield and quality
3. To evaluate the storage potential of seeds under ambient storage condition

17

Review of literature

2. REVIEW OF LITERATURE

Seed is the basic input in crop production and use of quality seed alone would increase productivity per unit area to the extent of 20 per cent. However, lack of quality seeds continues to be one of the greatest drawbacks to bridge the vast yield gap. Even with ideal soil, water and climate, desired yield and quality cannot be achieved with inferior seed. Good agriculture relies upon good seed and vice versa, one cannot exist or advance without the other (Sen, 1974). Thus, seed is the single well recognized carrier of production technology facilitating our quest for higher and better crop yields.

Seed treatment refers to the application of certain agents physical, chemical or biological to the seed prior to sowing in order to suppress, control or repel pathogens, insects and other pests that attack seeds, seedlings or plants (Sharma *et al.,* 2015). Seed treatment with plant growth regulators is one among the several seed treatment techniques employed to improve the growth, yield and quality. Plant hormones also called as plant growth regulators, are numerous naturally occurring chemical substances that profoundly influence the growth and differentiation of plant cells, tissues and organs. It helps in efficient utilization of metabolites in certain physiological process going on in plant systems. In recent years, scientists have given due attention to the idea of regulating plant growth as third most important factor in improving the growth, yield and quality with the application of plant growth regulators in various ways (Bhagure and Tambe, 2013).

Effect of plant growth regulators are prominently visible in plants right from germination of seeds to its senescence stage either through enhancement or stimulation of the natural growth regulatory system thereby bringing about favourable morpho-physiological changes in the plant. Hastening of growth or reduction of the plant height, branching, flowering, fruit development, ripening and seed yield and quality has been obvious with changes in levels of growth regulators in plant system.

For any scientific investigation, a critical and comprehensive review of literature is crucial for better understanding of the problem. The successful investigation of research relies heavily on thorough review of the existing knowledge of the problem. Related literature to the topic 'Effect of growth regulators on growth, seed yield and quality' have been reviewed below in brief

2.1 Effect of plant growth regulators on growth parameters

2.1.1 Plant height

Crop	Experimental details	References
Okra	Significant increase in plant height was noticed when seeds of okra cv. Pusa Sawani were treated with various concentration of GA_3 for 24 hours before sowing.	Das and Pattanaik (1971)
Okra	An investigation on the effect of seed treatment with growth regulators GA_3 and IAA (25, 50, 75, 100 ppm) on germination, growth and yield of okra cv. Pusa Sawani was carried out. It was clearly evident that gibberellic acid at different concentrations significantly increased the plant height.	Pawar *et al.* (1977)
Okra	Okra seeds were treated with CCC (1000 and 1500 ppm). Cycocel at high concentration was found to reduce plant height.	Narase and Gowda (1980)
Okra	Growth regulators GA_3, NAA, MH and CCC at 25, 50, 200 and 1000 ppm were applied on okra cv. Pusa Sawani. GA_3 treatments significantly enhanced the plant height (85.76 cm) over control.	Suryanarayana and Subba Rao (1981)
Okra	Seeds of okra cv. Pusa Sawani were soaked for 10 hours in water, NAA (10, 25 and 50ppm) and cycocel (100, 250 and 500 ppm) and the crop raised. CCC significantly reduced plant height as compared to control.	Mangal *et al.* (1988)
Okra	The effect of cycocel at different concentrations – 25, 50, 75 and 100 ppm were studied. Cycocel at 75 ppm reduced height of plant	Arora and Dhankar (1992)

Okra	Seeds of okra cv Pusa Sawani were treated with different concentrations of CCC and GA_3. It was observed that all concentrations of GA_3 increased the plant height whereas cycocel reduced it.	Patel and Singh (1993)
Okra	An experiment was conducted to study the beneficial effect of plant growth regulators on aged seeds of okra under field conditions. Plant height (82.13 cm) was found to be the highest when the seeds were soaked in the aqueous solution of GA_3 (50 ppm) unlike the control (66.29 cm).	Sanjaykumar *et al.* (1996)
Okra	The effect of pre-sowing treatment of GA_3 (0, 15, 30 and 45 ppm) on okra cv. Pusa Sawani was studied and it was concluded that the plant height of okra increased by 8.97% over control when seeds were treated with GA_3 at 45 ppm	Singh and Kumar (1998)
Okra	Observed that foliar application of GA_3 (gibberellic acid; 20, 30 and 40 ppm) and NAA (50, 75 and 100 ppm) increased plant height when compared with control.	Singh *et al.* (1999)
Okra	The ameliorative potential of gibberellic acid and NAA on growth and yield attributes of okra variety was studied. Gibberellic acid 75 ppm treatment resulted in a plant height of 114.77 cm.	Naruka and Paliwal (2000)
Okra	Seeds soaked in 50 ppm gibberellic acid resulted in higher plant height.	Kumar and Sen (2004)
Okra	An investigation on the effect of seed treatment with gibberellic acid and maleic hydrazide on growth, seed yield and quality of okra cv. Parbhani Kranti pointed out that GA_3 at 50 ppm was more effective in increasing the plant height.	Patil *et al.* (2008)
Okra	GA_3 at 50 and 100 ppm increased the plant height, in okra, when applied at 30 and 45 days after sowing.	Bhagure and Tambe (2013)

Okra	A study on effect of plant growth regulators on growth and yield of okra pointed out that GA_3 at 150 ppm significantly increased the plant height (107.74 cm).	Dhage *et al.* (2011)
Okra	The result of the study entitled effect of growth retardant on growth and yield of okra (*Abelmochus esculentus* (L.) Moench) indicated that cycocel at 500 ppm significantly reduced the plant height.	Kagwade (2012)
Okra	Soaking seeds in GA_3 (100ppm) solution for 3-4 hours increased plant height, leaf area, number of leaves and yield	Bello (2015)
Bitter gourd	An investigation was conducted with two varieties of bitter gourd (MHBI-15 and Chaman Plus) and three growth regulators at different concentrations – GA_3 (20, 40 and 60 ppm), NAA at 50 ppm and CCC (100 and 200 ppm) at Agricultural Research Station, University of Agricultural Sciences, Dharwad. Significantly higher vine length (61.1cm) was observed in GA_3 20 ppm treatment.	Geeta *et al.* (2010)
French bean	A study entitled the effect of growth regulators on growth and yield of French bean (*Phaseolus vulgaris* L.) reported that the treatment GA_3 at 200 ppm registered a plant height of 34.53 cm, whereas cycocel at 200 ppm resulted in stunted growth (25.93 cm).	Rathod *et al.* (2015)

2.1.2 Nodes per plant

Crop	**Experimental details**	**References**
Okra	Number of pods per plant increased in treatments with GA_3 (20, 30 and 40 ppm) and NAA (50, 75 and 100 ppm) in comparison to control.	Singh *et al.* (1999)

Okra	A study entitled effect of growth retardant cycocel (0, 250, 500, 750 and 1000 ppm) on growth of summer okra (Parbhani Kranti) revealed that nodes per plant increased in plants treated with 1000 ppm CCC.	Mahorkar *et al.* (2007)
Okra	Seed treatment with GA_3 at 50 ppm in okra cv. Parbhani Kranti resulted in more number of nodes per plant.	Patil *et al.* (2008)
Okra	Studied the effect of growth retardant on growth and yield of okra (*Abelmochus esculentus* (L.) Moench) and concluded that cycocel at 500 ppm significantly increased the number of nodes.	Kagwade (2012)
Soybean	Plant growth regulators cycocel and TIBA significantly increased the number of nodes in soybean.	Shinde (2010)

2.1.3 Internode length

Crop	**Experimental details**	**References**
Okra	Cycocel (1000 or 1500 ppm.) at high concentration reduced internodal length in bhendi.	Narase and Gowda (1980)
Okra	Internode length was found to be significantly high subsequent to seed treatment with GA_3 at 50 ppm in okra cv. Parbhani Kranti.	Patil *et al.* (2008)
Okra	GA_3 at 50 and 100ppm increased the internode length.	Bhagure and Tambe (2013)
Okra	GA_3 at 150 ppm significantly increased internodal length	Dhage *et al.* (2011)
Okra	Cycocel at 500 ppm significantly reduced the internodal length.	Kagwade (2012)

2.1.4 Branches per plant

Crop	Experimental details	References
Okra	Significant increase in number of branches were observed when the seeds of okra cv. Pusa Sawani were treated with various concentration of GA_3 for 24 hours before sowing.	Das and Pattanaik (1971)
Okra	Studied the effect of growth regulators treated okra seed [GA3 and IAA (25, 50, 75, 100 ppm)] cv. Pusa Sawani. It was clearly evident from the result that gibberellic acid at different concentrations significantly increased the number of branches per plant over control.	Pawar *et al.* (1977)
Okra	Cycocel at high concentration increased the number of branches	Narase and Gowda (1980)
Okra	Cycocel at 75 ppm resulted in more number of branches per plant.	Arora and Dhankar (1992)
Okra	Seeds soaked in 50 ppm gibberellic acid exhibits higher number of branches.	Kumar and Sen (2004)
Pea	A series of experiments were carried out in pea cv. Aparna and Azad-P-1 using different concentrations of plant growth regulators (0,100, 250, 500 and 1000ppm) cycocel and GA_3. Both growth regulators were found to be effective in increasing the branches per plant.	Bora and Sharma (2006)
Okra	Seed treatment with maleic hydrazide 80 ppm in okra cv. Parbhani Kranti resulted in more number of branches.	Patil *et al.* (2008)
Soybean	Cycocel and TIBA significantly increased the number of branches in soybean	Shinde (2010)

Okra	A study on effect of plant growth regulators on growth and yield of okra pointed out that IAA at 100 ppm exhibited maximum number of branches (3.53).	Dhage *et al.* (2011)
Okra	Influence of growth retardant on growth and yield of okra concluded that cycocel at 500 ppm significantly increased the number of branches	Kagwade (2012)
French bean	Studied the effect of growth regulators on growth and yield of French bean (*Phaseolus vulgaris* L.) and reported that the treatment GA_3 at 200 ppm resulted in more number of branches per plant (7.66) whereas cycocel at 200 ppm registered the least number of branches per plant (5.20).	Rathod *et al.* (2015)

2.1.5 Days to flowering

Crop	Experimental details	References
Okra	Significant reduction in days to flowering was observed when the seeds of okra cv. Pusa Sawani were treated with various concentration of GA_3 for 24 hours before sowing.	Das and Pattanaik (1971)
Okra	Seed treatment with 10 ppm GA_3 advanced flowering by 6.33 days over the control.	Rattan *et al.* (1987)
Okra	Days to first flowering was advanced by 3.33 days over control when seeds were treated with GA_3 at 45 ppm, in okra cv. Pusa Sawani.	Singh and Kumar (1998)
Okra	Application of 160 ppm GA_3 significantly reduced the days to first flowering (37.13) and days to 50% flowering (41.33) in okra.	Singh *et al.* (2012)
Okra	MDU-1 seeds of okra were treated with IAA (25, 50 and 75ppm), GA_3 (25, 50 and 75ppm) and benzyladenine (20, 60	Vijayaraghavan (2000)

	and 60 ppm). The seed treatment with 50 ppm GA_3 exhibited minimum days to flowering (36.5)	
Okra	Minimum number of days to 50% flowering was observed in plants raised from seeds treated with NAA at 20 ppm.	Hussaini and Babu (1989)
Brinjal	Increasing concentrations of naphthalene acetic acid (75 ppm) decreased the time taken to 50% flowering.	Singh and Mukherjee (2000)
Okra	GA_3 at 150 ppm reduced the number of days to first flowering (39.67 days).	Dhage *et al.* (2011)
Garden pea	A study on influence of plant growth substances on growth, flowering, yield and economics of Garden pea, (*Pisum sativum*) L cv. Bonneville revealed that the days to first flowering were the found least (48.97) on seed treatment GA_3 (100ppm), while other treatments were statistically on par with each other.	Thomson *et al.* (2015)

2.1.6 Fruits per plant

Crop	Experimental details	References
Okra	Number of fruits per plant increased significantly when the seeds of okra cv. Pusa Sawani were treated with GA_3 for 24 hours before sowing.	Das and Pattnaik (1971)
Okra	A study elucidate the effect of cycocel and naphalene acetic acid application on production of okra revealed that cycocel at 250 ppm significantly increased the fruit yield per plant (26.4 -28.5 g/plant) over control (10.4 g/plant).	Mangal *et al.* (1988)
Okra	Studied the effects of CCC at 100 and 200 ppm on seed yield and seed quality parameters of okra crop and observed that	Vijaykumar *et al.* (1988)

	CCC at 100 ppm produced 10 fruits per plant which was found to be superior over control.	
Okra	When seeds were treated with different concentrations of CCC and GA_3 in okra cv. Pusa Sawani, cycocel 1000 ppm registered significantly higher number of fruits per plant.	Patel and Singh (1991)
Okra	An experiment was conducted to understand the beneficial effect of some plant growth regulators on aged seeds of okra under field condition. Number of fruits per plant (16.13), were found to be high when seeds were soaked in the aqueous solution of GA_3 50 ppm over the control.	Sanjaykumar *et al.* (1996)
Okra	MDU-1 seeds of okra were treated with IAA (25, 50 and 75ppm), GA_3 (25, 50 and 75ppm) and benzyladenine (20, 60 and 60 ppm). The seed treated with 50 ppm GA_3 resulted in maximum number of fruits per plant (12.5), and highest fruit yield (15.7 t/ha) whereas, the control yield was 8.07 t/ha.	Vijayaraghavan, (2000)
Okra	Seeds of okra cv. Pusa Sawani were treated with different concentrations of gibberellic acid and NAA (both at 25, 50 and 75 ppm) to study the ameliorative potential of gibberellic acid and NAA on growth and yield attributes of okra. With increase in concentrations of GA_3 and NAA there was corresponding increase in number of fruits per plant.	Naruka and Paliwal (2000)
Okra	Studied the flowering and yield attributes of okra as influenced by different plant growth regulators and concluded that NAA at 25 ppm resulted in more fruits per plant, fruit yield per plot (6.69) and yield per hectare (92.90/q) in comparison with NAA at 50 ppm and control.	Kore *et al.* (2003)
Okra	A study on the effect of seed treatment with growth regulators GA_3 (50, 100, 150 ppm) and maleic hydrazide (20, 40, 80ppm)	Patil *et al.* (2008)

	on seed yield and quality of okra cv. Parbhani Kranti revealed that GA_3 at 50 ppm exhibited significantly superior performance in fruit yield per plant over all other treatments.	
Bitter gourd	A study on the effect of IAA and GA_3 on yield attributes of Bitter gourd (*Momordica charantia* L.) with three concentrations each of IAA *viz.* 2.5, 5.0 and 10 ppm and GA_3 *viz.* 2.5, 5.0 and 10 ppm revealed that IAA at 10 ppm significantly increased the number of fruits (12.33).	Akter and Rahman (2010)
Okra	Effect of plant growth regulators on growth and yield of okra and concluded that GA_3 at 150 ppm had higher fruit set and fruit yield per hectare.	Dhage *et al.* (2011)
Chilli	Studied the influence of different growth regulators on growth and yield of chilli (*Capsicum annuum* L.). Higher number of fruits per plant (14.83) was recorded in plants raised from treatment with NAA (75 ppm).	Chandiniraj *et al.* (2016)

2.1.7 Fruit length

Crop	**Experimental details**	**References**
Brinjal	GA_3 at 200 ppm exhibited better size (length and diameter) of fruits, resulting in the highest yield of 257.55 fruits/ha.	Sorte *et al.* (2001)
Okra	GA_3 at 50 ppm exhibited significantly superior performance in length of fruit in okra cv. Parbhani Kranti.	Patil *et al.* (2008)
Okra	Combined application of GA_3 and NAA (200+200 ppm) had significantly increased fruit length in okra.	Muhammed *et al.* (2013)
Chilli	Studied the influence of different growth regulators on growth and yield of chilli (*Capsicum annuum* L.). A fruit length of 6.80	Chandiniraj *et al.* (2016)

	cm was recorded in plants raised from treatment with NAA (75 ppm) which was longer than the control.	

2.1.8 Fruit weight

Crop	Experimental details	References
Okra	Fruit weight increased significantly when the seeds of okra cv. Pusa Sawani were treated with GA_3 for 24 hours before sowing.	Das and Pattnaik (1971)
Okra	Cycocel significantly increased the fruit yield per plant (26.4 - 28.5 g/plant) over control (10.4 g/plant)	Mangal *et al.* (1988)
Okra	Cycocel at 1000 ppm had significantly higher fruit weight and fruit yield per hectare in okra cv. Pusa Sawani.	Patel and Singh (1991)
Okra	Seed treatment with GA_3 and NAA revealed that GA_3 100 ppm produced fruits with higher weight compared to the other treatments.	Munda *et al.* (2000)
Okra	Increase in concentrations of GA_3 and NAA led to a corresponding increase in average fruit weight and yield.	Naruka and Paliwal (2000)
Bitter gourd	IAA at 10 ppm significantly increased the fresh weight of fruits.	Akter and Rahman (2010)
Okra	GA_3 at 50 ppm showed significant increase in pod weight, 100 seed weight, over all other treatments in cv. GAO-5.	Rawat and Makani (2015)

2.1.9 Seeds per fruit

Crop	Experimental details	References
Okra	Cycocel 1000 ppm significantly increased the number of seeds per fruit (68.40) than control (50.79) in cv. Pusa Sawani.	Patel and Singh (1991)

Okra	Beneficial effect of some plant growth regulators on aged seeds of okra under field conditions was studied. The number of seeds/fruit (40.83), was found to be high when the seeds were soaked in an aqueous solution of GA_3 50 ppm. Control recorded a value of 24.84.	Sanjaykumar *et al.* (1996)
Okra	Seed treatment with GA_3 (100 ppm) resulted in significantly higher number of seeds per pod.	Munda *et al.* (2000)
Okra	NAA at 40 ppm produced more number of seeds per pod (53.83).	Hussaini and Babu (1989)
Okra	GA_3 at 50 ppm resulted in significantly superior performance with respect to seeds per fruit over all other treatments in cv. Parbhani Kranti.	Patil *et al.* (2008)
Okra	GA_3 increased the number of seeds per pod in okra.	Mohammadi *et al.* (2014)

2.1.10. Seed yield per plant

Crop	**Experimental details**	**References**
Onion	Seeds soaked with NAA at 20 ppm for 7-8 hours resulted in higher yield (326.5 q per hectare) compared to control (206.3 q/ha). GA_3 at 7.5 ppm was the next best treatment with a yield of 245 q per hectare.	Singh *et al.* (1982)
Okra	250 ppm GA_3 treatment produced a yield of 87.39 q/ha while control yielded 64.97 q/ha.	Maurya *et al.* (1985)
Okra	Seed yield/plant (35.50 g) was higher when seeds were soaked in the aqueous solution of GA_3 50 ppm while control yielded 29.50 g.	Sanjaykumar *et al.* (1996)
Okra	MDU-1 seeds of okra were treated with IAA (25, 50 and 75 ppm), GA_3 (25, 50 and 75ppm) and benzyladenine (20, 60 and	Vijayaraghavan, (2000)

	seed yield per plant (166.8 g).	
Okra	Applications of different concentration of growth hormones *viz,* GA_3 and NAA on okra seeds revealed that GA_3 100 ppm as seed treatment had significantly superior seed yield per ha over all other treatments.	Munda *et al.* (2000)
Okra	Seeds treated with GA_3 resulted in higher seed yield per plant.	Singh *et al.* (2006)
Okra	GA_3 at 50 ppm exhibited significantly higher seed yield per plant over all other treatments [seed treatments with growth regulators GA_3 (50, 100, 150 ppm) and maleic hydrazide (20, 40, 80ppm)] in cv. Parbhani Kranti.	Patil *et al.* (2008)

2.1.11 100 seed weight.

Okra	CCC at 100 ppm had a 100 seed weight of 5.78 g which was superior over the control.	Vijaykumar *et al.* (1988)
Okra	GA_3 at 100 ppm as seed treatment was found to be significantly superior for 100-seed weight.	Munda *et al.* (2000)
Okra	Studied the influence of plant growth regulators on growth, seed yield and seed quality in okra [*Abelmoschus esculentus* (L.) Moench] cv. GAO-5. Among the different growth regulators used, GA_3 at 50 ppm resulted in significant increase in 100 seed weight, over all other treatments.	Rawat and Makani, (2015)

2.2. Effect of plant growth regulators on seed quality during storage

The storage potential of seed is greatly affected by their quality at the time they enter storage or their pre-storage history. Seeds of a given lot, size, chronological age and germination level do not maintain viability equally well in

conditions (Vanagamudi, 1988). It is not clear what the critical factors are and by what mechanisms loss of viability occurs. According to Copeland (1998), the deteriorative changes taking place in a seed during storage that leads to the death of seed are due to failure of beneficial enzymes involved in anabolism, increased activity of catalytic enzymes like catalase and peroxidase, accumulation of toxic metabolites, lipid oxidation, and reduction in cell membrane integrity and the decreased activity of repair mechanism.

Literature on seed storage potential of seeds treated with growth regulators is reviewed hereunder: -

2.2.1. Germination (%)

Okra	Seeds of okra cv. Pusa Sawani were treated with plant growth regulators gibberellic acid (50, 100 and 200 ppm), NAA (50, 100 and 200 ppm) and cycocel (250, 500 and 1000 ppm) at different concentrations. At initial stage all the concentrations of GA_3 increased the germination per cent and GA_3 at 200 ppm resulted in 100% germination. Meanwhile cycocel delayed germination in all concentrations with the lowest in CCC at 250 ppm.	Reddy (1973)
Okra	CCC at 100 ppm exhibited a germination percentage of 95%, which was found to be superior over control.	Vijaykumar *et al.* (1988)
Bell pepper	Seeds of bell pepper cv. California Wonder were invigorated with certain growth regulators and micronutrients to understand their effect on seedling vigour and germination. The result indicates that seed	Yogananda *et al.* (2004)

	invigoration with GA_3 at 200 ppm recorded high germination per cent.	
Okra	Seeds soaked with 50 ppm GA_3 had the highest germination per cent (81.60%) in okra. Control recorded 78.58 per cent	Kumar and Sen (2004)
Brinjal	Significant increase in speed of germination (14.28), germination percent (100%), was recorded in seeds soaked with GA_3 at 200 ppm for 6 hours compared to control (13.14 and 92.10%, respectively).	Sathishkumar (2005)
Okra	Germination (90.77 and 89.59%) was significantly increased in both years in GA_3 at 100 ppm.	Singh *et al.* (2006)
Chilli	Seeds treated with NAA at 10 ppm exhibited the highest germination percent and seedling vigour followed by NAA at 50 ppm. Lowest germination per cent was recorded in control	Sultana *et al.* (2006)
Okra	Effects of GA_3, NAA (50, 100, 150, 200 and 300 ppm) and KNO_3 (1 and 2%) on seed germination was studied in cv Arka Anamika. GA_3 recorded the maximum value for seed germination, followed by 1% KNO_3 and 100 ppm NAA.	Priyanka *et al.,* (2008)
Okra	Early germination and high germination per cent was observed in okra seeds soaked with GA_3 at 50 ppm compare to control.	Bhagure and Tambe (2013)
Okra	NAA at 25 ppm recorded the highest germination (93%).	Premchand *et al.* (2013)

2.2.2. Shoot length and root length (cm)

Bell pepper	Invigorated seeds of bell pepper cv. California Wonder with certain growth regulators and micronutrients indicates that GA_3 at 200 ppm resulted in maximum shoot and root length when compared with control.	Yogananda *et al.* (2004)
Brinjal	A study on influence of seed pelleting and pre-sowing seed treatment on longevity and storability in brinjal (*Solanum melongena* L.) indicated significant increase in shoot length (5.99 cm) and root length (3.10 cm), when seeds were soaked with GA_3 at 200 ppm for 6 hours.	Sathishkumar (2005)
Okra	Seedling obtained from seeds pre-soaked with 50 ppm GA_3 recorded the maximum value for seedling length followed by 1% KNO_3 and 100 ppm NAA.	Priyanka *et al.* (2008)
Okra	Seeds treated with NAA @ 25 ppm recorded highest shoot and root length (29.80 cm and 19.16 cm),	Premchand *et al.* (2013)

2.2.3. Seedling dry weight

Bell pepper	Seed invigoration with GA_3 at 200 ppm resulted in maximum seedling dry weight when compared to control	Yogananda *et al.* (2004)
Okra	NAA at 25 ppm recorded highest seedling dry weight of 24.0 mg	Premchand *et al.* (2013)
Okra	GA_3 at 50ppm resulted in significant increase in seedling dry weight over all other treatments.	Rawat and Makani, (2015)

2.2.4. EC of leachate

Brinjal	Seed soaked with GA_3 at 200 ppm for 6 hours resulted in minimum electrical conductivity (0.010) compared to control (0.022 dSm^{-1})	Satheeshkumar (2005)

2.2.5. Seedling vigour indices

Bell pepper	Seed invigoration with GA_3 at 200 ppm resulted in maximum seedling vigour indices when compared with control	Yogananda *et al.* (2004)
Brinjal	Significant increase in seedling vigour index (909) was noticed in seeds soaked with GA_3 at 200 ppm for 6 hours and least in control (667)	Satheeshkumar (2005)
Okra	Vigour index (2303.69 and 2076.13) increased significantly in both years in GA_3 at 100 ppm	Singh *et al.* (2006)
Chilli	Seeds treated with NAA at 10 ppm resulted in high germination per cent and seedling vigour followed by NAA at 50 ppm. Meanwhile lowest germination percent was recorded in control.	Sultana *et al.* (2006)
Okra	Seedling obtained from seeds presoaked with 50 ppm GA_3 recorded the high seed vigour index followed by 1 per cent KNO_3 and 100 ppm NAA.	Priyanka *et al.* (2008)
Okra	Seed treated with NAA at 25 ppm resulted in high seedling vigour index -I and II (4833 and 2369)	Premchand *et al.* (2013)
Okra	Among the different growth regulators used to study the influence of plant growth regulators on growth, seed yield	Rawat and Makani, (2015)

	and seed quality in okra, seed treated GA_3 at 50 ppm showed significant increase in seedling vigour index-II over all other treatments	

2.2.6 Seed moisture

Onion, tomato, okra	Vegetable seeds with six to eight per cent moisture content could be stored for a longer period in polythene bags (700 Gauge)	Saxena (1994)
Paddy	Polythene bags of 400 Gauge density is also equally preferred for storing paddy seeds having a moisture content of 10 per cent or less.	KAU (2011)
Groundnut	Seeds stored in cloth bags recorded a rapid increase in moisture content whereas the seeds stored in polythene bags of 700 Gauge densities showed a very low increase in moisture content.	Narayanan and Prakash (2014)

2.2.7 Seed microflora

Seed borne pathogens play an important role in deterioration of seeds. Christensen and Kaufman (1969) divided the fungi invading seeds into two groups *i.e.* field fungi and storage fungi. These fungal pathogens can be a major cause of quality losses in seed.

Onion seed of variety Pusa Red stored at 15^0C for 18 months with a moisture content of five percent recorded least mycoflora infection of 3.3 per cent. (Jagadish *et al.*, 1994

Crop	Organism observed	Reference
Paddy	*Curvularia spp. Fusarium spp., Heliminthosporium oryzae, Nigrospora oryzae, Pyricularia oryzae*	Neergaard and Saad (1962)
Chilli, Brinjal, Tomato, Bhendi, Radish	*Alternaria tenuis, Aspergillus spp, Clodosporium spp, Colletotrichum capsica, Curvularia lunata, penicillium spp, Phoma spp etc.*	Siddiqui *et al.* (1974)
Tomato	*Aspergillus glaucas, Aspergillus Condidus and Penicillium spp*	Kononkov and Dudina, (1986)
Paddy	*Drechslera oryzae, Fusarium spp., Curvularia spp., Aspergillus spp. Rhizopus spp*	Sharma and Chaudhary (1986)
Cowpea	*Rhizopus sp., Aspergillus spp.*	Aswathi (2015)
Paddy	*Alternaria spp, Heliminthosporium oryzae, Rhizopus spp. and Aspergillus spp.*	Suganya (2015)
Chilli	*Aspergillus niger, A.flavus, Pencillium spp., Fusarium spp., Pencillium spp., Fusarium spp.*	Navya (2016)
Chilli	*Aspergillus niger, A.flavus, Pencillium spp., Alternaria spp*	Sandhya (2016)
Oriental pickling melon	*Aspergillus niger, A.flavus*	Nagendra (2017)

Materials and Methods

3. MATERIALS AND METHODS

The present investigation entitled 'Effect of seed treatments on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench)', was carried out in the Department of Seed Science and Technology, College of Horticulture, Vellanikkara, Kerala Agricultural University with an indent to find the effect of growth regulators on growth, seed yield and quality in okra and delineate their effect on seed quality and longevity. The details of the materials used and methods adopted are given hereunder.

3.1 Location

The field experiment was conducted at the Department of Seed Science and Technology, College of Horticulture, Vellanikkara, Kerala Agriculture University (KAU), Vellanikkara, Thrissur, between June and October 2017. Seeds obtained from the field experiment were stored under ambient conditions to assess its quality and longevity.

3.3 Experimental material

The freshly harvested okra seeds of variety Arka Anamika, obtained from Agricultural Research Station, Mannuthy, Thrissur were used to conduct the study.

3.4 Experiment details

The study comprised of two experiments

Experiment 1: Effect of seed treatment on growth, seed yield and quality in okra

Experiment 2: Seed quality assessment during storage

3.4.1 Treatment details

Growth regulators such as GA_3, IAA, NAA, CCC and Maleic hydrazide were partially soluble in water, therefore to dissolve them, other solvents were used. GA_3, IAA and NAA were dissolved in acetone while maleic hydrazide and CCC were

dissolved in sodium hydroxide (NaOH). Thiourea dissolved directly in water while stirring.

3.4.1.1 Effect of seed treatments on growth, seed yield and quality

The field experiment was laid out in a Randomised Block Design with three replications and spacing of 60 x 45 cm. Seeds of the variety Arka Anamika were treated with the different growth regulators as listed in table 1 below before sowing:

Table 1. Details of treatments

Treatment no.	Growth regulator used	Concentration and duration
T_0	Control	
T_1	GA_3	50 ppm for 12 hours
T_2	GA_3	100 ppm for 12 hours
T_3	GA_3	50 ppm for 24 hours
T_4	GA_3	100 ppm for 24hours
T_5	IAA	50ppm for 12 hours
T_6	IAA	100ppm for 12 hours
T_7	IAA	50ppm for 24 hours
T_8	IAA	100ppm for 24 hours
T_9	NAA	50ppm for 12 hours
T_{10}	NAA	100ppm for 12 hours
T_{11}	NAA	50ppm for 24 hours
T_{12}	NAA	100ppm for 24 hours
T_{13}	CCC	100ppm for 12 hours
T_{14}	CCC	150ppm for 12 hours
T_{15}	CCC	100ppm for 24 hours
T_{16}	CCC	150ppm for 24 hours
T_{17}	MH	40 ppm for 12 hours

40

T_{18}	MH	80 ppm for 12 hours
T_{19}	MH	40 ppm for 24 hours
T_{20}	MH	80 ppm for 24hours
T_{21}	Thiourea	500ppm for 12 hours
T_{22}	Thiourea	1000 ppm for 12 hours
T_{23}	Thiourea	500ppm for 24hours
T_{24}	Thiourea	1000ppm for 24hours

The treated seeds were sown immediately. Recommended agronomic practices as per package of practices of KAU (2011) was followed during crop growth period to raise a good crop. Observations on biometrical traits were recorded on five randomly selected plants from each replication at different growth stages.

3.4.2 Observations

For the study, five plants from each plot were selected randomly and tagged for recording the observations.

3.4.2.1 Days to first flowering

Number of days taken from sowing to emergence of first flower in each plant was recorded and average number of days to first flower was worked out and expressed in days

3.4.2.2 Plant height (cm)

The plant height was recorded at maturity. Main shoot height of five tagged plants was measured in centimetre from ground level to tip of main shoot and average height per plant was calculated.

Plate 1. Land preparation

Plate 2. General view of experimental plot during sowing

Plate 3. General view of experimental plot at seedling stage

Plate 4. Flowering stage

Plate 5. Field view at fruit development stage

Plate 6. Field view at maturity stage

Plate 7. Field view at harvesting stage

3.4.2.3 Nodes per plant

Number of nodes per plant was recorded by taking count of nodes on main stem from tagged plants and the average worked out.

3.4.2.4 Internode length (cm)

The length of the internode between fifth and sixth node on main stem of plant was recorded from the five plants and the average value was expressed in centimetre.

3.4.2.5 Branches per plant

Total number of branches was recorded by counting the number of branches arising from the main stem of each tagged plant and average computed to per plant.

3.4.2.6 Fruits per plant

Total number of edible green fruits on each of the five selected plants was counted at edible fruit maturity stage and its average was worked out.

3.4.2.7 Fruit length (cm)

Fruit length was measured by taking the length of five fruits from each replication from the point of fruit attachment to stalk to the tip of fruit of tagged plants and then its average was worked out and expressed in centimetre

3.4.2.8 Fruit weight (g)

Fruit weight was measured by taking the weight of five fruits from the five tagged plants and its average value was expressed in gram.

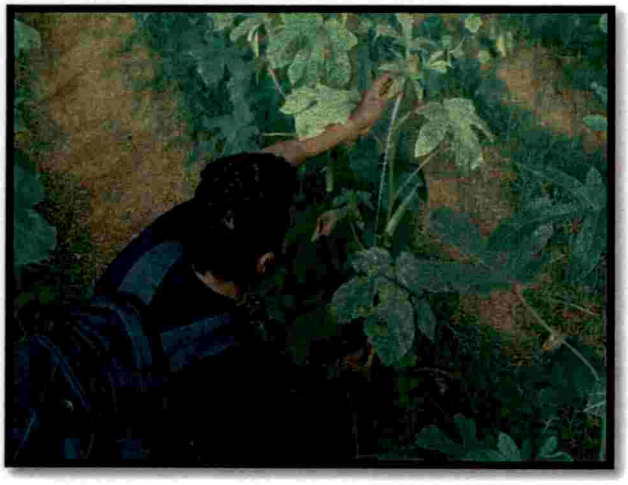


Plate 8. Overall view of observations taken during field experiment.

3.4.2.9 Estimated fruit yield (g)

Fruit yield was calculated as the product of the number of fruits per plant and fruit weight and its average value was expressed in gram.

3.4.2.10 Seeds per fruit

Five fruits were selected at random from tagged plants and number of seeds per fruit was counted and their average was computed.

3.4.2.11 Shrivelled seeds per fruit

The shrivelled seeds per fruit was counted from the five fruits selected for counting seeds per fruit and their average was worked out.

3.4.2.12 Seed yield per plant (g)

The seeds extracted from the harvested pods was recorded from the five tagged plants of each replication and their mean were computed.

3.4.2.13 100 seed weight (g)

Seed sample was taken randomly from the seed obtained from each replication of the treatment and 100 seeds were randomly picked from the sample and their weight recorded in gram.

3.4.3 Seed quality assessment during storage

Seeds obtained from the experiment was assessed for its quality and longevity. The seeds from the twenty five treatments in experiment 1 were dried to below eight per cent and stored in polythene covers (700 G) and stored under ambient condition. The experiment was conducted as a completely randomized block design with three replications and twenty five treatments. Quality parameters of the seeds stored under

ambient conditions were evaluated at monthly intervals following standard procedures for a period of six months.

3.4.3.1 Observations

Data on seed germination (%), shoot length (cm), root length (cm), seedling dry weight (g), EC of leachate (dSm^{-1}), mean gemination time (days) and time taken for 50 % germination (days) were recorded at the start of storage and subsequently at monthly intervals. The observations on seed moisture and seed microflora were however taken at the start and the end of storage period. The procedure followed for determining seed quality parameters are detailed below.

3.4.3.2 Germination (%)

The germination test was conducted as prescribed by ISTA. From each replication of treatment, four sets of hundred seeds were drawn and placed on wet sand for germination. The sand trays were kept at a constant temperature of 25 ^{0}C and 90±3 per cent relative humidity. The number of normal seedlings at the 7th day of germination was counted and germination per cent was worked out using the formula.

$$\text{Germination (\%)} = \frac{\text{number of seeds germinated}}{\text{total number of seeds sown}} \times 100$$

3.4.3.3 Seedling shoot length (cm)

Ten normal seedlings were randomly selected from each replication of the treatment on the 7th day of the germination for measuring the shoot length. The shoot length was measured from the base of primary leaf to the collar region and the mean shoot length was expressed in centimetre.

3.4.3.4 Seedling root length (cm)

The ten seedlings used for measuring shoot length were used to record the root length.

The length between collar region and the tip of the primary root was measured and expressed in centimetre.

3.4.3.5 Seedling dry weight (g)

The ten seedlings used for measuring shoot and root length were placed in a butter paper cover and dried in hot air oven at a temperature of 85°C for 24 hours. The seedlings were removed and allowed to cool in desiccators for 30 minutes before weighing in digital balance and expressed in gram.

3.4.3.6 Electrical conductivity of seed leachate (µS/cm)

The observation on electrical conductivity of seed leachate (EC) was recorded using 50 seeds of each replication. The seeds were soaked in 50ml distilled water. After incubation, leachate was collected in a beaker. The EC of the seed leachate was recorded with EUTECH CON-510 digital conductivity meter with a cell constant of 0.1 and recorded as micro Siemens per centimetre (µS/cm).

3.4.3.7 Mean germination time (days)

Mean germination time (MGT) for each treatment was calculated using the formula cited by Ellis and Roberts (1980).

Mean germination time (MGT) = $\Sigma Dn/\Sigma n$

Where,

n = number of newly germinated on day D

D = days from the starting of the germination test,

$\sum n$ = final germination

Plate 9. Conduct of germination test in okra

Plate 10. Seeds soaked for conducting electrical conductivity test

3.4.3.8 Time taken for 50% germination (T50)

Time taken for 50% of germination was calculated using the equation suggested by Coolbar *et al.* (1984).

$$T50 = ti + \left[\frac{\left[\left(\frac{N+1}{2}\right) - ni\right]}{ni - ni}\right] x\ (tj - ti)$$

Where,

N = No. of seeds germinated finally

ni and nj = Cumulative number of seeds germinated by adjacent counts at times ti and tj while ni< N/2 <nj.

3.4.3.9 Vigour indices

The seedling vigour indices consist of Vigour index 1 and Vigour index II.

3.4.3.9.1 Vigour index I

The seedling vigour index 1 was calculated using the formula suggested by Abdul- Baki and Anderson (1973).

Vigour index I = Germination (%) x seedling length (cm)

3.4.3.9.2 Vigour index II

Vigour index II was computed as suggested by Abdul- Baki and Anderson (1973).

Vigour index II = Germination (%) x seedling dry weight (mg)

3.4.3.10 Seed moisture content (%)

The seed moisture content through high constant temperature method was estimated as per the standard procedure of ISTA (1985). Five gram of two replicates of seeds were weighed and ground to coarse powder. The coarse powdered seed material was placed inside a weighed aluminium cup and sealed with a lid. Then the aluminium cup along the seed material was kept in a hot air oven maintained at a temperature of 103 ± 2°C and allowed to dry for 17 ± 1 hour. After removing the aluminium cup from the hot air oven, it was allowed to cool in a dessicator for thirty minutes. Later, the aluminum cup along with seed and lid was weighed in an electronic balance and the moisture content was worked out using the following formula,

$$\text{Moisture content (\%)} = \frac{M_2 - M_3 \text{ X } 100}{M_2 - M_1}$$

Where,

M_1 = weight of the aluminium cup with lid alone

M_2 = weight of the aluminium cup with lid + sample before drying

M_3 = weight of the aluminium cup with lid + sample after drying

3.4.3.11 Seed microflora

3.4.3.11.1 Blotter method

The infestation on seeds by storage fungi was detected through Blotter method prescribed by ISTA (1999). Ten seeds were equidistantly placed on a three layer sterlilised moistened blotter placed in a petriplate. Three replications of each treatment were kept and they were incubated at a temperature of 20°C for 7 days for an alternate cycle of 12 hours' time period near ultraviolet range and remaining 12 hours in dark. The plates were examined on the eighth day under stereo binocular microscope for the

presence seed borne fungi. The infected seeds were counted, identified and expressed in percentage.

3.4.3.11.2 Agar plate method

In agar plate method, three replicates of ten seeds per each treatment was used. The seeds were equidistantly placed in a Potato Dextrose Agar media under the laminar airflow chamber after it is sterilized using 0.1% mercuric chloride. The petriplates were kept for incubation under the bell jar and the fungal growth was examined after the incubation period under the stereo binocular microscope.

3.5. Statistical analysis

3.5.1 Analysis of data from Experiment I

The statistical analysis of the data recorded in Experiment I was performed using Web Agri. Stat Package (WASP) for Randomized Block Design (RBD) developed by Indian Council of Agricultural Research (ICAR) and the significant test by Duncan's Multiple Range Test (DMRT). The data obtained were subjected to the analysis of variance (ANOVA) as shown below.

ANOVA for randomized block design (RBD)

Source of variation	Degrees of freedom	Sum of squires	Mean sum of squires	F-calculated
Replications	t-1	RSS	MSR	MSR/ MSE
Treatments	r-1	TrSS	MSTr	MSTr/MSE
Error	(t-1) (r-1)	ESS	MSE	
Total	N-1	TSS		

Where,

t = no. of treatments

r = no. of replications

N = no. of total observations

RSS = replication sum of squires

TrSS = treatment sum of squires

ESS = error sum of squires

TSS = total sum of squires

MSR= Mean sum of squires due to replication

MSTr = Mean sum of squires due to treatment

MSE = Mean sum of squires due to error

3.5.2 Analysis of data from Experiment II

Statistical analysis of the data on various seed quality parameters was performed using Web Agri Stat Package (WASP) developed by Indian Council of Agricultural Research for completely randomized design and significant test by Duncan's Multiple Range Test (DMRT). The treatment efficacy criteria expressed as per cent and the numbers having low counts and zero values were transformed to square root of $(x + 0.5)$ before analysis of variance (ANOVA). Data obtained were subjected to analysis of variance (ANOVA).

ANOVA for completely randomized design (CRD)

The data recorded in each observation were analyzed using ANOVA so as to test the differences among two or more independent groups.

Source of variation	**Degree of freedom (df)**	**Sum of squares (SS)**	**Mean square MS = SS/df**	**Computed F**
Treatment	t – 1	SST	MST	MST/MSE
Error	n – t	SSE	MSE	
Total	N – 1	SSTO		

Where,

t =Treatment

n = Total number of observation

SST = sum of squares of treatment

SSE = Sum of squares of error

SSTO = Sum of squares of total

MST = Mean square of treatments

MSE = Mean square of error

3.5.3 Pair wise comparison using DMRT test

Duncan's multiple range test (DMRT) is used for experiments that require the evaluation of all possible pairs of treatment means, especially when the total number of treatments is large. Computation of numerical boundaries that allow for the classification of difference between any two treatments or means as significant or non-significant was done. However, unlike the LSD test in which only a single value is required for any pair comparison at a prescribed level of significance, the DMRT requires computation of a series of values, each corresponding to a specific series, of pair comparisons. The following steps were followed for ranking the data (Gomez and Gomez, 1976).

Step 1: The treatment means were ranked in decreasing (or increasing) order. It is customary to rank the treatment means according to the order of preference.

Step 2: The sd value was computed following the appropriate procedure.

Step 3: The (t-1) values of the shortest significant ranges was computed as:

$$sd = \sqrt{\frac{2\,S^2}{r}}$$

Step 3: Compute the (t - 1) values of the short

$$Rp = \frac{(rp)(sd)}{\sqrt{2}} \quad \text{for } p = 2,3,\ldots\ldots$$

where,'t' is the total number of treatments,'s' is the standard error of the mean difference computed in step 2, 'r' values are the tabular values of the significant ranges, and 'p' is the distance in rank between the pairs of treatment means to be compared (i.e., p = 2 for the two means with consecutive rankings and p = t for the highest and lowest means).

Step 4: All treatment means that do not differ significantly from each other were identified and grouped together

Step 5: Alphabet notation were used according to the ranking to present the test results.

Results

4. RESULTS

The present investigation 'Effect of seed treatments on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench)' was carried out in the Department of Seed Science and Technology, College of Horticulture, Vellanikkara during 2017-18.

The study comprised of two experiments using a single variety of okra (Arka Anamika) namely

Experiment 1: Effect of seed treatments on growth, seed yield and quality

Experiment 2: Seed quality assessment during storage

The influence of growth regulators on seed yield attributes *viz.*, days to first flowering, plant height, internode length, nodes per plant, branches per plant, fruits per plant, fruit length, fruit weight, seeds per fruit, shrivelled seeds per fruit, 100 seed weight, seed yield per plant and seed quality parameters *viz.*, seed germination (%), shoot length (cm), root length (cm), seedling dry weight (g), EC of leachate (dSm^{-1}), mean germination time (days), time taken for 50 % germination (days), seed moisture and seed microflora are presented in this chapter.

4.1. Effect of seed treatments with on growth, seed yield and quality

The results obtained from the field experiment are detailed below

4.1.1 Analysis of variance

The analysis of variance (Table 2) revealed that most of the characters under investigation were significantly influenced by the application of different growth regulators as seed treatment.

Table 2. Analysis of variance for vegetative, fruit and seed yield attributes in okra

Source of variation	Df	Plant height	Nodes per plant	Internode length	Branches per plant	Days to first flowering	Fruits per plant	Fruit length	Estimated fruit yield	Fruit weight	Seeds per fruit	Shriveled seeds per fruit	Seed yield per plant	100 seed weight
Replication	2	379.82	1.0	8.36	0.39	0.14	4.08	0.56	1828.68	0.68	1.34	1.09	50.92	0.02
Treatments	24	155.17	7.11**	1.32**	0.27**	3.83**	1.98*	10.39**	1421.96**	9.21**	79.08**	1.97**	52.48**	0.15**
Error	48	53.17	0.41	0.44	0.07	0.54	1.07	0.11	468.22	0.08	0.67	0.38	10.30	0.01
CV (%)		13.51	4.65	12.57	13.49	1.90	13.17	1.87	14.55	1.51	1.72	9.59	13.91	1.22
CD (0.05)		11.97	1.05	1.09	0.44	1.21	1.70	0.55	35.49	0.47	1.34	1.01	5.27	0.10
CD (0.01)		15.97	1.39	1.45	0.59	1.61	NS	0.74	47.31	0.62	1.79	1.35	7.02	0.16

*The value was significant at 5% level of significance

**The value was highly significant at 1% level of significance

NS The value was non-significant

4.1.2 Plant height (cm)

From the data tabulated in Table 3, it is evident that there is a significant influence of the growth regulators on plant height. The mean plant height varied from 44.43 cm (T_{14}) to 72.34 cm (T_{24}). The highest plant height was noticed in T_{24} (Thiourea 1000 ppm for 24 h;72.34 cm) which was statistically on par with T_4 (64.43 cm), T_{17} (63.93 cm) and T_{21} (60.54 cm). While T_{14} (Cycocel at 150 ppm for 12 h; 44.43 cm) and T_{20} (Maleic Hydrazide at 80 ppm for 24 h; 44.81cm) recorded the lower values for this character.

4.1.3 Nodes per plant

The number of nodes per plant varied significantly among the treatments (Table 3). The number of nodes per plant ranged between 11.20 (T_2: GA_3 at 100 ppm for 12 h) and 17.06 (T_{16}: CCC at 150 ppm for 24 h). T_{16} (17.06) recorded the highest number of nodes per plant which was on par with T_{15} (CCC at 100 ppm for 24 h; 16.40) and T_{14} (CCC at 150 ppm for 12 h; 16.06), while the lowest number of nodes per plant was recorded in T_2 (11.20).

4.1.4 Internode length (cm)

Internode length varied significantly among the treatments from 3.99 cm (T_{20} : Maleic Hydrazide at 80 ppm for 24 h) to 7.15 cm (T_{24} : Thiourea 1000 ppm for 24 h). The highest value for this trait was recorded in T_{24} (7.15) which was statistically on par with T_{21} (Thiourea 500 ppm for 12 h; 6.34) and T_{23} (Thiourea 500 ppm for 24 h; 6.22). The internode length in control was 5 cm.

4.1.5 Branches per plant.

It is evident from the data tabulated in the Table 3 that the treatments varied significantly among themselves. Treating seeds with CCC at 150 ppm for 12 h (T_{14};

2.73) recorded the highest number of branches and it was on par with T_{18} (2.60), T_{15} (2.46) and T_{10} (2.40). Control and T_2 recorded low number of branches per plant (1.60)

4.1.6 Days to first flowering

Days taken for the emergence of first flower varied from 36.26 (T_3: GA_3 at 50 ppm for 24 h) to 40.46 (T_5: IAA at 50 ppm for 12 h) days. Among the treatments, T_3 GA_3 (50 ppm for 24 hours) flowered early at 36.26 days which was found to be on par with T_{17} (MH at 40 ppm for 12 h: 37.33), T_2 (GA_3 at 50 ppm for 12 h: 37.38) and T_{18} (MH at 80 ppm for 12 h: 37.43). Delayed flowering was recorded in treatment T_5 (IAA at 50 ppm for 12 h: 40.60) and control (40.10).

4.1.7 Fruits per plant

Among the treatments fruits per plant varied from 9.7 (T_{24}: Thiourea at 1000 ppm for 24 h) to 6.46 (T_7: IAA at 50 ppm for 24 h) (Table 3). Treatments T_{15} (CCC at 100 ppm for 24 h: 8.80), T_6 (IAA at 100 ppm for 12 h: 8.66) and T_{23} (Thiourea at 500 ppm for 24 h: 8.60) were on par with T_{24} which recorded the highest value for this trait while the control (7.13) was statistically on par with the lowest number of fruits per plant (6.46).

4.1.8 Fruit length (cm)

The data pertaining to fruit length presented in table 4 reveal that there exists a significant difference among the treatments for the trait fruit length. The mean fruit length varied from 15.29 cm (T_{17}: MH at 40 ppm for 12 h) to 21.69 cm (T_4: GA_3 at 100 ppm for 24 h). Treatments T_3 and T_{24} had also recorded higher values for this trait. Lower values were recorded in T_{17} (15.29 cm) T_{19} (15.52 cm) and T_{20} (15.72 cm).

4.1.9 Fruit weight (g)

Mean fruit weight varied among the treatments from 15.24 g (T_{19}: MH at 40 ppm for 24 h) to 21.56 g (T_{11}: NAA at 50 ppm for 24 h). Other significant treatments

Table 3. Effect of seed treatments with growth regulators on plant growth in okra

Treatments	Plant height (cm)	Nodes per plant	Internode length (cm)	Branches / plant	Days to first flowering	Fruits per plant
T_0	47.66^{efghi}	13.13^{fghij}	5.00^{defgh}	1.60^{h}	40.01^{abcd}	7.13^{bcdefg}
T_1	49.20^{defghi}	12.80^{ghijk}	4.96^{defgh}	1.86^{efgh}	38.73^{efgh}	6.93^{defg}
T_2	46.06^{ghi}	11.20^{l}	5.29^{bcdefg}	1.60^{h}	37.38^{ij}	6.73^{fg}
T_3	53.80^{bcdefghi}	13.62^{efgh}	5.41^{bcdef}	2.13^{cdef}	36.26^{j}	8.53^{abcd}
T_4	64.43^{ab}	15.00^{c}	5.71^{bcde}	1.80^{fgh}	37.58^{hi}	8.20^{abcdef}
T_5	56.86^{bcdefgh}	13.73^{efg}	5.37^{bcdef}	1.80^{fgh}	40.60^{a}	7.13^{bcdefg}
T_6	58.20^{bcdef}	13.80^{efg}	5.48^{bcdef}	1.80^{fgh}	39.33^{bcdef}	8.66^{abc}
T_7	46.40^{fghi}	13.60^{efgh}	4.64^{efgh}	1.80^{fgh}	39.09^{cdefg}	6.46^{g}
T_8	45.60^{hi}	13.26^{fghi}	4.58^{fgh}	1.93^{efgh}	40.05^{abc}	7.06^{cdefg}
T_9	49.88^{defghi}	12.26^{ijk}	5.75^{bcd}	1.86^{efgh}	40.06^{abc}	7.33^{bcdefg}
T_{10}	59.46^{bcde}	12.60^{hijk}	5.12^{defg}	2.40^{abcd}	38.01^{ghi}	8.13^{bcdefg}
T_{11}	56.34^{bcdefghi}	13.80^{efg}	5.18^{cdefg}	2.20^{bcdef}	39.10^{cdefg}	8.20^{abcdef}
T_{12}	56.29^{bcdefghi}	14.40^{cde}	5.14^{cdefg}	1.93^{efgh}	40.40^{ab}	8.20^{abcdef}
T_{13}	49.13^{defghi}	13.93^{def}	4.95^{defgh}	1.86^{efgh}	39.66^{abcde}	7.40^{bcdefg}
T_{14}	44.43^{i}	16.06^{ab}	4.24^{gh}	2.73^{a}	39.68^{abcde}	8.46^{abcde}
T_{15}	49.93^{fghi}	16.40^{a}	4.68^{defgh}	2.46^{abc}	37.53^{hi}	8.80^{ab}
T_{16}	52.66^{bcdefghi}	17.06^{a}	5.19^{cdefg}	1.86^{efgh}	38.00^{ghi}	7.93^{bcdefg}
T_{17}	63.93^{abc}	14.86^{cd}	5.75^{bcd}	2.00^{defgh}	37.33^{ij}	8.33^{abcde}
T_{18}	59.33^{bcd}	15.13^{bc}	5.42^{bcdef}	2.60^{ab}	37.43^{ij}	8.41^{abcd}
T_{19}	52.00^{cdefghi}	13.80^{efg}	5.20^{cdefg}	2.06^{cdefg}	39.06^{cdefg}	6.80^{efg}
T_{20}	44.81^{i}	15.33^{bc}	3.99^{h}	1.80^{fgh}	39.73^{abcde}	6.93^{defg}
T_{21}	60.54^{abcd}	12.13^{jkl}	6.34^{ab}	2.13^{cdef}	38.53^{efghi}	8.00^{abcdefg}
T_{22}	55.13^{bcdefghi}	12.00^{kl}	5.26^{bcdefg}	1.80^{fgh}	39.10^{cdefg}	8.26^{abcdef}
T_{23}	57.86^{bcdefg}	12.26^{ijk}	6.22^{abc}	1.66^{gh}	38.83^{defg}	8.60^{abcd}
T_{24}	72.34^{a}	11.80^{kl}	7.15^{a}	2.26^{bcde}	38.26^{fghi}	9.70^{a}
SE(m)	4.21	0.36	0.38	0.16	0.42	0.59
CD(.05)	11.97	1.05	1.09	0.44	1.21	1.70

include T_{12} (NAA at 100 ppm for 24 h: 21.29 g), T_3 (GA_3 at 50 ppm for 24 h: 21.21g) and T_4 (GA_3 at 100 ppm for 24 h: 21.18 g) while the control recorded a fruit weight of 17.30 g. Treatments T_{19} (15.24), T_{20} (15.83) and T_{17} (16.34) recorded the low values.

4.1.10 Estimated fruit yield (g)

The higher values for the parameter estimated fruit yield was recorded in T_{24} (Thiourea at 1000 ppm for 24 h) which was on par with T_{11} (NAA at 50ppm for 24 h), T_3 (GA_3 at 50 ppm for 24 h), T_4 (GA_3 at 100 ppm for 24 h), T_{12} (NAA at 100 ppm for 24 h) and all other treatments of thiourea. While control (123.28) was statistically on par the lower value 103.75 (T_{19}).

4.1.11 Seeds per fruit

Among the treatments, the mean number of seeds per fruit varied from 36.60 (T_{19}: MH at 40 ppm for 24 h) to 55.86 (T_4: GA_3 at 100 ppm for 24 h). The highest number of seeds per fruit was noticed in T_4 (55.86) which was on par with T_{12} (NAA at 100 ppm for 24 h: 54.80) and the least number of seeds per fruit was in T_{19} (36.60). The number of seeds per fruit in control was 41.73.

4.1.12 Shrivelled seeds per fruit

The average shrivelled seeds per fruit ranged from 5.26 (T_{13}: CCC at 100 ppm for 12 h and T_{18}: MH at 80 ppm for 12 h) to 7.86 (T_4: GA_3 at 100 ppm for 24 h). The shriveled seeds per fruit was found to be lowest in T_{13} and T_{18} (5.26). Significantly higher shriveled seeds per fruit was observed in T_4 (7.86) which was statistically on par with T_3, T_{23} (7.73), T_{24} (7.53), T_{22} (7.33), T_{21} (7.20), T_1 (7.13) and T_8 (6.86) (Table 3)

Table 4. Effect of seed treatment with growth regulators on fruit, seed yield parameter in okra.

Treatments	Fruit length(cm)	Fruit weight (g)	Estimated fruit yield (g)	Seeds per fruit	Shrivelled seeds	Seed yield /plant (g)	100 seed weight (g)
T_0	16.88^{ij}	17.30^{i}	123.28^{ghi}	41.73^{m}	$6.40^{defghij}$	16.77^{hij}	5.91^{nm}
T_1	18.26^{gh}	19.69^{cd}	137.61^{efghi}	48.13^{gh}	7.13^{abcdef}	20.28^{fghij}	6.08^{ijk}
T_2	19.58^{d}	20.53^{b}	138.09^{efghi}	50.26^{ef}	$6.20^{efghijk}$	$20.75^{defghij}$	6.14^{ghij}
T_3	21.07^{b}	21.21^{a}	181.13^{ab}	54.00^{bc}	7.73^{ab}	28.25^{ab}	6.13^{hij}
T_4	21.69^{a}	21.18^{a}	173.72^{abcd}	55.86^{a}	7.86^{a}	27.88^{ab}	6.07^{jkl}
T_5	18.00^{h}	18.84^{e}	134.28^{efghi}	47.13^{hi}	$6.53^{cdefghi}$	$21.10^{cdefghu}$	6.26^{efg}
T_6	17.00^{ij}	18.81^{e}	163.08^{abcdef}	46.26^{ij}	6.13^{fghijk}	25.72^{abcde}	6.43^{bc}
T_7	17.02^{i}	19.56^{cd}	126.42^{ghi}	43.06^{lm}	6.06^{ghijk}	17.49^{hij}	6.20^{fghi}
T_8	17.73^{h}	19.72^{cd}	139.47^{defgh}	46.00^{ij}	$6.86^{abcdefg}$	20.82^{defghi}	6.39^{cd}
T_9	18.09^{h}	19.93^{c}	146.35^{bcdefg}	48.40^{gh}	5.73^{hijk}	$21.81^{cdefghi}$	6.14^{ghij}
T_{10}	18.70^{fg}	20.69^{b}	168.27^{abcde}	50.73^{de}	5.533^{ijk}	26.22^{abc}	6.36^{cde}
T_{11}	18.98^{ef}	21.56^{a}	177.26^{abc}	53.33^{c}	5.73^{hijk}	28.58^{a}	6.54^{ab}
T_{12}	19.35^{de}	21.29^{a}	174.57^{abcd}	54.80^{ab}	5.86^{ghijk}	28.24^{ab}	6.28^{def}
T_{13}	16.65^{ijk}	17.69^{hi}	131.01^{fghi}	44.40^{kl}	5.26^{k}	19.06^{ghij}	5.79^{nop}
T_{14}	15.87^{lm}	18.57^{ef}	$157.11^{abcdefg}$	48.93^{fg}	$6.20^{efghijk}$	25.27^{abcdef}	6.10^{ijk}
T_{15}	16.45^{jk}	18.67^{ef}	164.62^{abcdef}	47.53^{h}	$6.73^{bdcefgh}$	24.99^{abcdef}	5.98^{klm}
T_{16}	16.12^{kl}	17.88^{gh}	141.93^{cdefgh}	45.26^{jk}	$6.73^{bcdefgh}$	20.51^{efghi}	5.71^{op}
T_{17}	15.29^{n}	16.34^{j}	136.23^{efghi}	41.80^{m}	5.73^{hijk}	23.09^{bcdefg}	6.62^{a}
T_{18}	16.12^{kl}	16.36^{j}	139.38^{defgh}	40.00^{n}	5.26^{k}	21.98^{cdefgh}	6.43^{bc}
T_{19}	15.52^{mn}	15.24^{l}	103.75^{i}	36.60^{q}	6.06^{ghijk}	15.52^{j}	6.22^{fgh}
T_{20}	15.72^{lmn}	15.83^{k}	109.76^{hi}	38.46^{op}	5.40^{jk}	16.16^{ij}	6.07^{jk}
T_{21}	19.14^{efg}	18.61^{ef}	$148.95^{abcdefg}$	50.60^{de}	7.20^{abcde}	24.87^{abcdef}	6.15^{ghij}
T_{22}	19.64^{d}	18.26^{fg}	$151.01^{abcdefg}$	51.20^{de}	7.33^{abcd}	25.18^{abcdef}	5.94^{lm}
T_{23}	20.20^{c}	19.35^{d}	166.67^{abcde}	50.60^{de}	7.73^{ab}	25.82^{abcd}	5.94^{m}
T_{24}	20.87^{b}	18.86^{e}	182.71^{a}	51.77^{d}	7.53^{abc}	30.06^{a}	5.98^{klm}
SE(m)	0.19	0.16	6.54	0.47	0.35	1.85	0.04
CD(0.05)	0.55	0.47	35.49	1.34	1.01	5.27	0.12

4.1.13 Seed yield per plant (g)

The data pertaining to seed yield per plant presented in table 4 reveals that there were significant differences among the treatments for this character. The mean seed yield per plant varied from 15.52 (T_{19}: MH at 40 ppm for 24 h) to 30.06 (T_{24}: Thiourea 1000 ppm for 24 h). The highest seed yield per plant was obtained from T_{24} (30.06) which was statistically on par with treatments T_{11} (NAA at 50 ppm for 24 h), T_3 (GA_3 at 50 ppm for 24 h) and T_{12} (NAA at 100 ppm for 24 h). They recorded a seed yield per plant of 28.58, 28.25 and 28.24 g respectively.

4.1.14 Hundred seed weight (g)

The average 100 seed weight ranged from 5.71 (T_{16}: CCC at 150 ppm for 24 h) to 6.62 g (T_{17}: MH at 40 ppm for 12 h). The treatments T_{17} (6.62) and T_{11} (6.54) were on par with each other, while the lowest was recorded in T_{16} (5.71) which was on par with T_{13} (5.79)

4.2. Experiment 2: Seed quality assessment during storage

Seeds obtained from the previous experiment were assessed for its quality and longevity. The seeds from the twenty five treatments were dried and stored in polythene covers (700 G). The experiment was conducted as completely randomized block design with three replications and twenty five treatments. Seed quality of the seeds stored under ambient conditions were evaluated at monthly intervals for a period of seven months

4.2.1. Initial seed quality of okra

The initial seed quality parameters were recorded at the start of the experiment and presented in Table 5.

4.2.1.1. Germination (%)

There was no significant influence of growth regulators on germination before storage. The germination per cent ranged between 50.66 (T_{17}: MH at 40 ppm for 24 h) and 63.33 (T_5: IAA at 50 ppm for 12 h).

4.2.1.2. Seedling shoot length (cm)

The freshly harvested seeds showed significant differences among the treatments for this parameter. Higher values for seedling shoot length was recorded in T_8 (21.21 cm) which was statistically on par with T_{21} (Thiourea 500 ppm for 12 h: 20.99 cm) and T_{10} (NAA at 100 ppm for 12 h: 20.91 cm), while the least value for seedling shoot length was observed in T_1 (GA_3 at 50 ppm for 12 h: 19.61 cm) which was statistically on par with the control (20.17 cm).

4.2.1.3. Seedling root length (cm)

There are no significant differences among the treatments for seedling root length.

4.2.1.4. Seedling dry weight (g)

The effect of growth regulators on seedling dry weight was found to be non-significant.

4.2.1.5. EC on seed leachate (µS/cm)

There is no significant treatment effect on electrical conductivity on seed leachate in the initial period.

Table 5: Initial seed quality parameters of okra seeds before harvest.

Treatments		Germination (%)	Shoot length (cm)	Root length(cm)	Seedling dry weight (g)	EC ($\mu S\ cm^{-1}$)	Vigour index I	Vigour index II
T_0	Control	56.66	20.17 ^{bcdef}	5.09	0.029	192.66	1432.52	1.61
T_1	GA_3 (50 ppm for 12 hours)	60.66	19.61 ^{f}	4.70	0.030	189.66	1473.99	1.84
T_2	GA_3 (100 ppm for 12 hours)	57.33	20.16 ^{cdef}	4.90	0.029	201.66	1433.45	1.66
T_3	GA_3 (50 ppm for 24 hours)	54.00	19.84 ^{ef}	4.91	0.030	186.33	1334.74	1.60
T_4	GA_3 (100 ppm for 24hours)	56.66	19.99 ^{def}	4.84	0.031	203.00	1408.04	1.76
T_5	IAA (50ppm for 12 hours)	63.33	20.27 ^{bcdef}	5.17	0.031	189.00	1608.21	1.94
T_6	IAA (100ppm for 12 hours)	56.00	20.21 ^{bcdef}	4.77	0.030	188.00	1399.52	1.66
T_7	IAA (50ppm for 24 hours)	55.33	19.95 ^{def}	5.02	0.028	190.66	1381.67	1.57
T_8	IAA (100ppm for 24 hours)	54.66	21.21 ^{a}	5.08	0.031	176.33	1438.75	1.69
T_9	NAA (50ppm for 12 hours)	56.00	20.33 ^{bcdef}	5.08	0.030	209.00	1422.05	1.69
T_{10}	NAA (100ppm for 12 hours)	54.66	20.91 ^{abc}	5.11	0.031	186.00	1421.72	1.71
T_{11}	NAA (50ppm for 24 hours)	51.33	20.76 ^{abcd}	5.23	0.031	194.00	1332.61	1.59
T_{12}	NAA (100ppm for 24 hours)	56.66	20.97 ^{abc}	5.00	0.030	202.66	1474.88	1.63
T_{13}	CCC (100ppm for 12 hours)	56.66	20.55 ^{abcde}	5.05	0.029	206.33	1450.88	1.73
T_{14}	CCC (150ppm for 12 hours)	56.66	20.19 ^{bcdef}	5.00	0.028	174.66	1426.06	1.58

T_{15}	CCC (100ppm for 24 hours)	60.66	20.26 ^{bcdef}	5.23	0.028	204.00	1543.85	1.70
T_{16}	CCC (150ppm for 24 hours)	52.00	20.25 ^{bcdef}	4.74	0.030	207.00	1301.15	1.56
T_{17}	MH (40 ppm for 12 hours)	50.66	20.87 ^{abc}	5.07	0.029	200.66	1313.76	1.46
T_{18}	MH (80 ppm for 12 hours)	54.00	20.91 ^{abc}	4.96	0.031	190.33	1396.79	1.67
T_{19}	MH (40 ppm for 24 hours)	54.00	20.76 ^{abcd}	5.03	0.029	213.66	1392.45	1.57
T_{20}	MH (80 ppm for 24hours)	52.66	20.47 ^{abcde}	4.90	0.029	196.00	1336.23	1.53
T_{21}	Thiourea (500ppm for 12 hours)	56.00	20.99 ^{ab}	5.37	0.031	198.66	1473.93	1.71
T_{22}	Thiourea (1000 ppm for 12 hours)	54.00	20.01 ^{def}	5.12	0.030	197.33	1357.03	1.60
T_{23}	Thiourea (500ppm for 24hours)	54.00	20.57 ^{abcde}	5.25	0.032	180.33	1393.32	1.71
T_{24}	Thiourea (1000ppm for 24hours)	56.00	20.69 ^{abcd}	5.21	0.030	199.33	1447.16	1.63
	CD (0.01)	NS	NS	NS	NS	NS	NS	NS
	CD (0.05)	NS	0.83	NS	NS	NS	NS	NS

4.2.1.6. Vigour index I and II

Both vigour index I and II had no significant treatment effect on freshly harvested seeds

4.2.2. Seed quality assessment during storage

4.2.2.1 Analysis of variance

The analysis of variance of the seed quality parameters recorded at monthly intervals for seven months of storage revealed that, there existed significant differences among the various growth regulator treatments for seed quality parameters such as germination percent, seedling shoot length, seedling root length, seedling dry weight, seedling vigour index I and II, mean germination time, time and electrical conductivity of seed leachate.

4.2.2.2. Germination (%)

Germination per cent of seeds obtained from the twenty five treatments of the previous experiment were calculated at monthly intervals for a period of seven months. The effect of plant growth regulators on seed germination is presented in Table.6. Significant treatment differences were observed in germination per cent from second month onwards to the last month of storage (seventh month) except the third month.

During the course of storage, irrespective of treatments the germination per cent declined gradually. Highest germination per cent (82.66%) was observed during the first month of storage in T_8 (IAA at 100 ppm for 24 h) and T_{10} (NAA at 100 ppm for 12 h) while the lowest germination per cent (56 %) was recorded at the last month of storage in T_{17} (MH at 40 ppm for 12 h) which was on par with the control (56.66%).

Table 6: Effect of seed treatment with plant growth regulators on germination (%) during storage in okra

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_0	Control	78.00	75.33^{def}	72.66	70.00^{cd}	65.33 ^{gh}	59.33 ^{g}	56.66 ^{h}
T_1	GA_3 (50 ppm for 12 hours)	79.33	79.33^{abc}	72.66	71.33^{bcd}	67.33 ^{defgh}	62.00 ^{defg}	59.33^{defgh}
T_2	GA_3 (100 ppm for 12 hours)	80.66	78.66^{abcd}	73.33	71.33^{bcd}	68.66 ^{bcdef}	64.00 ^{bcdef}	59.33^{defgh}
T_3	GA_3 (50 ppm for 24 hours)	76.00	79.33^{abc}	74.66	74.66^{ab}	71.33 ^{ab}	66.66 ^{abc}	64.66 ^{ab}
T_4	GA_3 (100 ppm for 24hours)	78.66	78.33^{abcd}	75.33	73.33^{abc}	71.33 ^{ab}	65.33 ^{bcd}	62.00 ^{bcde}
T_5	IAA (50ppm for 12 hours)	80.66	79.33^{abc}	74.66	70.66 ^{cd}	66.00 ^{fgh}	60.66 ^{efg}	57.33 ^{gh}
T_6	IAA (100ppm for 12 hours)	77.33	74.66^{ef}	73.33	70.00 ^{cd}	64.66 ^{h}	64.00 b^{cdef}	60.66 ^{cdefg}
T_7	IAA (50ppm for 24 hours)	80.66	78.00^{bcde}	74.00	72.00 ^{bcd}	68.00 ^{cdefg}	64.66 ^{bcde}	61.33 ^{bcdef}
T_8	IAA (100ppm for 24 hours)	82.66	77.33^{bcde}	72.00	70.00 ^{cd}	67.33 ^{defgh}	63.33 ^{cdefg}	61.33 ^{bcdef}
T_9	NAA (50ppm for 12 hours)	77.33	74.66^{ef}	73.33	71.33 ^{bcd}	66.66 ^{efgh}	64 ^{bcdef}	60.66 ^{cdefg}
T_{10}	NAA (100ppm for 12 hours)	82.66	80.00^{abc}	76.00	74.66 ^{ab}	70.00 ^{abcd}	66.66 ^{abc}	63.33 ^{abc}
T_{11}	NAA (50ppm for 24 hours)	81.33	82.00^{a}	77.33	76.00 ^{a}	72.66 ^{a}	70.00 a	66.66 ^{a}
T_{12}	NAA (100ppm for 24 hours)	78.00	79.33^{abc}	76.66	74.66 ^{ab}	71.33 ^{ab}	68.00 ^{ab}	64.00 ^{abc}
T_{13}	CCC (100ppm for 12 hours)	78.00	73.33^{f}	73.33	70.66 ^{cd}	66.66 ^{efgh}	62.66 ^{cdefg}	58.66 ^{efgh}

	Treatment	1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_{14}	CCC (150ppm for 12 hours)	80.66	78.00^{bcde}	73.33	69.33 ^{d}	64.66 ^{h}	60.00^{fg}	57.33^{gh}
T_{15}	CCC (100ppm for 24 hours)	81.33	76.66^{cdef}	72.66	72.00^{bcd}	68.00^{cdefg}	66.00^{abcd}	62.00^{bcde}
T_{16}	CCC (150ppm for 24 hours)	78.00	79.33^{abc}	75.33	71.33^{abc}	69.33^{bcde}	60.66 ^{efg}	58.66^{efgh}
T_{17}	MH (40 ppm for 12 hours)	81.66	79.33^{abc}	73.33	69.33 ^{d}	65.33 ^{gh}	59.33 ^{g}	56.00 ^{h}
T_{18}	MH (80 ppm for 12 hours)	81.33	80.66^{ab}	76.00	71.33^{abc}	69.33 ^{bcde}	63.33 ^{cdefg}	60.66 ^{cdefg}
T_{19}	MH (40 ppm for 24 hours)	78.00	75.33^{def}	72.66	69.33^{d}	66.66 ^{efgh}	60.00 ^{fg}	58.00 ^{fgh}
T_{20}	MH (80 ppm for 24hours)	80.66	80.66^{ab}	72.00	70.66^{cd}	68.00 ^{cdefg}	62.66 ^{cdefg}	60.66 c^{defg}
T_{21}	Thiourea (500 ppm for 12hours)	80.00	77.33^{bcde}	74.66	72.66^{abcd}	68.66 ^{bcdef}	62.66 ^{cdefg}	59.33 ^{defgh}
T_{22}	Thiourea (1000ppm for 12hours)	78.00	75.33^{f}	71.33	71.33^{abc}	67.33 ^{defgh}	64.00 ^{bcdef}	61.33 ^{bcdef}
T_{23}	Thiourea (500ppm for 24hours)	79.33	78.66^{abcd}	75.33	72.66^{abcd}	70.66 ^{abc}	65.33 ^{bcd}	62.66 ^{bcd}
T_{24}	Thiourea (1000ppm for 24hours)	78.66	80.00^{abc}	76.66	73.33^{abc}	68.00^{cdefg}	63.33 ^{cdefg}	60.66 ^{cdefg}
	CD (0.01)	NS	5.224	NS	4.56	4.40	5.46	4.51
	CD (0.05)	NS	3.915	NS	3.43	3.30	4.09	3.38

At the end of the storage period (seventh month), T_{11} (NAA at 50 ppm for 24 h) exhibited the highest germination per cent (66.66%) which was significantly on par with T_3 (GA_3 at 50 ppm for 24 h; 64.66%). So, at the end of the storage period only these two treatments (T_{11} and T_3) retained the minimum seed certification standard of okra (65%).

All treatments including the control maintained the MSCS (Minimum Seed Certification Standard) of 65 per cent up to fifth month of storage. In the sixth month the germination per cent ranged between 60 per cent and 70 per cent

4.2.2.3. Seedling shoot length (cm)

Seedling shoot length exhibited significant differences among the treatments from third month of storage to the sixth month of storage (Table 7). In the first two months and last month of storage the treatment effect was found to be non-significant. In third month of storage, significantly higher shoot length was observed in T_{23} (Thiourea at 1000 ppm for 12 h; 21.73 cm) which was statistically on par with T_{10} (NAA at 100 ppm for 12 h; 21.26 cm) and T_{24} (Thiourea at 1000 ppm for 24 h; 21.186 cm).

At the sixth month of storage, higher seedling shoot length of 19.96 cm was recorded in T_{11} (NAA at 50 ppm for 24 h) which was found to be on par with T_{10} (NAA at 100 ppm for 12 h; 19.66 cm) and T_4 (GA3 at 100 ppm for 24 h;19.25 cm). The control (17.62 cm) was statistically on par with the lowest seedling shoot length of 17.43 cm in T_{17}.

4.2.2.4. Seedling root length (cm)

The seedling root length exhibited significant treatment effects in the fourth, fifth and the last month of storage (seventh month).

Table 7: Effect of seed treatment with plant growth regulators on seedling shoot length (cm) during storage

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_0	Control	20.22	20.15	19.94 ^{efgh}	18.80 ^{efgh}	18.17 ^{efgh}	17.62 ^{hij}	16.87
T_1	GA_3 (50 ppm for 12 hours)	19.38	20.49	19.79 ^{gh}	19.31 ^{cdefg}	19.59 ^{bcd}	18.72 ^{bcdefg}	17.52
T_2	GA_3 (100 ppm for 12 hours)	20.89	20.55	20.37 ^{bcdefgh}	20.14 ^{abcd}	20.82 ^{a}	19.08 ^{abcde}	17.49
T_3	GA_3 (50 ppm for 24 hours)	19.44	20.57	21.06 ^{abc}	20.38 ^{ab}	19.91 ^{abc}	19.06 ^{abcde}	17.76
T_4	GA_3 (100 ppm for 24hours)	20.48	21.69	21.05 ^{abc}	20.35 ^{ab}	20.05 ^{abc}	19.24 ^{abc}	17.81
T_5	IAA (50ppm for 12 hours)	20.83	22.11	20.46 ^{bcdefg}	19.59 ^{bcdef}	19.06 ^{cdef}	18.52 ^{cdefgh}	17.06
T_6	IAA (100ppm for 12 hours)	20.24	20.99	20.17 ^{cdefgh}	20.69 ^{a}	19.53 ^{bcd}	18.46 ^{cdefghi}	17.24
T_7	IAA (50ppm for 24 hours)	19.78	21.05	19.90 ^{efgh}	18.99 ^{efg}	18.72 ^{defgh}	18.01 ^{fghij}	17.19
T_8	IAA (100ppm for 24 hours)	21.39	20.56	20.50 ^{bcdefg}	20.37 ^{ab}	19.62 ^{bcd}	18.31 ^{cdefghij}	17.81
T_9	NAA (50ppm for 12 hours)	20.25	21.12	19.41 ^{h}	19.75 ^{abcdef}	19.33 ^{cd}	18.48 ^{cdefghi}	17.69
T_{10}	NAA (100ppm for 12 hours)	21.46	21.17	21.26 ^{ab}	20.26 ^{abc}	20.48 ^{ab}	19.66 ^{ab}	17.95
T_{11}	NAA (50ppm for 24 hours)	21.27	21.65	20.90 ^{abcd}	19.80 ^{abcde}	20.46 ^{ab}	19.96 ^{a}	17.50
T_{12}	NAA (100ppm for 24 hours)	21.24	21.46	20.80 ^{abcdef}	20.13 ^{abcd}	20.01 ^{abc}	19.19 ^{abcd}	17.60
T_{13}	CCC (100ppm for 12 hours)	20.30	20.95	19.86 ^{fgh}	20.14 ^{abcd}	19.60 ^{bcd}	18.69 ^{bcdefg}	17.88

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_{14}	CCC (150ppm for 12 hours)	20.50	20.81	19.46 ^{h}	19.00 ^{efg}	18.82 ^{defg}	18.20 ^{efghij}	17.03
T_{15}	CCC (100ppm for 24 hours)	20.39	21.07	19.60 ^{gh}	19.01 ^{efg}	19.16 ^{cde}	18.24 ^{defghij}	17.05
T_{16}	CCC (150ppm for 24 hours)	20.58	20.84	20.47 ^{bcdefg}	19.21 ^{defg}	18.81 ^{defgh}	18.27 ^{cdefghij}	16.95
T_{17}	MH (40 ppm for 12 hours)	20.85	21.22	19.66 ^{gh}	18.39 ^{ghi}	18.00 ^{fgh}	17.43 ^{j}	16.70
T_{18}	MH (80 ppm for 12 hours)	21.31	20.88	19.82 ^{gh}	18.84 ^{efgh}	18.21 ^{efgh}	17.53 ^{ij}	16.99
T_{19}	MH (40 ppm for 24 hours)	20.65	19.86	20.43 ^{bcdefg}	17.86 ^{i}	17.92 ^{gh}	17.67 ^{hij}	16.73
T_{20}	MH (80 ppm for 24hours)	20.90	20.87	20.02 ^{defgh}	17.99 ^{hi}	17.74 ^{h}	17.89 ^{ghij}	17.00
T_{21}	Thiourea (500ppm for 12hours)	21.47	20.72	20.53 ^{bcdefg}	18.48 ^{ghi}	18.17 ^{efgh}	18.07 ^{fghij}	16.95
T_{22}	Thiourea (1000ppm for 12hours)	20.74	21.74	20.84 ^{abcde}	19.00 ^{efg}	18.64 ^{defgh}	18.75 ^{bcdefg}	17.50
T_{23}	Thiourea (500ppm for 24hours)	21.04	21.31	21.73 ^{a}	19.76 ^{abcde}	19.02 ^{cdef}	18.87 ^{bcdef}	17.25
T_{24}	Thiourea (1000ppm for 24hours)	20.92	21.14	21.19 ^{ab}	20.05 ^{abcd}	19.32 cd	19.16 ^{abcde}	17.66
	CD (0.01)	NS	NS	1.28	1.29	1.42	1.30	NS
	CD (0.05)	NS	NS	0.96	0.96	1.07	0.97	NS

A gradual decline can be found in the seedling shoot length with the advancement of the storage period (Table 8).

Higher value for seedling root length was recorded in the first month of storage in T_{20} (MH at 80 ppm for 24 h; 6.32cm) and the lowest seedling root length was recorded at the end of storage period in T_{19} (MH at 40 ppm for 24 h; 2.97 cm).

At the end of storage period, T_2 (GA_3 at 100 ppm for 12 h) recorded the highest seedling root length of 3.75 cm which was on par with T_{10} (3.64 cm) and T_4 (3.60 cm) while the treatment T_{19} (MH at 40 ppm for 24 h; 2.97 cm) recorded the least value for this character which was statistically on par with the control (3.31 cm).

4.2.2.5. Seedling dry weight (g)

Seedling dry weight was found to be declining over the period of storage (Table 9). Significant treatment influence was noted only in the fourth and sixth month of storage.

The highest seedling dry weight (0.033g) was recorded at the first month of storage in T_4 (GA_3 at 100 ppm for 24 h), T6 (IAA at 100 ppm for 12 h) and T_{18} (MH at 80 ppm for 12 h)

At the end of storage T_{15}, T_{17}, T_{18} had the lowest value (0.022g) in seedling dry weight while the control was 0.023 g.

4.2.2.6. Electrical conductivity (µS/cm)

The electrical conductivity of seed leachate was found to be significantly influenced by the treatments throughout the period of storage (Table 10). Over the period of storage, seed leachate was found to increase gradually irrespective of the treatments. So as expected lower values of electrical conductivity was found in the first month and higher values at the end of the storage period.

Table 8: Effect of seed treatment with plant growth regulators on seedling root length (cm) during storage in okra

Treatment		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_0	Control	5.38	5.05	4.60	4.06 ^{bcdef}	3.99 ^{bc}	3.62	3.31^{bcde}
T_1	GA_3 (50 ppm for 12 hours)	4.87	5.04	4.68	3.91 ^{def}	4.03 ^{abc}	3.67	3.37 ^{abcde}
T_2	GA_3 (100 ppm for 12 hours)	5.15	4.95	5.04	4.51 ^{ab}	4.46 ^{a}	3.97	3.74 ^{a}
T_3	GA_3 (50 ppm for 24 hours)	5.31	5.04	4.83	4.42 ^{abc}	4.24 ^{ab}	3.92	3.49 ^{abc}
T_4	GA_3 (100 ppm for 24hours)	5.47	5.36	4.87	4.32 ^{abcd}	4.17 ^{ab}	3.96	3.60^{ab}
T_5	IAA (50ppm for 12 hours)	5.66	5.23	4.85	4.13 ^{abcdef}	4.08 ^{abc}	3.94	3.35^{abcde}
T_6	IAA (100ppm for 12 hours)	4.97	5.09	4.80	3.95 ^{cdef}	4.12 ^{abc}	3.86	3.58 ^{ab}
T_7	IAA (50ppm for 24 hours)	5.18	5.32	4.81	4.49 ^{ab}	4.46 ^{a}	4.10	3.52 ^{abc}
T_8	IAA (100ppm for 24 hours)	5.40	5.71	4.73	4.13 ^{abcdef}	3.95^{bcd}	3.73	3.47 ^{abc}
T_9	NAA (50ppm for 12 hours)	5.35	5.11	5.06	4.07 ^{bcdef}	4.05^{abc}	3.81	3.44 ^{abcd}
T_{10}	NAA (100ppm for 12 hours)	5.35	5.33	5.04	4.23 ^{abcde}	4.18^{ab}	3.89	3.64 ^{ab}
T_{11}	NAA (50ppm for 24 hours)	6.32	5.31	5.10	4.31^{abcd}	4.17 ^{ab}	3.92	3.59^{ab}
T_{12}	NAA (100ppm for 24 hours)	5.34	5.17	4.91	3.91^{def}	3.84^{bcd}	3.76	3.41 ^{abcd}
T_{13}	CCC (100ppm for 12 hours)	5.32	5.07	4.52	4.44 ^{abc}	4.09 ^{abc}	3.83	3.44 ^{abcd}

Treatment		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_{14}	CCC (150ppm for 12 hours)	5.32	5.18	4.63	3.70 ^{f}	3.54 ^{d}	3.47	3.05 ^{de}
T_{15}	CCC (100ppm for 24 hours)	5.38	5.11	4.79	4.19 ^{abcdef}	4.06 ^{abc}	3.82	3.15^{cde}
T_{16}	CCC (150ppm for 24 hours)	4.84	5.49	5.17	4.58 ^{a}	4.16 ^{ab}	4.02	3.60 ^{ab}
T_{17}	MH (40 ppm for 12 hours)	5.28	5.46	5.41	4.17^{abcdef}	3.94 ^{bcd}	3.55	3.03 ^{de}
T_{18}	MH (80 ppm for 12 hours)	5.35	5.49	5.27	3.96 ^{cdef}	3.82 ^{bcd}	3.66	3.50^{abc}
T_{19}	MH (40 ppm for 24 hours)	5.49	5.42	4.62	3.79 ^{ef}	3.68^{cd}	3.50	2.97 ^{e}
T_{20}	MH (80 ppm for 24hours)	5.60	5.26	4.68	3.84 ^{def}	3.69 ^{cd}	3.64	3.13 ^{cde}
T_{21}	Thiourea (500ppm for 12hours)	5.55	5.28	4.91	3.89 ^{def}	3.80 ^{bcd}	3.92	3.64 ^{ab}
T_{22}	Thiourea (1000ppm for 12hours)	5.53	5.42	5.32	3.71 ^{f}	3.91 ^{bcd}	3.86	3.52 ^{abc}
T_{23}	Thiourea (500ppm for 24hours)	5.90	5.34	5.12	4.24 ^{abcde}	4.22 ^{ab}	4.12	3.59 ^{ab}
T_{24}	Thiourea (1000ppm for 24hours)	5.64	5.40	4.81	4.07 ^{bcdef}	3.95 ^{bcd}	3.90	3.49^{abc}
	CD (0.01)	NS	NS	NS	NS	NS	NS	NS
	CD (0.05)	NS	NS	NS	0.50	0.44	NS	0.41

Table 9: Effect of seed treatment with plant growth regulators on seedling dry weight (g) during storage in okra

Treatment		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_0	Control	0.031	0.029	0.028	0.025 ^{ef}	0.025	0.024 ^{abcd}	0.023
T_1	GA_3 (50 ppm for 12 hours)	0.028	0.026	0.027	0.025 ^{ef}	0.024	0.023 ^{abcd}	0.023
T_2	GA_3 (100 ppm for 12 hours)	0.031	0.030	0.029	0.028 ^{abcd}	0.026	0.024 ^{abc}	0.023
T_3	GA_3 (50 ppm for 24 hours)	0.030	0.032	0.030	0.028 ^{abcd}	0.024	0.025 ^{ab}	0.024
T_4	GA_3 (100 ppm for 24hours)	0.033	0.030	0.028	0.027 ^{bcde}	0.026	0.025 ^{ab}	0.023
T_5	IAA (50ppm for 12 hours)	0.031	0.028	0.029	0.027^{abcde}	0.025	0.024 ^{abc}	0.023
T_6	IAA (100ppm for 12 hours)	0.033	0.031	0.029	0.027 ^{bcde}	0.026	0.024 ^{abcd}	0.023
T_7	IAA (50ppm for 24 hours)	0.029	0.027	0.028	0.026 ^{def}	0.024	0.023 ^{abcd}	0.023
T_8	IAA (100ppm for 24 hours)	0.030	0.027	0.026	0.026 ^{ef}	0.026	0.024 ^{abc}	0.024
T_9	NAA (50ppm for 12 hours)	0.029	0.028	0.028	0.026 ^{def}	0.024	0.024 ^{abcd}	0.024
T_{10}	NAA (100ppm for 12 hours)	0.032	0.029	0.030	0.026 ^{cdef}	0.026	0.025 ^{ab}	0.023
T_{11}	NAA (50ppm for 24 hours)	0.031	0.031	0.028	0.028 ^{abc}	0.025	0.024 ^{abc}	0.024
T_{12}	NAA (100ppm for 24 hours)	0.030	0.028	0.029	0.028 ^{ab}	0.026	0.025 ^{ab}	0.023
T_{13}	CCC (100ppm for 12 hours)	0.030	0.031	0.027	0.026 ^{cdef}	0.025	0.024 ^{abcd}	0.024

Treatment		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_{14}	CCC (150ppm for 12 hours)	0.028	0.031	0.028	0.027 ^{abcde}	0.025	0.024 ^{abcd}	0.023
T_{15}	CCC (100ppm for 24 hours)	0.028	0.029	0.026	0.024 ^{f}	0.024	0.023 ^{bcd}	0.022
T_{16}	CCC (150ppm for 24 hours)	0.032	0.032	0.029	0.027 ^{abcde}	0.025	0.024 ^{abcd}	0.023
T_{17}	MH (40 ppm for 12 hours)	0.029	0.029	0.027	0.026 ^{def}	0.025	0.023 ^{cd}	0.022
T_{18}	MH (80 ppm for 12 hours)	0.033	0.031	0.028	0.026 ^{cdef}	0.026	0.022 ^{d}	0.022
T_{19}	MH (40 ppm for 24 hours)	0.031	0.030	0.028	0.026 ^{ef}	0.025	0.023 ^{abcd}	0.023
T_{20}	MH (80 ppm for 24hours)	0.030	0.029	0.026	0.026 ^{cdef}	0.024	0.024 ^{abcd}	0.023
T_{21}	Thiourea (500 ppm for 12hours)	0.031	0.028	0.029	0.027 ^{abcde}	0.025	0.024 ^{abcd}	0.023
T_{22}	Thiourea (1000 ppm for 12hours)	0.029	0.029	0.030	0.029 ^{a}	0.025	0.025 ^{a}	0.023
T_{23}	Thiourea (500 ppm for 24hours)	0.031	0.028	0.028	0.028 ^{abc}	0.026	0.025 ^{ab}	0.024
T_{24}	Thiourea (1000 ppm for 24hours)	0.028	0.030	0.030	0.028 ^{abcd}	0.025	0.025 ^{ab}	0.023
	CD (0.01)	NS	NS	NS	NS	NS	NS	NS
	CD (0.05)	NS	NS	NS	0.002	NS	0.002	NS

In the first month of storage, electrical conductivity of seed leachate was found to be highest in T_{24} (Thiourea at 1000 ppm for 24 h; 264.33 µS/cm), followed by T_{19} (MH at 40 ppm for 24 h; 264 µS/cm), T_{13} (CCC at 100 ppm for 12 h] and control (259.00 µS/cm) which were statistically on par with each other. The least value of seed leachate (195.66 µS/cm) was observed in T_{10} (NAA at 100 ppm for 12 h) which was on par with T_5 (IAA at 50 ppm for 12 h; 209.00 µS/cm).

At the end of storage period, the highest value of electrical conductivity (404.67 µS/cm) was recorded in T_{17} (MH at 40 ppm for 12 h) which was statistically on par with the control (402.33 µS/cm) and the lowest value was in T_8 (IAA at 100 ppm for 24 h) followed by T_3 (343.33 µS/cm), T_4 (345.67 µS/cm) and T_{11} (347.33 µS/cm) (all were on par to each other).

4.2.2.7. Mean Germination Time (days)

It is evident from Table 11 that there was no significant influence of treatment on mean germination time during the initial months of storage (first three months). Significant variation on mean germination time was noticed between fourth and sixth month of storage. A progressive increase in mean germination time with advancement in storage period was observed in all treatments.

At the sixth month of storage, the highest value in mean germination time (4.17 days) was recorded in T_{15} (CCC at 100 ppm for 12 h) which was statistically on par with T_{13} (4.15 days) and T_6 (4.14 days).

Highest mean germination time was recorded at the end of storage period in T_{20} (4.21 days) and the lowest mean germination time was observed at the first month of storage in T_{21} (3.06 days).

Table 10: Effect of seed treatment with plant growth regulators on EC of leachate (µS/cm) during storage period in okra

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_0	Control	259.00 ^{abc}	269.00 ^{abcd}	299.66 ^{abc}	321.33 ^{ab}	345.00 ^{abc}	380.66 ^{a}	402.33 ^{a}
T_1	GA_3 (50 ppm for 12 hours)	244.33 ^{abcdef}	254.33 ^{abcd}	285.66 ^{abcde}	302.33 ^{bcdef}	333.33 ^{abcdef}	370.00 ^{ab}	389.33 ^{abc}
T_2	GA_3 (100 ppm for 12 hours)	241.33 ^{abcdef}	227.33 ^{defg}	257.00 ^{efg}	275.00 ^{ghij}	314.66 ^{efghi}	353.33 ^{bc}	377.33 ^{bcde}
T_3	GA_3 (50 ppm for 24 hours)	253.00 ^{abcde}	255.33 ^{abcd}	266.66 ^{defg}	273.33 ^{hij}	294.33 ^{ijk}	329.33 ^{cde}	343.33 ^{fg}
T_4	GA_3 (100 ppm for 24hours)	245.33 ^{abcdef}	244.33 ^{bcdef}	260.66 ^{efg}	277.33 ^{fghij}	292.33 ^{ijk}	331.66 ^{cde}	345.66 ^{fg}
T_5	IAA (50ppm for 12 hours)	209.00 ^{fg}	229.66 ^{defg}	268.66 ^{cdef}	303.00 ^{bcdef}	329.66 ^{abcdef}	364.33 ^{ab}	390.66 ^{abc}
T_6	IAA (100ppm for 12 hours)	237.00 ^{abcdef}	262.33 ^{abcd}	271.33 ^{bcdef}	294.33 ^{cdefgh}	336.00 ^{abcde}	346.33 ^{bcd}	373.33 ^{cde}
T_7	IAA (50ppm for 24 hours)	223.66 ^{bcdefg}	240.33 ^{cdefg}	257.66 ^{efg}	281.66 ^{defghi}	301.00 ^{hij}	324.33 ^{de}	355.33 ^{efg}
T_8	IAA (100ppm for 24 hours)	231.66 ^{abcdefg}	239.00 ^{cdefg}	236.33 ^{gh}	264.33 ^{ijk}	304.33 ^{ghij}	333.00 ^{cde}	347.33 ^{fg}
T_9	NAA (50ppm for 12 hours)	245.00 ^{abcdef}	254.00 ^{abcde}	270.33 ^{bcdef}	280.33 ^{fghi}	329.66 ^{abcdef}	349.33 ^{bcd}	376.33 ^{bcde}
T_{10}	NAA (100ppm for 12 hours)	195.66 ^{g}	205.00 ^{g}	235.66 ^{gh}	253.00 j^{k}	290.00 ^{jk}	317.00 ^{ef}	348.66 ^{fg}
T_{11}	NAA (50ppm for 24 hours)	220.00 ^{cdefg}	210.00 ^{fg}	223.33 ^{h}	240.33 ^{k}	274.33 ^{k}	297.33 ^{f}	332.66 ^{g}
T_{12}	NAA (100ppm for 24 hours)	223.66 ^{bcdefg}	247.66 ^{abcde}	254.00 ^{fgh}	262.33 ^{ijk}	289.33 ^{jk}	315.33 ^{ef}	348.00 ^{fg}
T_{13}	CCC (100ppm for 12 hours)	263.66 ^{a}	283.66 a	301.00 ^{ab}	321.33 ^{ab}	345.66 ^{ab}	371.33 ^{ab}	403.00 ^{a}

Treatment		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_{14}	CCC (150ppm for 12 hours)	223.66 ^{bcdefg}	257.66 ^{abcd}	279.66 ^{bcdef}	311.00 ^{abc}	343.00 ^{abcd}	379.00 ^{a}	395.66 ^{abc}
T_{15}	CCC (100ppm for 24 hours)	243.66 ^{abcdef}	266.66 ^{abc}	315.33 ^{a}	330.33 ^{a}	352.66 ^{a}	359.00 ^{ab}	383.00a ^{bcd}
T_{16}	CCC (150ppm for 24 hours)	262.33 ^{ab}	250.33 ^{abcde}	273.33 ^{bcdef}	285.00 ^{defghi}	310.33 ^{fghi}	363.00 ^{ab}	382.66 ^{abcd}
T_{17}	MH (40 ppm for 12 hours)	219.33 ^{defg}	233.66 ^{cdefg}	275.00 ^{bcdef}	299.66 ^{bcdefg}	332.33 ^{abcdef}	381.00 ^{a}	404.66 ^{a}
T_{18}	MH (80 ppm for 12 hours)	214.00 ^{efg}	234.00 ^{cdefg}	257.00 ^{efg}	285.66 ^{cdefghi}	303.00 ^{ghij}	361.33 ^{ab}	384.66 ^{abcd}
T_{19}	MH (40 ppm for 24 hours)	264.00 ^{a}	262.66 ^{abcd}	280.00 ^{bcdef}	307.33 ^{abcd}	326.00 ^{bcdefg}	383.33 ^{a}	396.66 ^{ab}
T_{20}	MH (80 ppm for 24hours)	253.66 ^{abcd}	276.66 ^{ab}	298.66 ^{abc}	302.33 ^{bcdef}	321.00 ^{cdefgh}	363.66 ^{ab}	382.33 ^{abcd}
T_{21}	Thiourea (500ppm for 12hours)	245.66 ^{abcdef}	260.33 ^{abcd}	297.66 ^{abcd}	307.00 ^{abcde}	322.00 ^{bcdefgh}	371.00 ^{ab}	393.00 ^{abc}
T_{22}	Thiourea (1000ppm for 12hours)	238.66 ^{abcdef}	242.66 ^{bcdef}	296.66 ^{abcd}	299.33 ^{bcdefg}	326.00 ^{bcdefg}	350.66 b^{c}	365.33 ^{def}
T_{23}	Thiourea (500ppm for 24hours)	213.33 ^{fg}	218.00 ^{efg}	263.33 ^{efg}	281.33 ^{efghi}	304.00 ^{ghij}	351.00 ^{bc}	364.66 ^{def}
T_{24}	Thiourea (1000ppm for 24hours)	264.33 ^{a}	259.00 ^{abcd}	259.66 ^{fg}	283.33 ^{defghi}	319.00 ^{defgh}	361.33 ^{ab}	378.66 ^{bcd}
	CD (0.01)	NS	48.14	41.51	34.48	32.51	34.15	30.693
	CD (0.05)	39.48	36.11	31.14	25.87	24.39	25.62	23.02

Table 11: Effect of seed treatment with plant growth regulators on mean germination time (MGT) during storage period in okra seeds

Treatment		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_0	Control	3.14	3.39	3.57	3.85 ^{ab}	3.94 ^{abc}	4.12 ^{ab}	4.17
T_1	GA_3 (50 ppm for 12 hours)	3.28	3.36	3.47	3.91 ^{a}	3.82 ^{abcd}	3.99 ^{abcdef}	4.06
T_2	GA_3 (100 ppm for 12 hours)	3.18	3.37	3.46	3.83 ^{abc}	3.89 ^{abc}	3.99 ^{abcdef}	4.07
T_3	GA_3 (50 ppm for 24 hours)	3.40	3.34	3.53	3.62 ^{defg}	3.75 ^{bcdef}	3.83 ^{f}	3.97
T_4	GA_3 (100 ppm for 24hours)	3.13	3.31	3.49	3.61 ^{defg}	3.62 ^{defg}	3.88 ^{def}	4.05
T_5	IAA (50ppm for 12 hours)	3.10	3.27	3.59	3.62 ^{defg}	3.92 ^{abc}	4.00 ^{abcdef}	4.13
T_6	IAA (100ppm for 12 hours)	3.24	3.38	3.51	3.69 ^{bcde}	3.99 ^{a}	4.14 ^{ab}	4.22
T_7	IAA (50ppm for 24 hours)	3.24	3.39	3.63	3.81 ^{abcd}	3.90 ^{abc}	4.01 ^{abcdef}	4.11
T_8	IAA (100ppm for 24 hours)	3.15	3.34	3.48	3.58 ^{efg}	3.97 ^{abc}	4.02 ^{abcde}	4.11
T_9	NAA (50ppm for 12 hours)	3.40	3.33	3.63	3.69 ^{bcde}	3.76 ^{bcde}	3.92 ^{cdef}	4.09
T_{10}	NAA (100ppm for 12 hours)	3.15	3.31	3.48	3.49 ^{fg}	3.78 ^{abcde}	3.85 ^{ef}	4.04
T_{11}	NAA (50ppm for 24 hours)	3.17	3.30	3.45	3.54 ^{efg}	3.81 ^{abcd}	3.95 ^{bcdef}	4.09
T_{12}	NAA (100ppm for 24 hours)	3.28	3.43	3.58	3.71 ^{bcde}	3.93 ^{abc}	4.01 ^{abcdef}	4.07
T_{13}	CCC (100ppm for 12 hours)	3.28	3.32	3.53	3.68 ^{bcdef}	3.94 ^{abc}	4.15 ^{a}	4.21

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T14	CCC (150ppm for 12 hours)	3.16	3.35	3.51	3.70 ^{bcde}	3.85 ^{abc}	4.09 ^{abc}	4.18
T_{15}	CCC (100ppm for 24 hours)	3.20	3.27	3.48	3.71 ^{bcde}	3.98 ^{ab}	4.17 ^{a}	4.20
T_{16}	CCC (150ppm for 24 hours)	3.20	3.35	3.57	3.64 ^{defg}	3.88 ^{abc}	4.06 ^{abcd}	4.16
T_{17}	MH (40 ppm for 12 hours)	3.18	3.31	3.59	3.60 ^{efg}	3.77 ^{abcde}	4.07 ^{abc}	4.17
T_{18}	MH (80 ppm for 12 hours)	3.23	3.34	3.63	3.70 ^{bcde}	3.74 ^{cdefg}	4.09 ^{abc}	4.10
T_{19}	MH (40 ppm for 24 hours)	3.15	3.37	3.57	3.64 ^{cdefg}	3.74 ^{cdefg}	4.07 ^{abc}	4.09
T_{20}	MH (80 ppm for 24hours)	3.26	3.41	3.59	3.69 ^{bcde}	3.82 ^{abcd}	4.13 ^{ab}	4.22
T_{21}	Thiourea (500ppm for 12hours)	3.06	3.20	3.52	3.47 ^{g}	3.51 ^{g}	3.96 ^{bcdef}	4.04
T_{22}	Thiourea (1000ppm for 12hours)	3.12	3.29	3.47	3.53 ^{efg}	3.53 ^{fg}	4.04 ^{abcd}	4.08
T_{23}	Thiourea (500ppm for 24hours)	3.14	3.27	3.46	3.62 ^{defg}	3.62 ^{defg}	4.02 ^{abcdef}	4.12
T_{24}	Thiourea (1000ppm for 24hours)	3.13	3.34	3.53	3.55 ^{efg}	3.55 ^{efg}	4.07 ^{abcd}	4.12
	CD (0.01)	NS	NS	NS	0.263	0.295	NS	NS
	CD (0.05)	NS	NS	NS	0.197	0.229	0.188	NS

4.2.2.8 Time taken for 50% germination (days)

Time taken for fifty percent germination was gradually increasing from the first to the last month of storage. But there was no significant treatment influence in this parameter during storage period except in the first month (Table 12)

In the first month more days were taken by T_9 (NAA at 50 ppm for 12 h; 3.87 days), T_1 and T_3 (3.79) days which were statistically on par to each other and the lower values were recorded in T_5 (IAA at 50 ppm for 12 h) which was on par with control (3.68 days)

4.2.2.9. Vigour index I

It is clearly evident from Table 13 that there was a significant difference among the treatments for seedling vigour index I throughout the storage period except during the first month. The table clearly indicates that seedling vigour index gradually declined over the storage period, irrespective of the treatments.

At the end of the storage period, significantly higher values for vigour index I was recorded in T_{11} (NAA at 50 ppm for 24 h; 1407.01) which was statistically on par with T_3 (GA_3 at 50 ppm for 24 h; 1373.85) and T_{10} (NAA at 100 ppm for 12 h; 1367.57), while the control (1143.98) was on par with the least value of 1104.76 (treatment T_{17}).

4.2.2.10. Vigour index II

The seedling vigour index II values obtained from the twenty five treatments over seven months of storage are presented in Table 14. From the table it is evident that seedling vigour index II was found to be non-significant in the initial two months of storage. However significant differences were noticed among the treatments form the third month of storage.

Table 12: Effect of seed treatment with plant growth regulator on time taken for 50% germination during storage in okra

Treatments		1 MAS	2 MAS	3 MAS	4 MAS	5 MAS	6 MAS	7 MAS
T_0	Control	3.68 ^{de}	3.97	4.02	4.32	4.4	4.87	5.25
T_1	GA_3 (50 ppm for 12 hours)	3.79 ^{ab}	3.90	4.01	4.12	4.36	4.94	5.09
T_2	GA_3 (100 ppm for 12 hours)	3.71 ^{bcde}	3.98	4.10	4.22	4.33	5.18	5.27
T_3	GA_3 (50 ppm for 24 hours)	3.79 ^{ab}	3.85	3.95	4.18	4.38	4.66	5.04
T_4	GA_3 (100 ppm for 24hours)	3.71 ^{bcde}	3.85	4.00	4.06	4.28	4.52	4.85
T_5	IAA (50ppm for 12 hours)	3.66 ^{e}	3.87	3.95	4.31	4.45	5.30	5.30
T_6	IAA (100ppm for 2 hours)	3.78 ^{bc}	3.98	4.07	4.20	4.27	5.02	5.24
T_7	IAA (50ppm for 24 hours)	3.72 ^{bcde}	3.87	3.99	4.04	4.26	4.95	5.02
T_8	IAA (100ppm for 4 hours)	3.68 ^{de}	3.97	3.96	3.97	4.33	5.31	5.31
T_9	NAA (50ppm for 12 hours)	3.87 ^{a}	3.89	3.98	4.25	4.27	4.64	4.90
T_{10}	NAA (100ppm for 2 hours)	3.70 ^{cde}	3.93	3.95	4.19	4.33	4.77	5.02
T_{11}	NAA (50ppm for 24 hours)	3.75 ^{bcde}	3.88	3.93	4.16	4.24	4.67	4.86
T_{12}	NAA (100ppm for 24 hours)	3.74 ^{bcde}	3.94	4.11	4.20	4.21	4.66	4.84
T_{13}	CCC (100ppm for 12 hours)	3.78 ^{bcd}	3.95	4.01	4.27	4.46	5.02	5.20
T_{14}	CCC (150ppm for 12 hours)	3.708 ^{cde}	3.93	4.19	4.26	4.41	5.01	5.22

	Treatment	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS	6 MAS	7 MAS
T_{15}	CCC (100ppm for 24 hours)	3.75 ^{bcde}	3.88	3.89	4.26	4.47	5.04	5.27
T_{16}	CCC (150ppm for 24 hours)	3.79 ^{b}	3.94	4.02	4.27	4.41	5.11	5.13
T_{17}	MH (40 ppm for 12 hours)	3.73 ^{bcde}	3.89	3.96	4.26	4.39	4.73	4.94
T_{18}	MH (80 ppm for 12 hours)	3.75 ^{bcd}	3.91	4.05	4.203	4.38	5.29	5.27
T_{19}	MH (40 ppm for 24 hours)	3.73 ^{bcde}	3.93	3.92	4.19	4.45	4.84	5.16
T_{20}	MH (80 ppm for 24hours)	3.77 ^{bc}	3.97	3.93	4.22	4.52	5.22	5.21
T_{21}	Thiourea (500ppm for 12hours)	3.72 ^{bcde}	3.93	3.89	4.08	4.06	4.87	5.11
T_{22}	Thiourea (1000ppm for 12hours)	3.75 ^{bcd}	3.93	3.91	4.15	4.31	5.05	5.21
T_{23}	Thiourea (500ppm for 24hours)	3.76 ^{bcd}	3.92	3.92	4.16	4.29	5.13	5.11
T_{24}	Thiourea (1000ppm for 24hours)	3.77 ^{bc}	3.89	3.93	4.19	4.20	4.97	5.13
	CD (0.01)	0.112	NS	NS	NS	NS	NS	NS
	CD (0.05)	0.087	NS	NS	NS	NS	NS	NS

Table 13: Effect of seed treatment with plant growth regulators on vigour index I during storage in okra

T	Treatment	1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_0	Control	1996	1898 ^{f}	1783 ^{ghi}	1601 ^{hijk}	1448 ^{gh}	1261 ^{lm}	1143 ^{ij}
T_1	GA_3 (50 ppm for 12 hours)	1926	2025 ^{bcdef}	1779 ^{hi}	1657 ^{fghij}	1589 ^{cde}	1387 ^{ghij}	1239 ^{defgh}
T_2	GA_3 (100 ppm for 12 hours)	2102	2006 ^{bcdef}	1863 ^{cdefghi}	1758 ^{bcdef}	1712 ^{ab}	1476 ^{bcdefg}	1260 ^{cdefg}
T_3	GA_3 (50 ppm for 24 hours)	1882	2031 ^{bcdef}	1932 ^{bcde}	1852 ^{ab}	1722 ^{ab}	1530 ^{bcd}	1373 ^{ab}
T_4	GA_3 (100 ppm for 24hours)	2041	2146 ^{ab}	1951 ^{bcd}	1901 ^{a}	1727 ^{ab}	1516 ^{bcde}	1328 ^{abcd}
T_5	IAA (50ppm for 12 hours)	2138	2248 ^{a}	1889 ^{bcdefgh}	1676 ^{fghi}	1527 ^{defgh}	1362 ^{hijkl}	1169 ^{ghij}
T_6	IAA (100ppm for 12 hours)	1948	1949 ^{def}	1831 ^{efghi}	1663 ^{fghi}	1529 ^{defgh}	1430 ^{defghi}	1263 ^{cdef}
T_7	IAA (50ppm for 24 hours)	2015	2059 ^{bcde}	1828 ^{efghi}	1691 ^{efgh}	1577 ^{def}	1430 ^{defghi}	1270 ^{cdef}
T_8	IAA (100ppm for 24 hours)	2169	2031 ^{bcdef}	1817 ^{efghi}	1714 ^{cdefgh}	1587 ^{cde}	1397 ^{fghij}	1307 ^{bcde}
T_9	NAA (50ppm for 12 hours)	1980	1958 ^{cdef}	1795 ^{fghi}	1698 ^{defgh}	1558 ^{defg}	1425 ^{defghi}	1282 ^{bcdef}
T_{10}	NAA (100ppm for 12 hours)	2216	2119 ^{ab}	1999 ^{ab}	1829 ^{abc}	1725 ^{ab}	1570 ^{ab}	1367 ^{ab}
T_{11}	NAA (50ppm for 24 hours)	2162	2131 ^{ab}	2075 ^{a}	1808 ^{abcd}	1818 ^{a}	1672 ^{a}	1407 ^{a}
T_{12}	NAA (100ppm for 24 hours)	2074	2112 ^{abc}	1973 ^{abc}	1794 ^{abcde}	1701 ^{abc}	1560 ^{bc}	1344 ^{abc}
T_{13}	CCC (100ppm for 12 hours)	2000	1907 ^{ef}	1786 ^{ghi}	1737 ^{cdefg}	1581 ^{de}	1412 ^{efghi}	1251 ^{cdefg}

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_{14}	CCC (150ppm for 12 hours)	2085	2027 ^{bcdef}	1766 ^{i}	1575. ^{ijk}	1445 ^{gh}	1300 ^{jklm}	1150 ^{hij}
T_{15}	CCC (100ppm for 24 hours)	2094	2007 ^{bcdef}	1771 ^{i}	1668 ^{fghi}	1577 ^{def}	1455 ^{cdefghi}	1253 ^{cdefg}
T_{16}	CCC (150ppm for 24 hours)	1982	2089 ^{bcd}	1931 ^{bcde}	1697 ^{defgh}	1591 ^{cde}	1352 ^{hijklm}	1205 ^{fghi}
T_{17}	MH (40 ppm for 12 hours)	2161	2117 ^{ab}	1838 ^{defghi}	1563 ^{ijk}	1433 ^{h}	1244 ^{m}	1104 ^{j}
T_{18}	MH (80 ppm for 12 hours)	2169	2128 ^{ab}	1906 ^{bcdef}	1627 ^{ghij}	1528 ^{defgh}	1343 ^{ijklm}	1243 ^{defgh}
T_{19}	MH (40 ppm for 24 hours)	2038	1903 ^{ef}	1821 ^{efghi}	1501 ^{k}	1440 gh	1270 ^{klm}	1142 ^{ij}
T_{20}	MH (80 ppm for 24hours)	2137	2108 ^{abc}	1778 ^{hi}	1542 ^{jk}	1458 ^{fgh}	1348 ^{ijklm}	1220 ^{efghi}
T_{21}	Thiourea (500ppm for 12hours)	2253	2009 ^{bcdef}	1899 ^{bcdefg}	1625 ^{ghij}	1508 ^{efgh}	1378 ^{ghijk}	1221 ^{efghi}
T_{22}	Thiourea (1000ppm for 12hours)	2047	2046 ^{bcdef}	1866 ^{cdefghi}	1621 ^{hij}	1519 ^{efgh}	1448 ^{defghi}	1289 ^{bcdef}
T_{23}	Thiourea (500ppm for 24hours)	2134	2096 ^{abcd}	1959 ^{abc}	1743 ^{bcdef}	1642 ^{bcd}	1500 ^{bcdef}	1305 ^{bcde}
T_{24}	Thiourea (1000ppm for 24hours)	2088	2123 ^{ab}	1993 ^{ab}	1768 ^{bcdef}	1582 ^{cde}	1461 ^{bcdefgh}	1283 ^{bcdef}
	CD (0.01)	NS	209.39	154.67	152.86	158.46	148.83	124.62
	CD (0.05)	NS	157.081	116.04	114.67	118.87	111.65	93.49

Table 14: Effect of seed treatment with plant growth regulators on seedling vigour index II during storage in okra

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T0	Control	2.39	2.18	2.01 efghi	1.80 ghi	1.61 i	1.40 ij	1.33 ijklm
T1	GA_3 (50 ppm for 12 hours)	2.20	2.04	1.98 efghi	1.81 fghi	1.72 defghi	1.45 ghij	1.36 ghijkl
T2	GA_3 (100 ppm for 12 hours)	2.53	2.37	2.10 bcdefgh	1.97 bcde	1.76 abcdefg	1.56 bcdefg	1.35 ghijkl
T3	GA_3 (50 ppm for 24 hours)	2.28	2.56	2.24 abc	2.06 abc	1.81 abcdef	1.65 abc	1.53 abc
T4	GA_3 (100 ppm for 24hours)	2.62	2.38	2.10 bcdefg	1.95 bcdefg	1.85 abcd	1.63 abcd	1.49 abcdef
T5	IAA (50ppm for 12 hours)	2.51	2.46	2.16 bcdef	1.91 cdefghi	1.63 hi	1.47 ghi	1.30 jklm
T6	IAA (100ppm for 12 hours)	2.55	2.29	2.15 bcdef	1.86 efghi	1.68 fghi	1.53 cdefgh	1.40 efghijk
T7	IAA (50ppm for 24 hours)	2.32	2.28	2.08 bcdefghi	1.87 defghi	1.67 ghi	1.51 defghi	1.39 efghijkl
T8	IAA (100ppm for 24 hours)	2.46	2.07	1.89 hi	1.79 ghi	1.71 efghi	1.54 cdefg	1.45 bcdefg
T9	NAA (50ppm for 12 hours)	2.25	2.08	2.05 cdefghi	1.85 efghi	1.68 fghi	1.52 defghi	1.43 cdefgh
T10	NAA (100ppm for 12 hours)	2.67	2.65	2.27 ab	1.97 bcdef	1.83 abcde	1.65 abc	1.52 abcd
T11	NAA (50ppm for 24 hours)	2.69	2.52	2.37 a	2.15 a	1.87 abc	1.73 a	1.58 a
T12	NAA (100ppm for 24 hours)	2.34	2.43	2.23 abcd	2.12 ab	1.88 a	1.68 ab	1.55 ab
T13	CCC (100ppm for 12 hours)	2.37	2.25	1.98 efghi	1.86 efghi	1.66 ghi	1.51 defghi	1.41 defghij

Treatments		1MAS	2MAS	3MAS	4MAS	5MAS	6MAS	7MAS
T_{14}	CCC (150ppm for 12 hours)	2.26	2.45	2.03 ^{defghi}	1.87 ^{defghi}	1.65 ^{ghi}	1.44 ^{ghij}	1.30 ^{klm}
T_{15}	CCC (100ppm for 24 hours)	2.27	2.35	1.91 ^{ghi}	1.75 ^{i}	1.67 ^{ghi}	1.52 ^{defghi}	1.38 ^{efghijkl}
T_{16}	CCC (150ppm for 24 hours)	2.49	2.54	2.16 ^{bcdef}	1.93 ^{cdefghi}	1.73 ^{cdefghi}	1.48 ^{ghi}	1.32 ^{hijkl}
T_{17}	MH (40 ppm for 12 hours)	2.36	2.33	1.96 ^{fghi}	1.80 ^{ghi}	1.61 ^{i}	1.34 ^{j}	1.22 ^{m}
T_{18}	MH (80 ppm for 12 hours)	2.65	2.52	2.16 ^{bcdef}	1.87 ^{defghi}	1.78 ^{abcdefg}	1.42 ^{hij}	1.35 ^{ghijkl}
T_{19}	MH (40 ppm for 24 hours)	2.44	2.29	2.06 ^{cdefghi}	1.79 ^{hi}	1.66 ^{ghi}	1.4 ^{ij}	1.29 ^{klm}
T_{20}	MH (80 ppm for 24hours)	2.41	2.36	1.86 ^{i}	1.86 ^{efghi}	1.72 ^{efghi}	1.48 ^{fghi}	1.37 ^{fghijkl}
T_{21}	Thiourea (500ppm for 12hours)	2.48	2.24	2.14 ^{bcdef}	1.96 ^{bcdef}	1.72 ^{efghi}	1.50 ^{efghi}	1.36 ^{ghijkl}
T_{22}	Thiourea (1000ppm for 12hours)	2.28	2.19	2.12 ^{bcdefg}	2.07 ^{abc}	1.75 ^{abcdefgh}	1.62 ^{abcde}	1.45 ^{bcdefg}
T_{23}	Thiourea (500ppm for 24hours)	2.44	2.22	2.11 ^{bcdefg}	2.06 ^{abc}	1.87 ^{abc}	1.63 ^{abcd}	1.49 ^{abcdef}
T_{24}	Thiourea (1000ppm for 24hours)	2.33	2.37	2.27 ^{ab}	2.02 ^{abcd}	1.75 ^{bcdefgh}	1.61 ^{abcdef}	1.42 ^{defghi}
	CD (0.01)	NS	NS	0.28	0.23	0.18	0.18	0.15
	CD (0.05)	NS	NS	0.21	0.16	0.13	0.13	0.11

Over the months of storage, seedling vigour index II declined gradually. At the end of the storage period, vigour index II value was recorded significantly maximum in T_{11} (NAA at 50 ppm for 24 h; 1.576) which was on par with T_{12} (NAA at 100 ppm for 12 h; 1.55) and T_3 (GA_3 at 50 ppm for 24 h; 1.53), while the minimum was recorded in T_{17} (1.22) and the control was statistically on par with the minimum

4.2.2.11. Seed moisture (%)

Seed moisture was estimated only at the start and end of storage (Table 15). The seeds obtained from the twenty five treatments were dried up to a moisture level of 7% and stored in polythene covers (700 G) under ambient condition.

At the end of the storage period, there was no significant treatment difference in seed moisture content. However there was a slight increase in seed moisture content in all treatments while compared to the values at the start of storage.

4.2.2.12 Seed microflora (%)

The effect of growth regulators on seed microflora was found to be non-significant at the start and the end of the storage period. The per cent of seed infection by seed micro flora increased at the end of storage, irrespective of the treatment effect. The organism observed were *Aspergillus flavus* and *Aspergillus niger* (Table 16)

A. Blotter paper method

B. Agar plate method

Plate 11. Seed micro flora study

Table 15: Seed moisture (%) at the start and end of storage period

Treatments		Initial seed moisture (%)	Final seed moisture (%)
T_0	Control	7.10	7.65
T_1	GA_3 (50 ppm for 12 hours)	7.30	7.53
T_2	GA_3 (100 ppm for 12 hours)	7.13	7.50
T_3	GA_3 (50 ppm for 24 hours)	7.13	7.45
T_4	GA_3 (100 ppm for 24hours)	7.17	7.47
T_5	IAA (50ppm for 12 hours)	7.07	7.54
T_6	IAA (100ppm for 12 hours)	7.17	7.43
T_7	IAA (50ppm for 24 hours)	7.06	7.46
T_8	IAA (100ppm for 24 hours)	7.17	7.47
T_9	NAA (50ppm for 12 hours)	7.10	7.49
T_{10}	NAA (100ppm for 12 hours)	7.10	7.45
T_{11}	NAA (50ppm for 24 hours)	7.16	7.47
T_{12}	NAA (100ppm for 24 hours)	7.13	7.51
T_{13}	CCC (100ppm for 12 hours)	7.10	7.62
T_{14}	CCC (150ppm for 12 hours)	7.17	7.53

Treatments		Initial seed moisture (%)	Final seed moisture (%)
T_{15}	CCC (100 ppm for 24 hours)	7.03	7.53
T_{16}	CCC (150 ppm for 24 hours)	7.13	7.59
T_{17}	MH (40 ppm for 12 hours)	7.20	7.62
T_{18}	MH (80 ppm for 12 hours)	7.10	7.67
T_{19}	MH (40 ppm for 24 hours)	7.06	7.67
T_{20}	MH (80 ppm for 24hours)	7.10	7.39
T_{21}	Thiourea (500 ppm for 12hours)	7.07	7.34
T_{22}	Thiourea (1000ppm for 12hours)	7.03	7.52
T_{23}	Thiourea (500ppm for 24hours)	7.13	7.46
T_{24}	Thiourea (1000ppm for 24hours)	7.10	7.45
	CD (0.01)	NS	NS
	CD (0.05)	NS	NS

Table16: Effect of seed treatment with plant growth regulators on seed micro flora (%) during storage in okra

Treatments		Initial seed micro flora (%)	Final seed micro flora (%)
T0	Control	16.67	43.33
T1	GA_3 (50 ppm for 12 hours)	16.67	40.00
T2	GA_3 (100 ppm for 12 hours)	13.33	36.67
T3	GA_3 (50 ppm for 24 hours)	13.33	33.33
T4	GA_3 (100 ppm for 24hours)	16.67	36.67
T5	IAA (50ppm for 12 hours)	13.33	40.00
T6	IAA (100ppm for 12 hours)	13.33	36.67
T7	IAA (50ppm for 24 hours)	16.67	30.00
T8	IAA (100ppm for 24 hours)	13.33	40.00
T9	NAA (50ppm for 12 hours)	13.33	36.67
T10	NAA (100ppm for 12 hours)	13.33	33.33
T11	NAA (50ppm for 24 hours)	16.67	36.67
T12	NAA (100ppm for 24 hours)	13.33	36.67

Treatment		Initial seed micro flora %	Final seed micro flora %
T13	CCC (100ppm for 12 hours)	16.67	40.00
T14	CCC (150ppm for 12 hours)	20.00	43.33
T_{15}	CCC (100ppm for 24 hours)	16.67	43.33
T_{16}	CCC (150ppm for 24 hours)	16.67	43.33
T_{17}	MH (40 ppm for 12 hours)	16.67	40.00
T_{18}	MH (80 ppm for 12 hours)	16.67	40.00
T_{19}	MH (40 ppm for 24 hours)	13.33	43.33
T_{20}	MH (80 ppm for 24hours)	13.33	43.33
T_{21}	Thiourea (500ppm for 12hours)	13.33	36.67
T_{22}	Thiourea (1000ppm for 12hours)	13.33	40.00
T_{23}	Thiourea (500ppm for 24hours)	16.67	40.00
T_{24}	Thiourea (1000ppm for 24hours)	13.33	36.67
	CD (0.01)	NS	NS
	CD (0.05)	NS	NS

Discussion

5. DISCUSSION

Seed plays a vital role in sustained growth of agriculture since it is the basic and primary material for propagation. The importance of seed has been recognized since time immemorial. Several techniques have been employed to improve the seed yield and quality. Seed treatment with plant growth regulators is one such technology which has consistently proven to improve seed quality.

The results of the present study entitled 'Effect of seed treatments on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench)', conducted at the Department of Seed Science and Technology, College of Horticulture, Vellanikkara is discussed in this chapter with the support of earlier scientific findings

5.1 Experiment 1: Effect of seed treatment with on growth, seed yield and quality.

The result of the study revealed that seed treatment with plant growth regulators exerts significant effect on almost all characters under investigation like plant height, nodes per plant, internode length, branches per plant, days to first flowering, branches per plant, fruits per plant, fruit weight, seeds per fruit, shrivelled seeds per fruit, seed yield per plant and hundred seed weight.

5.1.1 Plant height

Plant growth regulators had significant influence on plant height when compared with control (T_0). The highest plant height was observed in in T_{24} i.e treatment with thiourea 1000 ppm for 24 hours (72.34 cm) which was statistically on par with T_4 (GA_3 at 100 ppm for 24 hours; 64.43 cm), T_{17} (63.93 cm) and T_{21} (60.54 cm).

Application of thiourea, enhanced cell division in plants leading to increased leaf area which increased the net photosynthetic rates as well as the total chlorophyll content in the leaves ultimately leads to increased plant height. Rawat and Makani

(2015) opined that thiourea significantly increases nitrate reductase activity and concentration of soluble proteins, playing a positive role in enhancing nitrogen metabolism.

GA_3 at 100 ppm was statistically on par with thiourea in case of plant height. Increased plant height is due to its effect on cell elongation and multiplication of cells in sub-apical meristem which leads to stem elongation. Increase in plant height by GA_3 application has been reported by Pawar *et al.* (1977), Naruka and Paliwal (2000), and Bhagure and Tambe (2013).

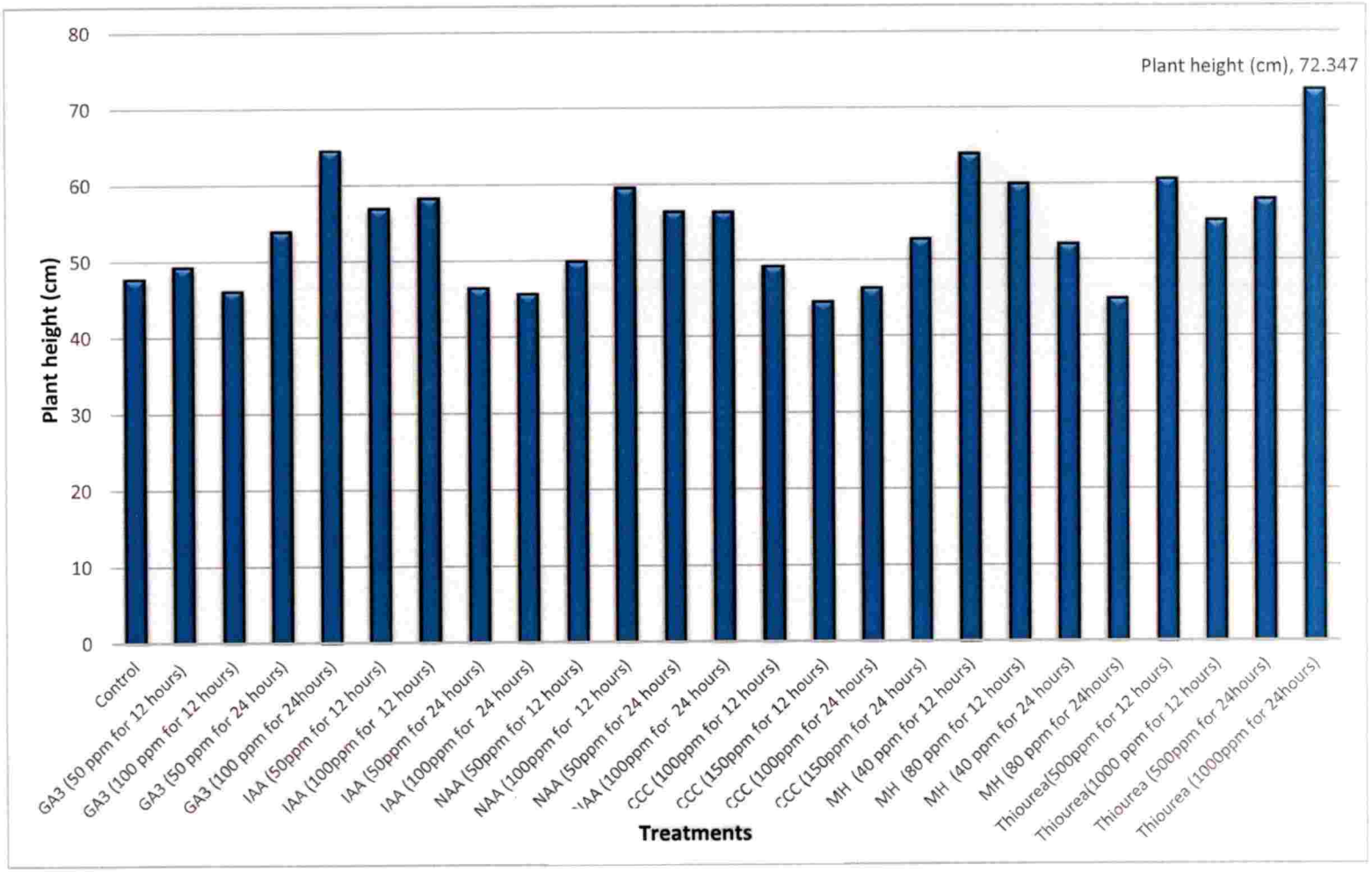
5.1.2 Nodes per plant

The number of nodes per plant varied significantly among the treatments. T_{16} (CCC at 150 ppm for 24 h; 17.06) recorded the highest number of nodes per plant which was on par with T_{15} (16.40) and T_{14} (16.06), while the lowest number of nodes per plant was recorded in T_2 (11.20). The length of internodes decreased with the application of cycocel at high concentrations. The reduced internodal length by restricted cell division, increased the number of internodes, ultimately results in more number of nodes per plant. The results of the present study are in conformity to the reports of Mahorkar *et al.* (2007), Shinde (2010) and Kagwade (2012).

5.1.3. Internode length

Internode length varied significantly among the treatments from 3.99 cm (T_{20}) to 7.15 (T_{24}) cm. The highest value for this trait was recorded in T_{24} (7.15 cm) which was statistically on par with T_{21} (6.34 cm) and T_{23} (6.22 cm). The lowest internode length was recorded in T_{20} (MH at 80 ppm for 24 h; 3.99cm) which was on par with T_{14} (4.24 cm) while the control recorded 5 cm internode length. It is evident from the result that it was the thiourea treatments which had the highest internode length. But

Fig.1 Effect of seed treatment with plant growth regulators on plant height (cm) in okra



the nodes per plant in these treatments were comparatively less (T_{24} had 11.80 nodes/plant), which obviously leads to more internodal length.

Maleic hydrazide and cycocel were effective in suppressing apical dominance which restricts cell division and elongation in the apical meristem which leads to short internodes. Similar results were obtained by Narase and Gowda (1980), Patil *et al*,2008) and Kagwade (2012).

5.1.4. Branches per plant

The treatments significantly varied over control which recorded the least number of branches per plant. Treating seeds with CCC at 150 ppm for 12 hours T_{14} (2.73) recorded the highest number of branches and it was on par with T_{18} (2.60), T_{15} (2.46) and T_{10} (2.40). Control and T_2 recorded least number of branches per plant (1.60). More number of branches per plant in seeds treated with cycocel may be due to its action in suppressing apical dominance and promoting axillary buds and there by more lateral branches. These results are in conformity with the findings of Narase and Gowda (1980), Arora and Dhankar (1992), Bora and Sharma (2006).

5.1.5. Days to first flowering

Days taken for the emergence of first flower varied from 36.26 (T_3) to 40.46 (T_5) days. Among the treatments T_3 (GA_3 50 ppm for 24 h) flowered early at 36.26 days which was statistically on par with T_{17} (37.33), T_2 (37.38) and T_{18} (37.43). Delayed flowering was recorded in treatment T_5 (40.60) and control (40.10).

The application of GA_3 induces early germination and remained physiologically more active to build up adequate food reserves and better mobilization of photosynthates at faster rate. This may be the reason in early transformation from vegetative phase to reproductive phase. This result is in accordance with the findings of Das and Patnaik (1971), Singh and Kumar (1998) and Vijayaraghavan (2000).

5.1.6. Fruits per plant

Among the treatments fruits per plant varied from 9.7 (T_{24}) to 6.46 (T_7). Treatments T_{15} (8.80), T_6 (8.66) and T_{23} (8.60) were on par with T_{24} which recorded the highest value for this trait while the control (7.13) was statistically on par with the lowest number of fruits per plant 6.46 (T_7).

Thiourea could have delayed leaf ageing and senescence and thus enhanced photosynthetic efficiency leading to increase in growth and yield of plants. Thus, thiourea application favourably affected both carbohydrate and nitrogen metabolism, which in turn enhanced plant performance. Similar findings was reported by Mathur *et al.* (2006) in mung bean. Exogenous application of thiourea stimulated the effect of natural occurring hormones that accelerated and modified the growth and development of plants. Similar results were also reported by Sharma and Singh (2004), Yadav *et al.* (2004) and Burman *et al.* (2006) in cluster bean.

5.1.7. Fruit length

The data pertaining to fruit length revealed that there exists a significant difference among the treatments for the trait fruit length. The mean fruit length varied from 15.29 cm (T_{17}: MH at 40 ppm for 12 h) to 21.69 cm (T_4: GA_3 (100 ppm for 24 h). Treatments T_3 and T_{24} had also recorded higher values for this trait. Lower values were recorded in T_{17} (15.29 cm) T_{19} (15.52 cm) and T_{20} (15.72 cm).

Higher fruit length in GA_3 treatments may due to the result of cell elongation and cell enlargement by the supply of growth regulators within the plant. Similar results were observed by Pawar *et al.* (1977), Singh and Kumar (1998) and Patil and Patel (2010).

5.1.8 Fruit weight

Mean fruit weight varied among the treatments from 15.24 g (T_{19}: MH at 40 ppm for 24 h) to 21.56 g (T_{11}: NAA at 50ppm for 24 h). Other significant treatments include T_{12} (21.29 g), T_3 (21.21 g) and T_4 (21.18 g) while the control recorded a fruit weight of 17.30 g. Treatments T_{19} (15.24 g), T_{20} (15.83 g) and T_{17} (16.34 g) recorded the least values. Higher fruit weight in seed treated with NAA may be due to greater mobilization of reserved food materials to the fruit and seed i.e. more than enough carbohydrates synthesized for vegetative growth is diverted to reproductive growth. These findings were in line with Pawar *et al.* (1977), Naruka and Paliwal (2000) and Prasad *et al.* (2013)

5.1.9. Estimated fruit yield

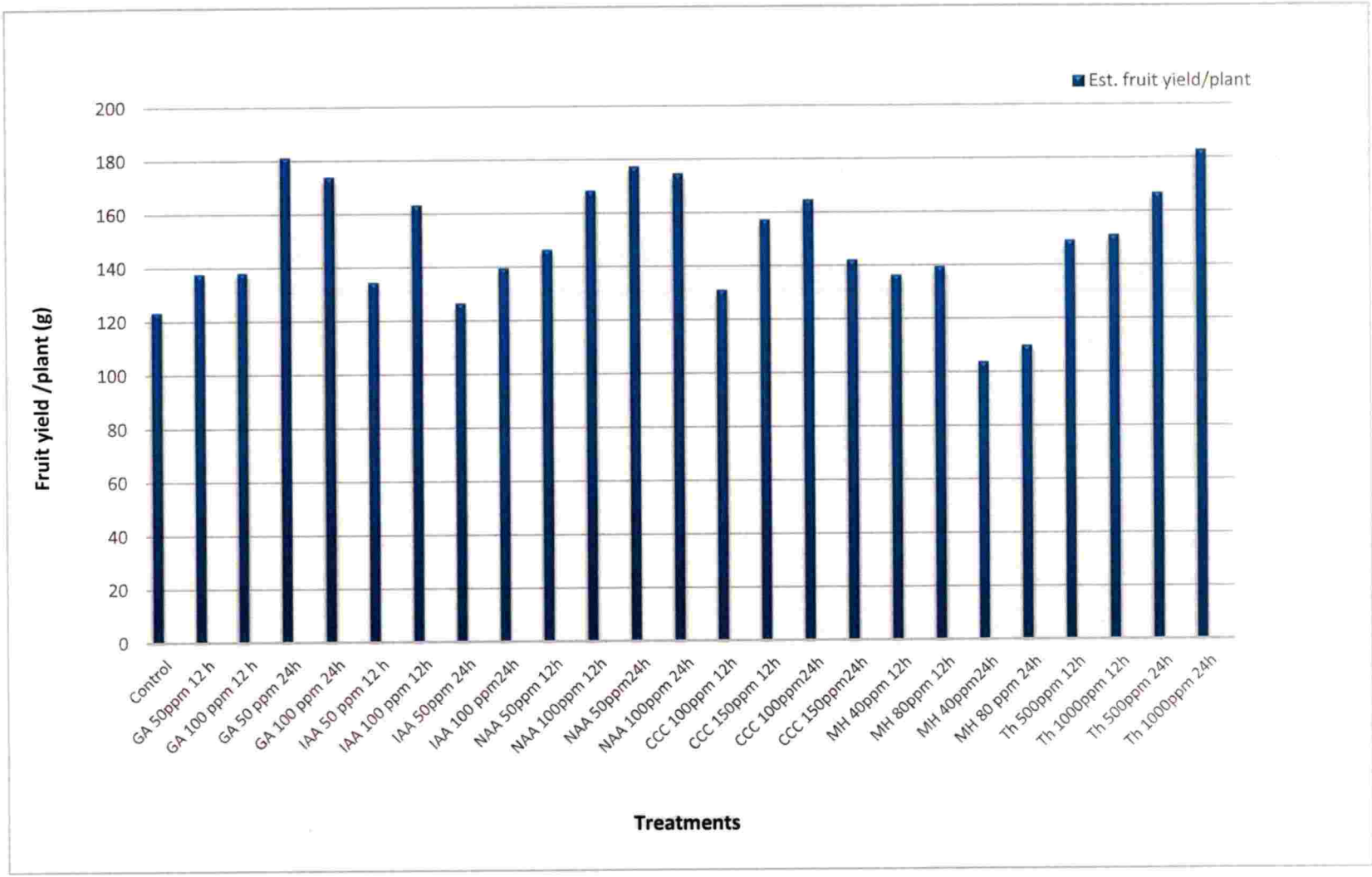
The higher values for the parameter estimated fruit yield was recorded in T_{24} (Thiourea 1000 ppm for 24 h) which was on par with T_{11}, T_3, T_4, T_{12} and all other treatments of thiourea. While control (123.28 g) was statistically on par the lower value 103.75 g (T19).

Thiourea could have delayed leaf ageing and senescence and thus enhanced photosynthetic efficiency leading to increase in growth and yield of plants. Thus, thiourea application favourably affected both carbohydrate and nitrogen metabolism, which in turn enhanced plant performance. Similar findings was reported by Mathur *et al.* (2006) that application of thiourea enhanced pod and seed yield of mung bean. In case of GA_3 and NAA the effective mobilization of the higher amount of photosynthates produced and the accelerated reproductive phase ultimately resulted in more fruit yield.

5.1.10. Seeds per fruit

Among the treatments, the mean number of seeds per fruit varied from 36.60 (T_{19}) to 55.86 (T_4). The highest of seeds per fruit was noticed in T_4 (55.86) which was

Fig.2 Effect of seed treatment with plant growth regulators on fruit yield per plant in okra



on par with T_{12} (54.80) and the least number of seeds per fruit was in T_{19} (36.60). Meanwhile the number of seeds per fruit in control was 41.73.

Average number of seeds per fruit were significantly higher in GA_3 at 100 ppm for 24 hours (T_4) and NAA at 50 ppm for 12 hours(T_{10}) than the control. This may due to the effective mobilization of the higher amount of carbohydrate produced and the accelerated reproductive phase which ultimately resulted in more number of seeds. Similar results were obtained by Munda *et al.* (2000), Kishan *et al.* (2001) and Patil *et al.* (2008).

5.1.11. Shrivelled seeds per fruit

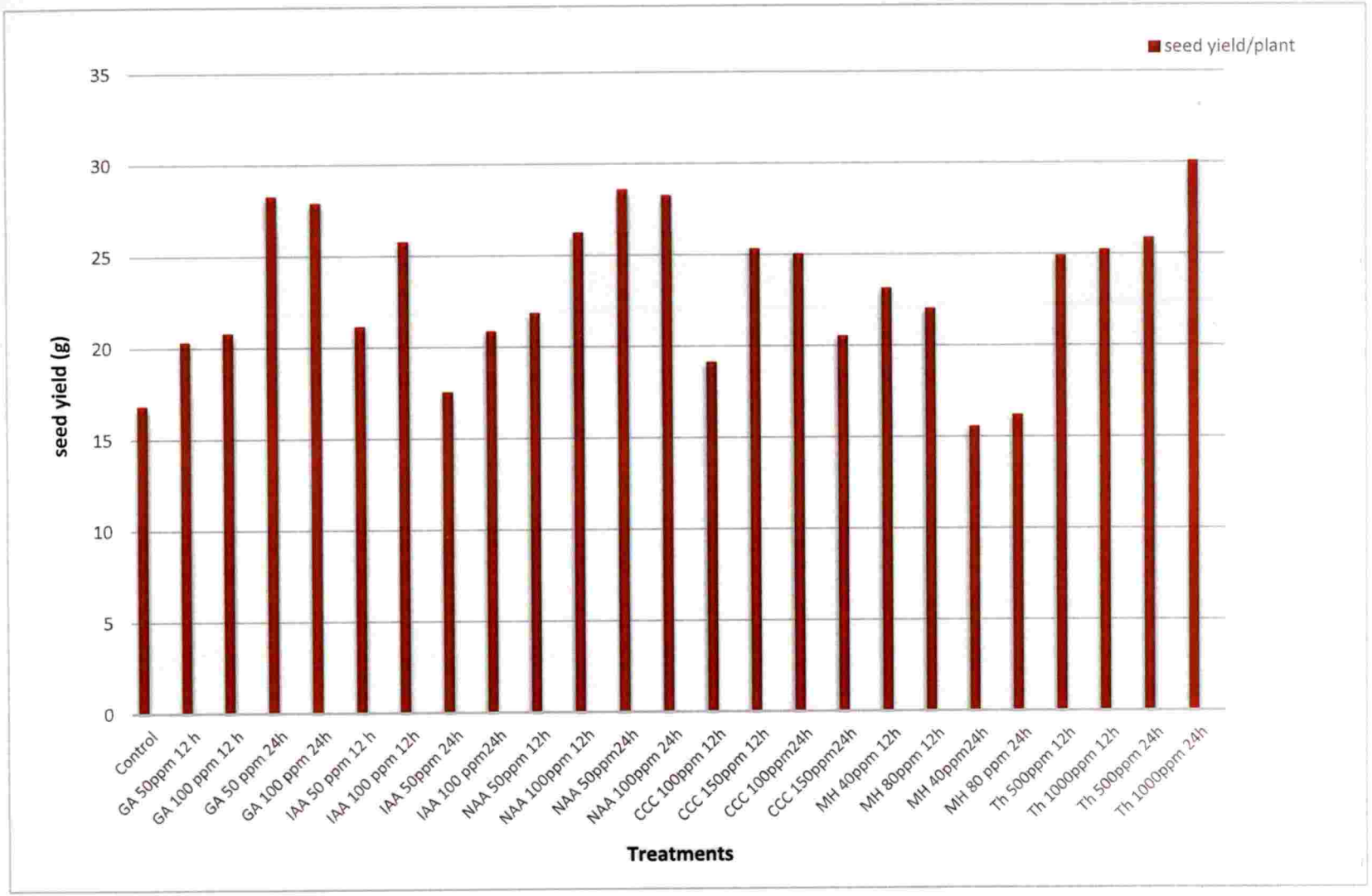
The average shrivelled seeds per fruit ranged from 5.26 (T_{13} and T_{18}) to 7.86 (T_4). The shriveled seeds per fruit was found to be lowest in T_{13} (CCC at 100 ppm for 12 h) and T_{18} (5.26) [Narase and Gowda (1980)]. Significantly higher shriveled seeds per fruit was observed in T_4 (7.86) which was statistically on par with T_3, T_{23} (7.73), T_{24} (7.53), T_{22} (7.33), T_{21} (7.20), T_1 (7.13) and T_8 (6.86).

5.1.12. Seed yield per plant (g)

There were significant differences among the treatments for this character. The mean seed yield per plant varied from 15.52 g (T_{19}) to 30.06 g (T_{24}). The highest seed yield per plant was obtained from T_{24} (Thiourea at 1000 ppm for 24 h; 30.06 g) which was statistically on par with treatments T_{11} (NAA at 50ppm for 24 h), T_3 (GA_3 at 50 ppm for 24 h) and T_{12} (NAA 100ppm for 24 h) recorded a seed yield per plant of 28.58 g, 28.25 g and 28.24 g respectively.

Higher seed yield in thiourea could have been due to delayed leaf ageing and senescence and enhanced photosynthetic efficiency which leads to increase in growth and yield of plants. Thus, thiourea application favorably affected both carbohydrate

Fig.3 Effect of seed treatment with plant growth regulators on seed yield per plant (g) in okra



and nitrogen metabolism, which in turn enhanced plant performance. Similar findings were reported by Mathur *et al.* (2006) that application of thiourea enhanced seed yield of mung bean. The increased yield in NAA may due to greater mobilization of photosynthates to fruit and seeds.

5.1.13. Hundred seed weight (g)

The average 100 seed weight ranged from 5.71 g (T_{16}) to 6.62 (T_{17}) g. The treatments T_{17} (MH at 40 ppm for 12 hours; 6.62 g) and T_{11} (6.54 g) were on par with each other, while the lowest was recorded in T_{16} (5.71 g) which was on par with T_{13} (5.79 g). This might due to higher per cent of bold seeds coupled with increased translocation of food reserves from source to sink (seed). The favourable effect of cycocel is in conformity to the findings of Vijaykumar *et al.* (1988).

5.2. Experiment 2: Seed quality assessment during storage.

Quality seed is the most strategic resource for higher production and productivity and this quality can be assessed by several seed quality parameters. One of the most basic needs for higher productivity is the seed quality which is characterized by vigour and viability of the seed. The results of the seed storage study are discussed here under:

5.2.1. Initial seed quality assessment in okra.

It was clearly evident from the result, that there was no significant treatment effect (effect of growth regulators as seed treatment) on initial seed quality parameters of freshly harvested seeds except seedling shoot length.

Higher values for seedling shoot length was recorded in T_8 (NAA at 50 ppm for 12 hours; 21.21 cm) which was statistically on par with T_{21} (20.99 cm) and T_{10} (20.91 cm), while the least value for seedling shoot length was observed in T_1 (19.61

cm) which was statistically on par with the control (20.17 cm). Similar results were obtained by Premchand *et al.* (2013).

5.2.2. Seed quality assessment during storage

Results obtained from the seed quality parameters recorded at monthly intervals for seven months of storage revealed that, there existed significant differences among the various growth regulator treatments for seed quality parameters such as germination per cent, seedling shoot length, seedling root length, seedling dry weight, seedling vigour index I and II, mean germination time, time and electrical conductivity of seed leachate.

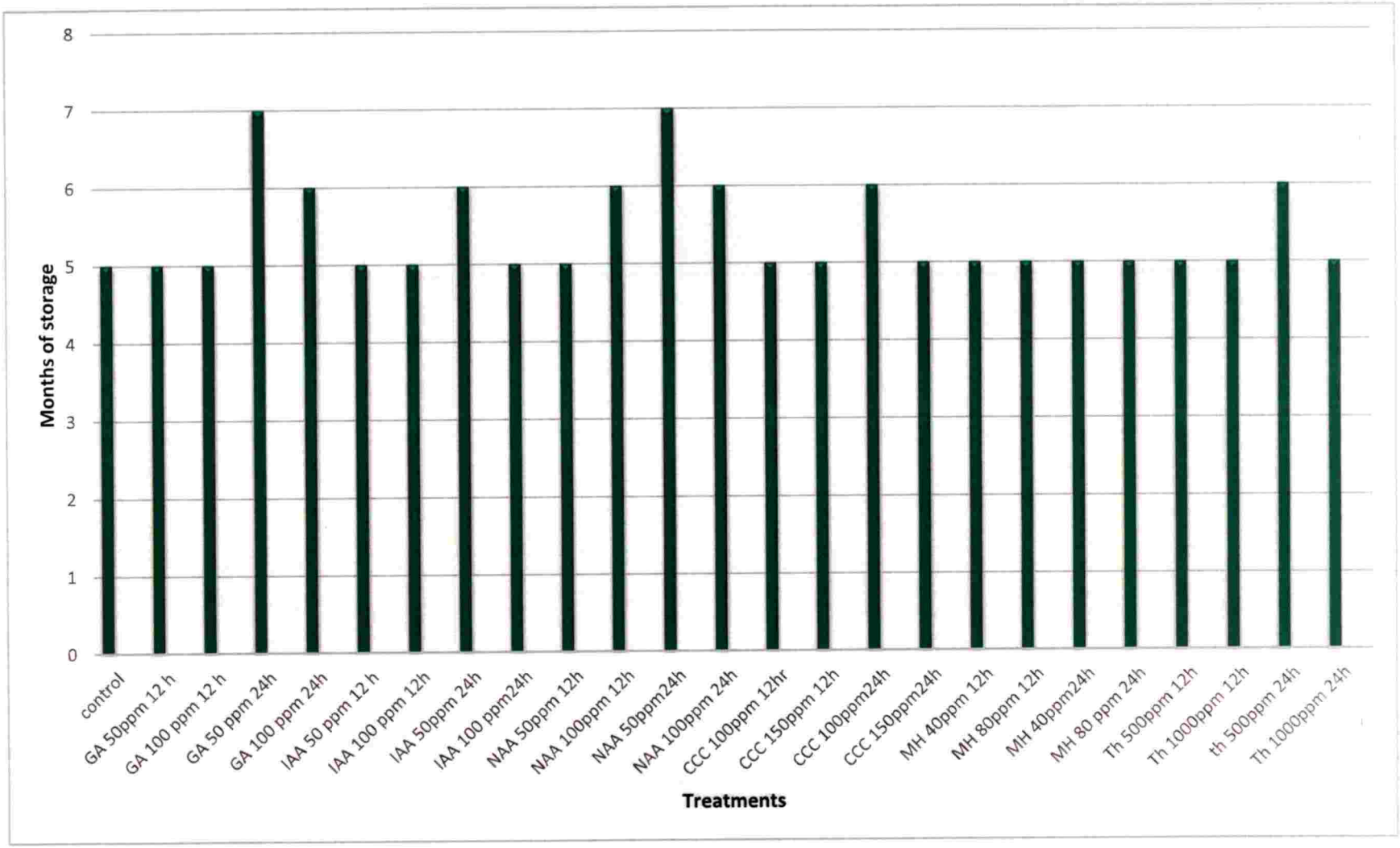
5.2.2.1. Germination (%)

Significant treatment differences were observed in germination per cent from second month onwards to the last month of storage (seventh month). During the course of storage, irrespective of treatments the germination per cent declined gradually with the advancement of storage. Such gradual and accelerated loss were also reported by Navya (2016) and Sandhya (2016) in chilli, Shobha (2016) in ash gourd and Nagendra (2017) in oriental pickling melon.

At the end of storage period (seventh month), T_{11}(NAA at 50 ppm for 24 hours) exhibited the highest germination per cent (66.66%) and which was significantly on par with T_3 (GA_3 at 50 ppm for 24 hours; 64.66%). So, at the end of the storage period only these two treatments (T_{11} and T_3) retained the minimum seed certification standard of okra (65%).

All treatments including the control maintained the MSCS (Minimum Seed Certification Standard) of 65 per cent up to fifth month of storage. In the sixth month the germination percent ranged between 60 per cent and 70 per cent and in the last month all the treatments except T_{11} and T_3 declined below MSCS.

Fig.4 Effect of seed treatment with growth regulators on seed longevity



It is clearly evident from the result that exogenous application of GA_3 and NAA in experiment 1 resulted in the production of quality seeds with high germination percent even in the last month of storage. Similar findings were reported by Sultana *et al.* (2006), Bhagure and Tambe (2013) and Premchand *et al.* (2013)

5.2.2.3. Seedling shoot length (cm)

Seedling shoot length exhibited significant differences among the treatments from third month of storage to sixth month of storage. In third month of storage, significantly higher shoot length was observed in T_{23} (Thiourea at 1000 ppm for 12 h; 21.73 cm) which was statistically on par with T_{10} (NAA at 100 ppm for 12 h; 21.26 cm), T_{24} (Thiourea at 1000 ppm for 24 h; 21.18 cm).

At six months of storage higher seedling shoot length of 19.96 cm was recorded in T_{11} (NAA at 50 ppm for 24 h) which was statistically on par with T_{10} (19.66 cm) and T_4 (GA3 at 100 ppm for 24 h; 19.25 cm). The control (17.62 cm) was statistically on par with the lowest seedling shoot length of 17.43 cm in T17.

Increased shoot length in treatments of NAA and GA_3 in the last month of storage might be due to the enhancement of seed quality in the seed produced by the application of these growth regulators in field experiment. Supporting findings were made by Premchand *et al.* (2013), Priyanka *et al.* (2008), Yogananda *et al.* (2004)

5.2.2.4. Seedling root length (cm)

The seedling root length exhibited significant treatment effects in the fourth, fifth and the last month of storage (seventh month). A gradual decline can be found in the seedling shoot length with the advancement of storage period. This gradual decline were observed in the findings of Aswathi (2015) in cowpea. It might be due to decline in seedling vigour over the storage period as the seeds starts to ageing. Similar results were observed by Shobha (2016)) and Nagendra (2017).

At the end of storage period, T_2 (GA_3 at 100 ppm for 12 h) recorded the highest seedling root length of 3.75 cm which was on par with T_{10} (3.64 cm) and T_4 (3.60 cm) while the treatment T_{19} (MH at 40 ppm for 24 h; 2.97 cm) recorded the least value for this character which was statistically on par with the control (3.31 cm).

All other treatments deteriorated including control at the end of storage, while treatments of GA_3 and NAA had a high vigour while comparing with other treatments. This might be the reason for increased root length in T_2, T_{10} and T_4. The results were in agreement with the findings of Yogananda *et al.* (2004), Priyanka *et al.* (2008),) and Premchand *et al.* (2013).

5.2.2.6. Seedling dry weight (g)

Significant influence of growth regulators on seedling dry weight was less. Over seven months of storage significant influence of treatments was noted only in fourth and sixth month of storage.

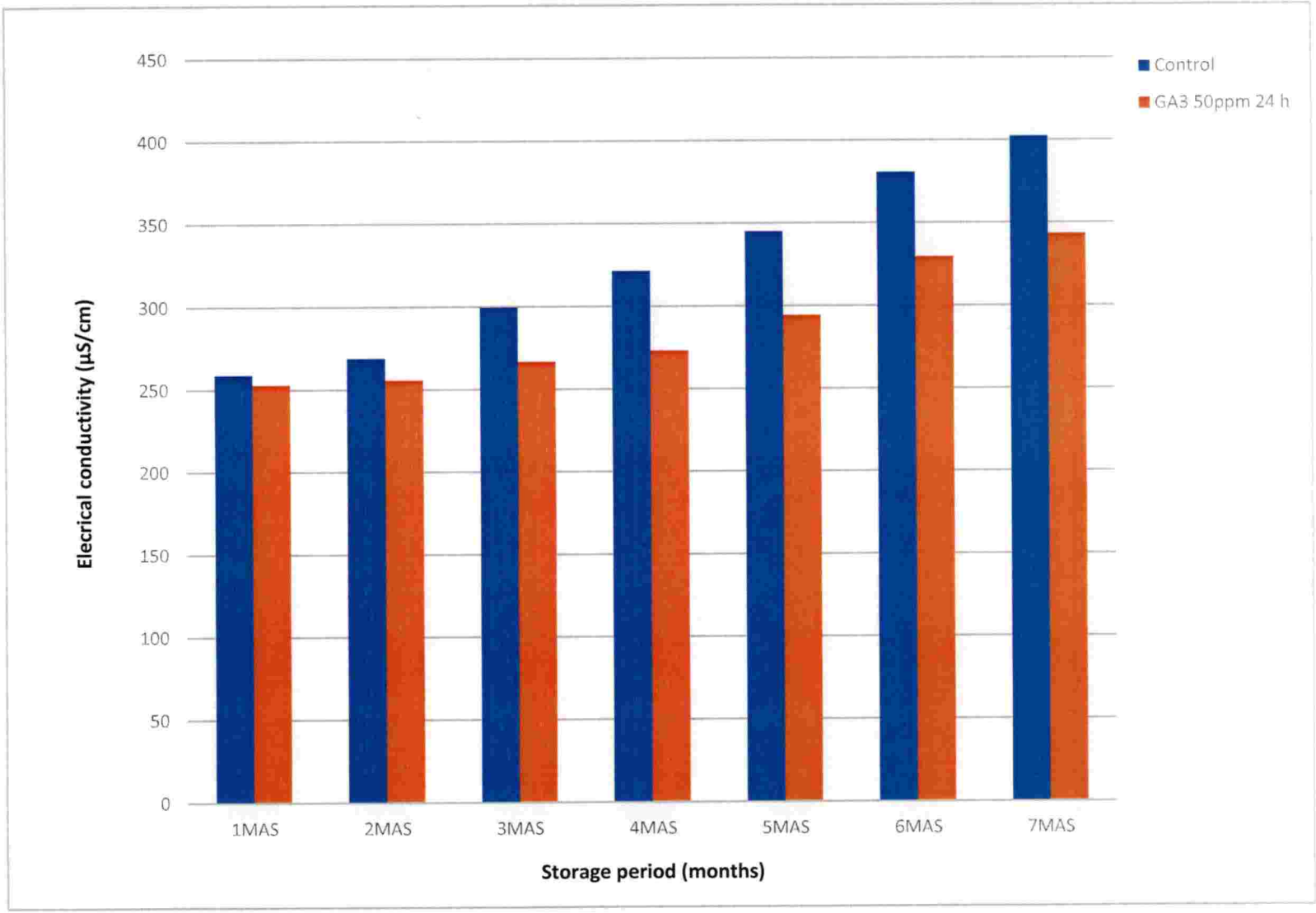
Irrespective of treatment effect, seedling dry weight was found to be declining over the period of storage. Similar observations were by Navya (2016) and Sandhya (2016) in chilli and Shobha (2016) in ash gourd.

The maximum seedling dry weight (0.033 g) was recorded at the first month of storage in T_4 (GA_3 at 100 ppm for 24 hours), T_6 (IAA at 100 ppm for 12 h) and T_{18} (MH at 80 ppm for 12 h). These findings were in line with Yogananda *et al.*, (2004) and Rawat and Makani. (2015)

5.2.2.6. Electrical conductivity (µS/cm)

The electrical conductivity of seed leachate was found to be significantly influenced by the treatments throughout the period of storage. Over the period of storage, seed leachate was found to increase gradually irrespective of the treatments.

Fig.5 Effect of seed treatment with GA_3 over the control on EC of leachate (µS/cm) during storage in okra



At the end of storage period, the highest value of electrical conductivity (404.67 µS/cm) was recorded in T_{17} (MH at 40 ppm for 12 h) which was statistically on par with the control (402.33 µS/cm) and the lowest value was in T_8 (IAA at 100 ppm for 24 h) followed by T_3 (343.33 µS/cm), T_4 (345.67 µS/cm) and T_{11} (347.33 µS/cm) (all are on par to each other).

Increased electrical conductivity in T_{17} (MH at 40 ppm for 12 h) may indicate low seed vigour. Poor membrane structure and leaky cells are usually associated with low vigour seeds results in a greater loss of electrolytes such as amino acids and organic acids from imbibing seeds and increased conductivity of seed leachates (Matthews and Brandnock, 1967). The lower values were in T_8, T_3 and T_4 which are expected to have high vigour. The result of the present study agrees with the findings of Satheeshkumar (2005).

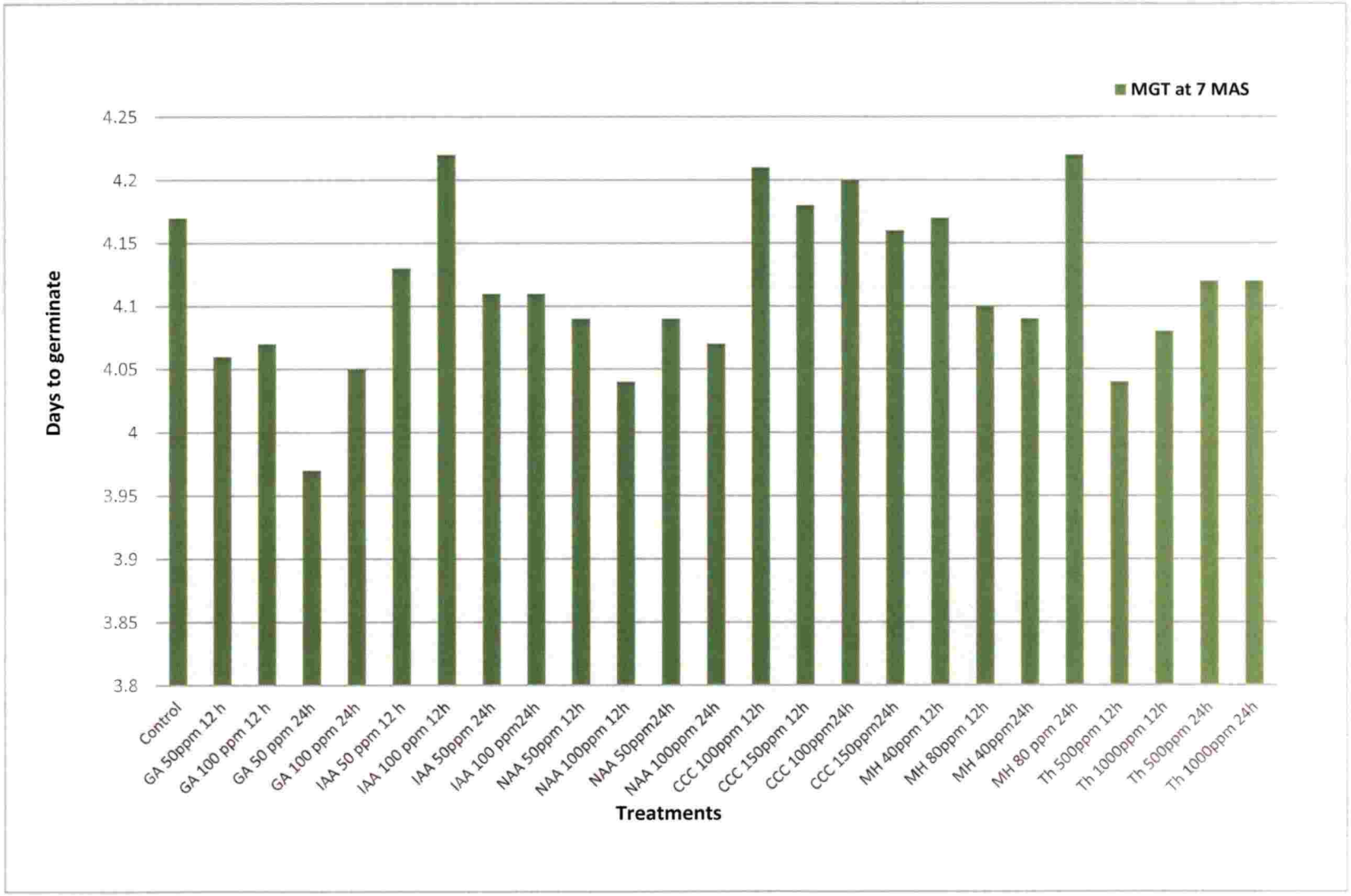
5.2.2.7. Mean Germination Time (days)

There was progressive increase in mean germination time in all the treatments with advancement in storage period. Similar observations was recorded by Nagendra (2017). At the sixth month of storage, the highest value in mean germination time (4.17 days) was recorded in T_{15} (CCC at 100 ppm for 12 h) which was statistically on par with T_{13} (4.15 days) and T_6 (4.14 days). It indicates that treatments T_{15}, T_{13} and T_6 takes more time to achieve mean germination which implies loss in vigour at the end of storage.

5.2.2.8 Time taken for 50% germination (days)

Time taken for fifty percent germination was gradually increasing from the first month of storage to the last month of storage. Progressive rise was observed in all

Fig.6 Effect of seed treatment with plant growth regulators on mean germination time (MGT) during storage in okra



treatments for this parameter with increase in storage period. Such gradual rise in this trait also reported by Nagendra (2016) in oriental pickling melon. However, there was no significant differences among treatments during storage period except the first month.

In the first month more days were taken by T_9 (NAA at 50 ppm for 12 hours; 3.87 days), T_1 and T_3 (3.79) days which were statistically on par to each other and the lower value was recorded in T_5 (IAA at 50 ppm for 12 h) which was on par with control (3.68 days).

5.2.2.9. Vigour index I

It is clearly evident from the result that there was a significant difference among the treatments for seedling vigour index I throughout the storage period except during the first month. Seedling vigour index gradually declined over the storage period, irrespective of the treatments. Similar observations are made by Narwal *et al.* (1998)

At the end of the storage period, significantly higher values for vigour index I was recorded in T_{11} (1407.01) which was statistically on par with T_3 (1373.85) and T_{10} (1367.57), while the control (1143.98) was on par with the least value of 1104.76 recorded in treatment T_{17}. These results are in conformity with the findings of Sultana *et al.* (2006) and Premchand *et al.* (2013)

5.2.2.10. Vigour index II

From the table it was evident that seedling vigour index II was found to be non-significant in the initial two months of storage. However significant differences were noticed among the treatments from the third month of storage.

Over the months of storage, seedling vigour index II declined gradually. Similar findings were made by Narwal *et al.* (1998). At the end of the storage period, vigour index II value was recorded significantly higher in T_{11} (1.576) which was on par with

Fig.7 Effect of seed treatment with plant growth regulators on vigour index I at the end of storage period in okra

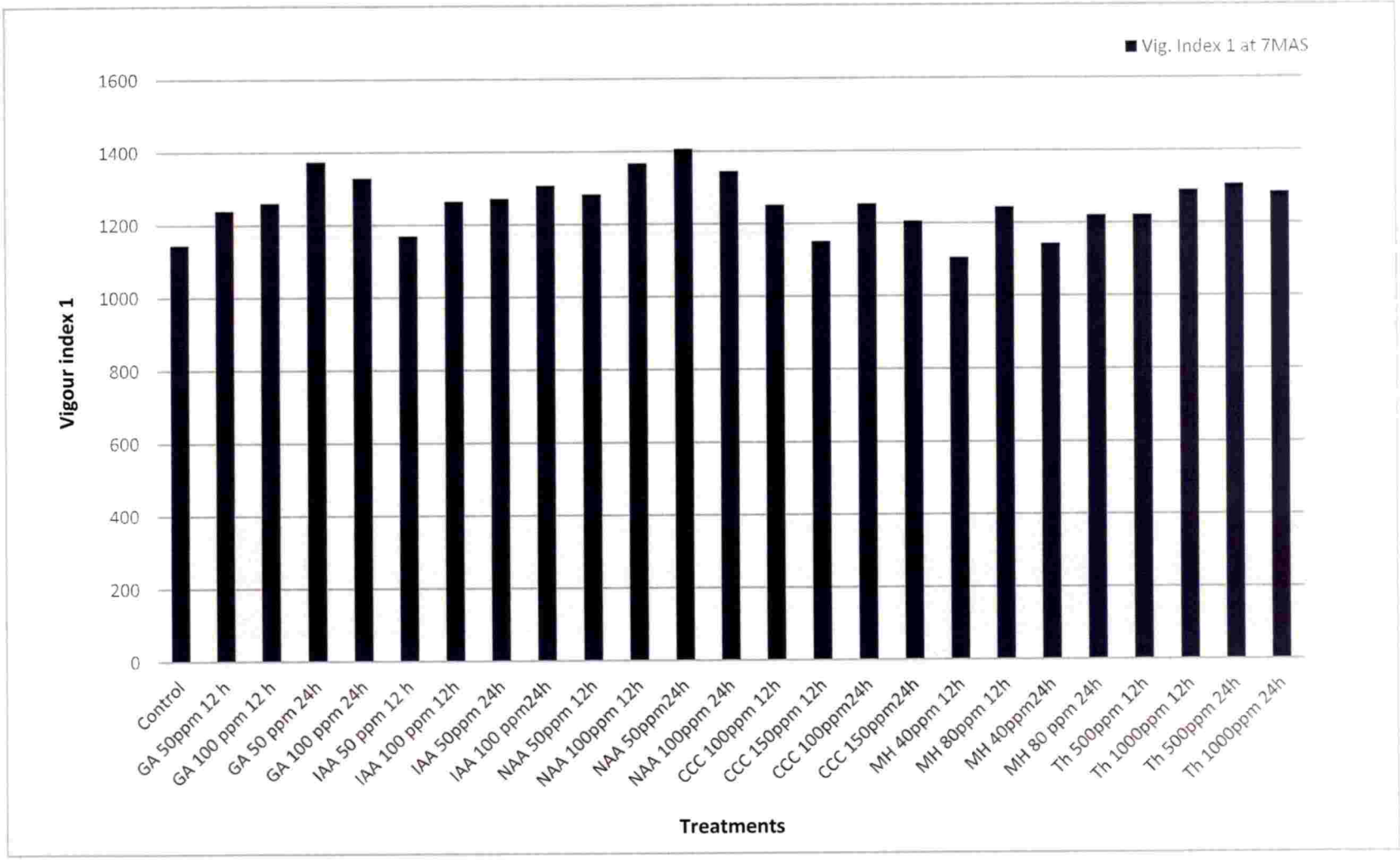
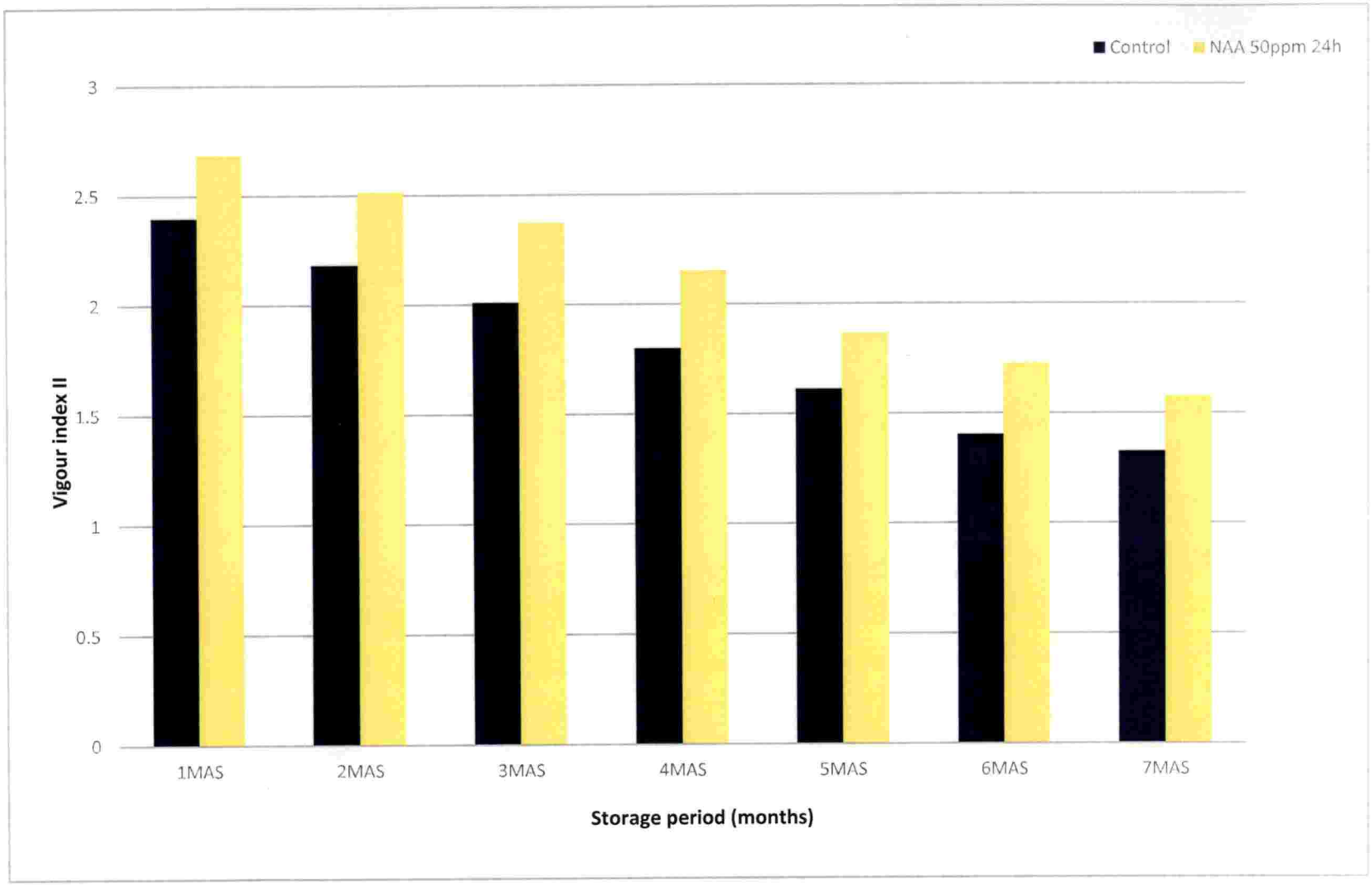


Fig.8 Effect of seed treatment with NAA on seedling vigour index II over the control during storage in okra



T_{12} (1.55) and T_3 (1.53), while the minimum was recorded in T_{17} (1.22) and the control was statistically on par with the minimum. Similar findings were observed by Sultana *et al.* (2006) and Premchand *et al.* (2013).

5.2.2.11. Seed moisture (%)

Seed moisture was estimated only at the start and end of the storage period. At the end of storage period, there was no significant treatment on seed moisture but there was a slight increase in seed moisture in all the treatments while comparing with the seed moisture at the start of storage month. The moisture content plays a key role in amplifying fungal biomass during storage period.

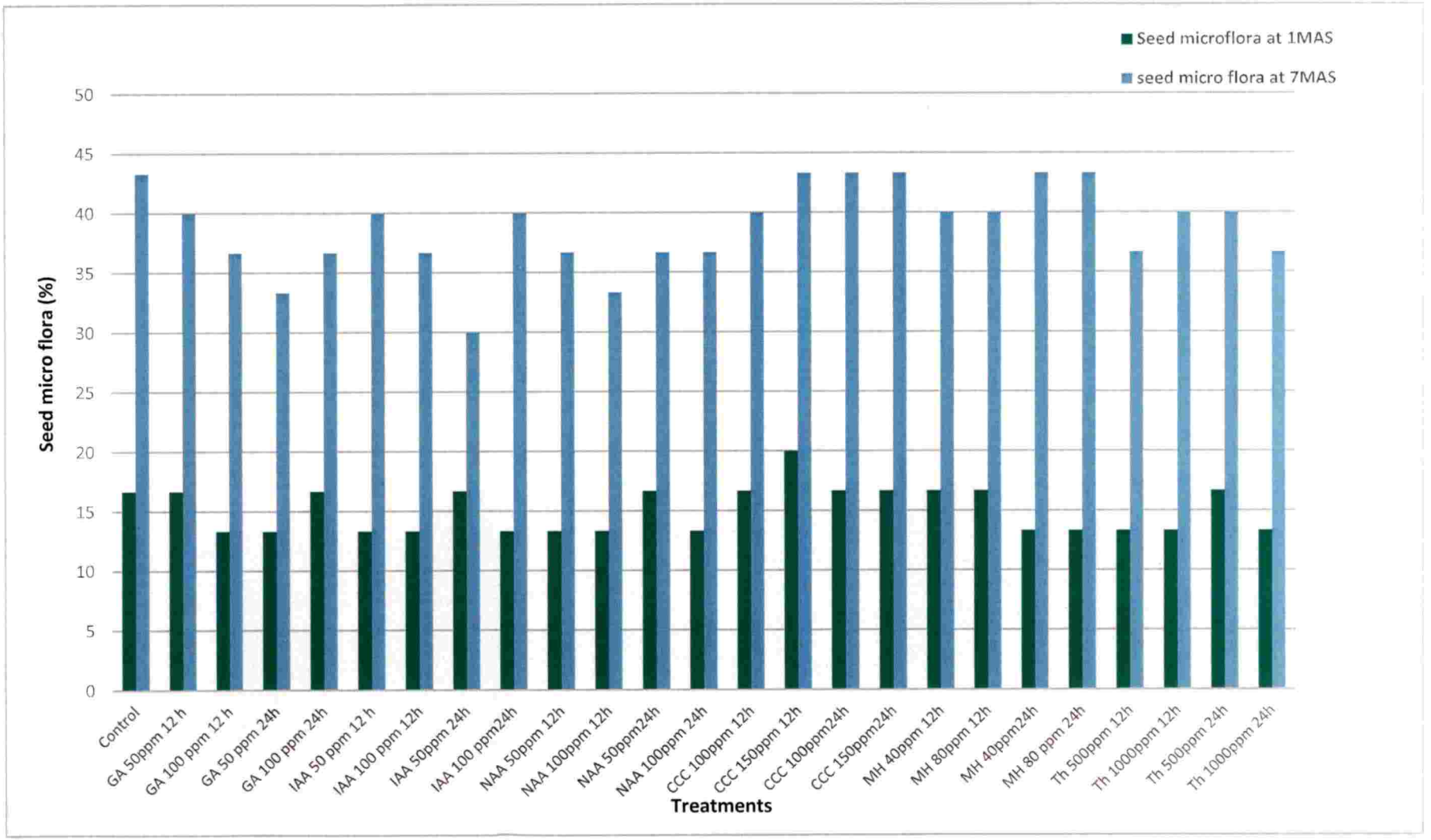
5.2.2.12 Seed microflora (%)

The effect of growth regulators on seed microflora was found to be non-significant at the starting and the end of the storage period. But the percent of seed infection by seed micro flora was increased at the end of storage period, irrespective of the treatment effect. The most commonly infected seed storage fungi were *Aspergillus niger, Aspergillus flavus,* and *Pencillum spp.* Similar results were obtained by Kononkov and Dudina (1986) in tomato, Sandhya (2016) in chilli and Nagendra (2017) in oriental pickling melon.

5.2.3. Scoring and ranking

The treatments undertaken in the present study were each effective for a few of the characters studied. Hence in order to identify treatments effective for improving seed yield and seed longevity ranking was undertaken for all the traits in experiment I and for seed germination and seed vigour index I of experiment II. For each character the genotypes were ranked in descending order except for days to first flowering and shriveled seeds per pod where the treatments were ranked in ascending order. The total score for each treatment was arrived at by summing up the ranks obtained for all the fourteen characters studied.

Fig.9 Effect of seed treatment with plant growth regulators on seed micro flora (%) during storage in okra



The score obtained from the table 17 clearly indicates that the growth parameters which influence vegetative growth, flowering, fruit development and subsequently leads to fruit yield (Rank I) were found to be best in treatment T_{24} (Thiourea at 1000 ppm for 24 hours) followed by T_3 (GA_3 at 50 ppm for 24 hours), T_4 (GA_3 at 100 ppm for 24 hours), T_{10} (NAA at 100 ppm for 12 hours) and T_{11} (NAA at 50 ppm for 24 hours).

Based on the score for seed yield and seed quality parameters (Rank II) treatment T11 (NAA at 50 ppm for 24 hours) was considered the best followed by T_{12} (NAA at 100 ppm for 24 hours), T_3 (GA_3 at 50 ppm for 24 hours, T_{10} (NAA at 100 ppm for 12 hours) and T_{24} (Thiourea at 1000 ppm for 24 hours).

The total score by summing up the ranks obtained for all the fourteen characters studied for each treatment reveals that, the growth, yield and seed quality of okra was best in T_{11} (NAA at 50 ppm for 24 hours) which was followed by T_3 (GA_3 at 50 ppm for 24 hours), T_{10} (NAA at 100 ppm for 12 hours),T_{24} (Thiourea at 1000 ppm for 24 hours) and T_4 (GA_3 at 100 ppm for 24 hours).It was noticed that all the superior treatments were subjected to a soaking period of 24 hours.

Seed treatment with thiourea at 1000 ppm for 24 hours could maintain the MSCS level (65 %) only for five months of storage, even though it was found best in increasing the growth parameters and fruit yield. While seed treatment with NAA and GA_3 at 50 ppm for 24 hours not only increased the growth and yield of okra but also enhanced the seed quality and longevity for a period of seven months in storage. Hence it can be concluded that seed treatment with NAA and GA_3 at 50 ppm for 24 hours is more effective in improving seed yield and quality in okra.

Table.17 Scoring and Ranking of growth regulators based on growth, yield and quality in okra

Treatment	Parameters on growth and fruit yield										Seed yield and seed quality parameters						
	Plant height	Nodes/ plant	Internode length	Branches/ Plant	Days to 1st flowering	Fruits/ Plant	Fruit length	fruit wt	Est fruit yld	total 1	seeds/ fruit	seed yield	100 seed wt	germ 7th	vig 1 7th	total 2	total
T_0	19	16	18	25	21	18	17	21	23	178	22	23	23	24	23	115	293
T_1	17	17	19	15	11	21	11	9	18	138	13	20	16	18	17	84	222
T_2	22	25	11	24	3	24	6	6	17	138	10	18	13	16	13	70	208
T_3	13	21	9	8	1	6	2	3	2	65	3	3	14	2	2	24	89
T_4	2	18	6	19	6	12	1	4	5	73	1	5	18	7	5	36	109
T_5	9	13	10	20	25	19	13	13	20	142	15	16	8	22	21	82	224
T_6	7	11	7	22	17	3	16	14	9	106	16	8	3	14	12	53	159
T_7	20	14	22	21	14	25	15	10	22	163	20	22	10	9	11	72	235
T_8	23	15	23	11	22	20	14	8	15	151	17	17	5	10	6	55	206
T_9	16	20	4	14	23	17	12	7	13	126	12	15	12	15	10	64	190
T_{10}	6	6	17	4	8	13	10	5	6	75	7	6	6	4	3	26	101
T_{11}	10	10	15	6	15	10	8	1	3	78	4	2	2	1	1	10	88
T_{12}	11	8	16	12	24	11	7	2	4	95	2	4	7	3	4	20	115
T_{13}	18	9	20	16	18	16	18	20	21	156	19	21	24	19	15	98	254
T_{14}	25	3	24	1	19	7	22	17	10	128	11	9	15	23	22	80	208
T_{15}	21	2	21	3	5	2	19	15	8	96	14	11	20	6	14	65	161
T_{16}	14	1	14	13	7	15	20	19	14	117	18	19	25	20	20	102	219
T_{17}	3	7	5	10	2	8	25	23	19	102	21	13	1	25	25	85	187
T_{18}	5	5	8	2	4	5	21	22	16	88	23	14	4	12	16	69	157
T_{19}	16	12	13	9	13	23	24	25	25	160	24	25	9	21	24	103	263
T_{20}	24	4	25	17	20	22	23	24	24	183	25	24	17	11	19	96	279
T_{21}	4	22	2	7	10	14	9	16	12	96	9	12	11	17	18	67	163
T_{22}	12	23	12	18	16	9	5	18	11	124	6	10	21	8	8	53	177
T_{23}	8	19	3	23	12	4	4	11	7	84	8	7	22	5	7	49	133
T_{24}	1	24	1	5	9	1	3	12	1	57	5	1	19	13	9	47	104

T	Treatments	Score for fruit yield	Rank I	Score of seed yield and quality	Rank II	Total score	Overall rank
T_0	Control	178	24	115	25	293	25
T_1	GA_3 (50 ppm for 12 hours)	138	18	84	19	222	19
T_2	GA_3 (100 ppm for 12 hours)	138	17	70	15	208	16
T_3	GA_3 (50 ppm for 24 hours)	65	**2**	24	**3**	89	**2**
T_4	GA_3 (100 ppm for 24hours)	73	**3**	36	**5**	109	**5**
T_5	IAA (50ppm for 12 hours)	142	19	82	18	224	20
T_6	IAA (100ppm for 12 hours)	106	12	53	9	159	9
T_7	IAA (50ppm for 24 hours)	163	23	72	16	235	21
T_8	IAA (100ppm for 24 hours)	151	20	55	10	206	15
T_9	NAA (50ppm for 12 hours)	126	15	64	11	190	14
T_{10}	NAA (100ppm for 12 hours)	75	**4**	26	**4**	101	**3**
T_{11}	NAA (50ppm for 24 hours)	78	**5**	10	**1**	88	**1**
T_{12}	NAA (100ppm for 24 hours)	95	8	20	**2**	115	6
T_{13}	CCC (100ppm for 12 hours)	156	21	98	22	254	22
T_{14}	CCC (150ppm for 12 hours)	128	16	80	17	208	17
T_{15}	CCC (100ppm for 24 hours)	96	10	65	12	161	10
T_{16}	CCC (150ppm for 24 hours)	117	13	102	23	219	18
T_{17}	MH (40 ppm for 12 hours)	102	11	85	20	187	13
T_{18}	MH (80 ppm for 12 hours)	88	7	69	14	157	8
T_{19}	MH (40 ppm for 24 hours)	160	22	103	24	263	23
T_{20}	MH (80 ppm for 24hours)	183	25	96	21	279	24
T_{21}	Thiourea (500ppm for 12 hours)	96	9	67	13	163	11
T_{22}	Thiourea (1000 ppm for 12 hours)	124	14	53	8	177	12
T_{23}	Thiourea (500ppm for 24hours)	84	6	49	7	133	7
T_{24}	Thiourea (1000ppm for 24hours)	57	**1**	47	6	104	**4**

Summary

6. SUMMARY

The present investigation entitled "Effect of seed treatments on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench) was carried out in the Department of Seed Science and Technology, College of Horticulture, Vellanikkara, Kerala Agricultural University with an objective to find the effect of growth regulators on growth, seed yield and quality in okra and delineate their effect on seed quality and longevity. the salient findings of the study are summarized here under.

Experiment 1: Effect of Seed treatments with plant growth regulators on growth, seed yield and quality

1. The experiment was laid out in a Randomised Block Design with three replications and twenty five treatments including control. Treatments included treating freshly harvested okra seeds of variety Arka Anamika, with different concentrations of growth regulators namely GA_3, IAA, NAA, Cycocel, Maleic hydrazide and Thiourea for two different time periods (12 hours and 24 hours).

2. Observations on plant height, nodes per plant, internode length, branches per plant, days to first flowering, fruits per plant, fruit length, fruit weight, estimated fruit yield, seeds per fruit, shrivelled seeds per fruit, seed yield per plant and 100 seed weight were recorded.

3. The results revealed that seed treatment with different plant growth regulators exhibited significant differences for all the characters studied.

4. Growth and yield characters like plant height, internode length, number of fruits per plant, estimated fruit yield and seed yield per plant were found to be high in T_{24} (Thiourea 1000 ppm for 24 hours), while T_{16} (CCC at 150 ppm for 24

hours) and T_{14} (CCC at 150ppm for 12 hours) registered higher values for nodes per plant and branches per plant respectively.

5. Higher values for fruit length and seeds per fruit were recorded in GA_3 100 ppm for 24 hours (T_4) and fruit weight was found to be higher in NAA 100 ppm for 24 hours (T_{11}).
6. Among the treatments T_3 (GA_3 50 ppm for 24 hours) flowered early at 36.26 days and lower number of shrivelled seeds was recorded in T_{13} and T_{18}.
7. In order to arrive at the best treatments ranking was undertaken for each character. The total score for each treatment was obtained by summing up the ranks obtained for all the characters studied.
8. The score obtained clearly indicates that growth parameters influence fruit development subsequently leading to increased fruit yield.
9. Treatment T_{24} (Thiourea at 1000 ppm for 24 hours) followed by T_3 (GA3 at 50 ppm for 24 hours) were ranked as best treatments to improve fruit yield.

Experiment II: Seed quality assessment during storage.

1. The seeds obtained under the field experiment were used to conduct the seed storage studies.

2. The seeds from each treatment of experiment I were dried separately to a moisture content of less than 8 per cent and packed in 700G polythene bags and sealed. Seeds were stored under ambient conditions and seed quality parameters evaluated at monthly intervals for a period of seven months. Experiment II was laid out following a Completely Randomized Design (CRD) with twenty five treatments (T_0 to T_{25}) as in experiment I and three replications.

3. Observations on seed germination (%), shoot length(cm), root length(cm), seedling dry weight(g), EC of leachate(dSm^{-1}), mean gemination time (days),

time taken for 50 % germination (days) were taken at the start of storage and subsequently at monthly intervals whereas observations on seed moisture and seed microflora were taken at the start and the end of storage period.

4. Significant differences existed among the treatments for all seed quality parameters studied except time taken for 50% germination, seed moisture and seed microflora.

5. From the storage studies, it was clearly evident that as storage period increases the seed quality decreases, irrespective of the treatments.

6. In germination, all treatments including the control maintained the Minimum Seed Certification Standard (MSCS) of 65 per cent up to fifth month of storage. At the end of the storage period (7 MAS) only two treatments (T_{11} –NAA 50ppm for 24 hours and T_3 – GA_3 50ppm for 24 hours) retained MSCS (65%).

7. Vigour index I and II had higher values in NAA 50ppm for 24 hours which was 23 per cent and 16 per cent increase over control respectively.

8. Seed quality parameters such as germination, vigour indices and seedling dry weight have decreased with the advancement of the storage period, whereas EC of seed leachate, germination time, time taken for 50% germination increased over the storage period.

9. The effect of growth regulators on seed microflora was found to be non-significant at the start and at the end of the storage period. However, there was an increase in the per cent of seed infection by seed microflora at the end of storage period, irrespective of the treatments.

10. Ranking of seed yield contributing characters in experiment I along with germination per cent and vigour index I of experiment II was undertaken to identify the superior treatments for improving the seed yield, quality and longevity.
11. Based on the score for seed yield and seed quality parameters treatment NAA at 50 ppm for 24 hours was considered the best followed by NAA at 100 ppm for 24 hours and GA3 at 50 ppm for 24 hours.
12. Considering the total score from both experiments it was found that seed treatment with NAA and GA_3 at 50 ppm for 24 hours not only increased the growth and yield of okra but also enhanced the seed quality and longevity for a period of seven months in storage. Hence, it can be concluded that seed treatment with NAA and GA_3 at 50 ppm for 24 hours is more effective in improving seed yield and quality in okra.

Future line of work

- Study the effect of foliar application of same growth regulators at the same concentration
- Seed storage and assessment of quality should be studied at different storage conditions and containers
- The same experiment should be conducted at different growing season recommended by KAU
- Study the effect of seed treatment with growth regulators on other vegetable crops

References

REFERENCES

[Anonymous]. 2017. India ranks first in lady finger production: Indian institute of vegetable research. *Times of India*. 28 Sept. 2017, P.4.

Abdul-Baki, A. A. and Anderson, J. D. 1972. Physiological and biochemical deterioration of seeds. *Seed Biol.* **2**(1): 283-315.

Abdul-Baki, A. A. and Anderson, J. D. 1973. Vigour determination in soybean seeds by multiple criteria. *Crop Sci.* 13: 630-633.

Akter, P. and Rahman, M. A. 2010. Effect of foliar application of IAA and GA3 on sex expression, yield attributes and yield of Bitter gourd (*Momordica charantia* L.). *The Chittagong Univ. J. B. Sci*. **5**(1-2): 55-62.

Arora, S. K. and Dhankar, B. S. 1992. Effect of seed soaking and foliar spray of cycocel on germination, growth, flowering, fruit set and yield of okra (*Abelmoschus esculentus* (L.) Moench). *Veg. Sci*. **19**(1): 79-85.

Aswathi, C. 2015. Variability in seed quality and storability of cowpea (*Vigna* spp.) varieties. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 126p.

Baruah, G. K. S. and Paul, S. R. 1997. Seed development and maturation studies in okra. *Ann. Agric. Res.* 18: 367-368.

Bello, O. A. 2015. Influence of hormones and imbibition on the growth and yield of *Abelmoschus esculentus* (Okra). *Researcher.* **7**(11): 73-76.

Bhagure, Y. L. and Tambe T. B. 2013. Effect of seed soaking and foliar sprays of plant growth regulators on germination, growth and yield of okra [*Abelmoschus esculentus* (L.) *Moench*] var. Parbhani Kranti. *Asian J. Hortic*. **8**(2): 399-402.

Bora, R. K. and Sharma, C. M. 2006. Effect of growth regulators on growth and yield of pea. *Adv. Plant Sci*. **18**(11): 835-839.

Burman, U., Garg, B. K. and Kathju, S. 2006. Influence of thiourea on photosynthesis, nitrogen metabolism and yield of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] under rainfed conditions of indian arid zone. *Plant Growth Regul.* **48**(3): 237-245.

Carter, L.M. and Chesson, J.H. 1996. Two USDA researchers develop a moisture seeking attachment for crop seeders that is designed to help growers plant seed in soil sufficiently moist for germination. Seed World. 134 (March): 14-15.

Chandiniraj, A., Holebasappa, K., Hore, J. K. and Chattopadyay, N. 2016. Growth and yield of chilli (*Capsicum annuum* L.) as influenced by different growth regulators. *J. life Sci.* 11: 385-388.

Christensen, C. M. and Kaufmann, M. H. 1969. *Grain Storage*. University of Minnesota, Press Minneapolis, 250p.

Copeland, L. O. 1998. Seed germination. In: Copeland, L. O. and McDonald, M. (eds.). *Principles of Seed Science and Technology,* Surjeet Publications, Delhi, pp. 55-212.

Covell, S., Ellis, R. H., Roberts and Summerfield, R. J. 1986. The influence of temperature on seed germination rate in grain legumes: I. A comparison of chick pea, lentil, soybean and cow pea at constant temperatures. *J. Expt. Bot*. 37: 705-715.

Das, R. C. and Pattanaik, A. 1971. Studies on effect of growth regulators treated okra seed (*Abelmochus esculentus* (L.) Moench) with respect to growth and subsequent development. *Indian J. Hortic*. **28**(4): 293-295.

Dhage, A. A., Nagre, P. K., Bhangre, K. K. and Pappu, A. K. 2011. Effect of plant growth regulators on growth and yield parameters of okra. *Asian J. Hortic.* **6**(1): 170-172.

Dhumal, B. S., Belorkar, P. V., Patil, B.N., Geolliwar, V.J. and Gaikwad, Y.S. 1993. Effect of seed treatment with gibberellic acid on growth and yield of okra (*Abelmochus esculentus* (L.) Moench). *J. Soils Crops,* **3**(1): 27-29.

Ellis, R. H., Hong, T. D. and Roberts, E. H. 1980. Seed moisture content, storage, viability and vigor. *Seed Sci. Res*. 1: 275–279.

Gadade, S. B., Shinde, V. S., Deosarkar, D. B. and Shinde, S. S., 2017. Effect of plant growth regulators on growth and yield of okra (Abelmoschus esculentus L.). *Plant Archives*, 17(1):177-180.

Geeta, B., Chetti, M. B. and Navalgatti, C. M. 2010. Effect of plant growth regulators on leaf biochemical characters and fruit yield components of bittergourd (*Momordica charantia* L.) cvs. MHBI-15 and Chaman Plus. *J. Hortic. Sci.* **9**(1): 43-47.

Gomez, K. A. and Gomez, A. A. 1976. *Statistical Procedures in Agricultural Research.* International Rice Research Institute, Los Banos, Philippines, 680p.

Halmer, P. (2004) Methods to improve seed performance in the field. In: Handbook of Seed Physiology; Application to Agriculture. R.L. Benech-Arnold and R.A. Sanchez (eds.). The Haworth Press, New York, pp. 125-165.

Hussaini, S. H. and Babu, R. T. 1989. Effect of inert clay fungicides, plant oils and insect growth regulators on the development of *Callasobruchus chinensis* and the viability of pulse seed. *Seed Res*. 1: 305-313.

ISTA [International Seed Testing Association]. 1985. International rules for seed testing. *Seed Sci. Technol.*11: 354-513.

ISTA [International Seed Testing Association]. 1999. International rules for seed testing. *Seed Sci. Technol.* 27: 1-340.

Jagadish, G. V., Prasanna, K. P. R. and Ranganathaiah, K. G. 1994. Influence of storage condition and containers on see storability in onion. *Seed Tech news*, 24: 15.

Kagwade, R. M. 2012. Effect of growth retardant on growth and yield of okra (*Abelmochus esculentus* (L.) Moench). M.Sc. (Agri.) Thesis, Marathwada Krishi Vidyapeeth, Parbhani, 82p.

KAU (Kerala Agricultural University). 2011. *Package of Practices Recommendations: Crops* (14th Ed.). Kerala Agricultural University, Thrissur, 162p.

Kononkov, P, F. and Dudina, Z. N. 1986. Fungi on vegetable crop seeds stored in conditions of high RH and temperature. *Seed Sci. Technol*. 14: 675-684.

Kore, V. N., Salunke, A. R., Gargi, S., Mane, A. V., Patil, R. and Bendale, V. W. 2003. Flowering and yield attributes of okra as influenced by different plant growth regulators. *J. Soils Crops*. **13**(2): 238-241.

Kumar, S., Mahesh, V., and Sen, N. L. 2004. Effect of zinc, boron and gibberellic acid on growth and yield of okra (*Abelmoschus esculentus* L. Moench). *Ann. Agric. Res*. **25**(4): 595-597.

Kumar, S., Poonam Singh, R. P., Katiyar, C. P., Vaish and Khan, A. A. 1996, Beneficial effect of some plant growth regulators on aged seeds of okra (*Abelmoschus esculentus* (L.) Moench.) under field conditions. *Asian J. Hortic*.**12**: 24-28.

Mahorkar, V. K., Thakar, C., Panchabhai, D. M., Dod, V. N., Peshattiwar, P. D. and Geomore, D. G. 2007. Effect of growth retardant and spacing on growth of summer okra cv. Parbhani Kranti. *Asian J. Hortic.* **2**(2): 195-198.

Mangal, J. L., Lal, S. and Arora, S. K. 1988. Studies on the effect of chlorocholine choride and naphalene acetic acid application on salt resistance and production of okra. *Haryana Agric. Univ. J. Res*. **18**(3): 191-197.

Marsh, L.1993. Moisture affects cowpea and okra seed emergence and growth at low temperatures. *Hortic Sci*. 28: 774-777.

Mathur, N., Singh, J., Bohra, S., Bohra, A. and Vyas, A. 2006. Improved productivity of mung bean by application of thiourea under arid condituion. *World J. Agric. Sci*., **2**(2): 185-187.

Matthews, S. and Brandnock, W. T. 1967. The detection of seed samples of wrinkle-seeded peas (*Pisum sativum* L.) of potentiality low planting value. *Proc. Int. Seed Test. Ass.*, 32: 553-563.

Maurya, A. N., Muthoo, A. K. and Kumar, A.1985. Use of gibbrellic acid and urea sprays in increasing yield of bhendi (*Abelmochus esculentus* (L.) Moench). *Haryana J. Hort. Sci*. **14**(3-4): 257-259.

Merentoshi, P. 2016. Effect of plant growth regulators on growth and yield attributes of Cucumber (*Cucumis sativus* L.). *Int. Res. Nat. App. Sci.* **3**(6): 42-49.

Mohammedi, G., Khah, E. M., Petropoulos, S. A., Chachalis, D. B., Akbari, F. and Yarsi, G. 2014. Effect of gibberellic acid and harvesting time on the seed quality of four okra cultivars. *J. Agric. Sci.* **6**(7): 200-211.

Munda, B. D. S., Singh, R. R. and Maurya, K. R. 2000. Effect of plant growth regulators on quality of seed of okra (*Abelmoschus esculentus*). *Asian J. Hortic.* **17**(2): 72-76.

Nagendra, M. S. 2017. Optimizing planting time, seed extraction and seed storing in oriental pickling melon (*Cucumis melo. var. conomon.* Mak.). M .Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 95p.

Narase, G. N. C. and Gowda, P. M. 1980. Effect of inter-row spacings and cycocel on growth and yield of Bhendi. *South Indian Hortic.* **31**(4-5): 210-214.

Narayanan, S. and Prakash, M. 2014. Influence of physical seed enhancement techniques on storability of groundnut kernals (*Arachis hypogaea* L.) cv. VRI 2. *Legume Res.* **37**(5): 460-466.

Naruka, I. S. and Paliwal, R. 2000. Ameliorative potential of gibberellic acid and NAA on growth and yield attributes of okra. *South Indian Hortic.* **48**(1-6): 129-13.

Narwal, A. K., Pandita, M. L., Malik, Y. S. and Khurana, S. C., 1998, Study on seed viability and vigour in okra varieties under ambient storage condition. Veg. Sci., **25**(2): 113-118.

Navya, P. 2016. Halogenation for improvement of storage life of chilli (*Capsicum annuum* L.) seeds. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 91p.

Neergaard, P. and Saad, S. 1962, Seed health testing of rice: A contribution to development of laboratory routine testing method. *Indian Phytopathol.* 15: 85-111.

Patel, K. M. and Singh, S. P. 1993. Efficiency of growth regulators and urea on plant growth and fruit yield in okra (*Abelmochus esculentus* (L.) Moench) cv. Pusa Sawani. *Sci. Hortic.* 3: 91-100.

Patil, C. N., Mahorkar, V. K., Dod, V. N., Peshattiwar, P. D., Kayande, N. V. and Gomase, D. G. 2008. Effect of seed treatment with gibberellic acid and maleic hydrazide on growth, seed yield and quality of okra cv. Parbhani Kranti. *Asian J. Hortic.* **3**(1): 74-78.

Patil, D. R. and Patel, M. N. 2010. Effect of seed treatment with GA3 and NAA on growth and yield of okra (*Abelmoschus esculentus* L. Moench). cv.GO-2, *Asian J. Hortic.* **5**(2): 269-272.

Pawar, P. R., Joshi, A. T. and Mahakal, K. G. 1977. Effect of seed treatment with growth regulators on germination, growth and yield of okra (*Abelmochus esculentus* (L.) Moench). *J. MAU.* **2**(1): 26-29.

Prasad P. N., Singh, S. K., Yadava, R. B, Chaurasia, S. N. S. 2013. Effect of GA3 and NAA on growth and yield of tomato. *Vegetable Sci.* **40**(2): 195-197.

Premchand. K., Channakeshava. B. C .and Narayanareddy. A. B., 2013. Effect of interaction due to plant growth regulators and fruit retention on crop growth, seed yield and quality in okra cv. Arka Anamika, *Indian Hortic. J.* **3**(2): 10-18.

Rathod, R. R., Gore, R. V. and Bothikar, P. A. 2015. Effect of growth regulators on growth and yield of French bean (*Phaseolus vulgaris* L.) Var. Arka komal. *J. Agric. Vet. Sci.* **8**(5): 36-39.

Rattan, R. S., Ghimire, N. P. and Kohli, U. K. 1987. Effect of different levels of plant growth regulators on some agronomic traits in okra (*Abelmochus esculentus* (L.) Moench). *Haryana Agric. Univ. J. Res.* **17**(2): 181-186.

Rawat, A. K. and Makani, N. 2015. Influence of plant growth regulators on growth, seed yield and seed quality in okra [*Abelmoschus esculentus* (L.) Moench] cv. GAO-5 under middle Gujarat condition. *Int. J. Agric. Sci.* **1**(1): 151-157.

Reddy, K. R. K. 1973. Studies on the effects of some plant growth regulators on germination of Lady's finger (*Abelmochus esculentus* (L.) Moench) Pusa Sawani. *Andhra Agric. J.* **20**(5-6): 128-138.

Sandya, R. 2016. Seed treatment with botanicals to enhance seedling vigour in chilli (*Capsicum annuum* L.). M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 119p.

Saxena, O. P. 1994. Physiological and biochemical changes in relation to storage in some crop seeds. *Seed Tech News*, 29: 24.

Sen, S. 1974. New Horizon for Developing Countries, Tat McGraw Hill Publishing Co., New Delhi, pp 2.

Sharma, A. and Choudhary, K. C. B. 1986. Seed mycoflora of paddy from Manipur state. *Seed Res.* 13: 131-134.

Sharma, M. L., Singh, G., Richa, K. 2015. Seed invigouration techniques – Important tool for sustainable agriculture – A review. *Int. J. Curr. Res. Biosci. Plant Biol.* **4**(1): 119-122.

Sharma, O. P. and Singh, G. D. 2004. Effect of sulfur and growth substance on yield, quality and nutrient of cluster bean [*Cyamopsis tetragonaloba* (L.) Taub.]. *Environ. Ecol.* **22**(4): 746-748.

Shinde, R. V. 2010. Influence of plant growth regulators on growth, physiology, yield and quality of soybean (*Glycine max* (L.) Merrill). M.Sc. (Agri.) Thesis, Univ. Agric. Sci. Dharwad. 92p.

Shobha, K. V. 2016. Seed invigoration to overcome dormancy in ash gourd (*Benincasa hispida* (Thumb.) Cogn.). M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 127p.

Siddiqui, M. H., Whaibi, A. L., M. H., Basalah, M. O.1974. Role of nitric oxide in tolerance of plants to abiotic stress. Protoplasma. 248: 447-455.

Singh L and Mukherjee S. 2000. Effect of foliar application of urea and NAA on Yield and yield attributes of chilli (*Capsicum annum* var.Longum). *Agric. Sci. Digest.* **20**(2): 116-117.

Singh, B., Naruka, I. S. and Singh, L. 1999. Effect of foliar application of nitrogen (urea) and gibberellic acid (GA_3) on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) cv. Pusa Sawani. *Progressive Hortic.* **30** (3-4): 175-180.

Singh, J., Singh, B. K., Singh, A. K., Panwar, M. and Singh, B. 2012. Effect of foliar spray of GA_3 and IBA on plant characters and yield of okra [*Abelmoschus esculentus* (L.) Moench]. *Environ. Ecology.* **30**(4): 1351-1353.

Singh, K. K., Singh, M. P., Sharma, C. P. and Singh, D. B. 1982. Effect of growth regulator along with nitrogen and potash on growth and yield of onion. *JNKVV Res. J.* **16**(3): 287-288.

Singh, P., Singh, V., Maurya, C. L., Swarnakar, S. K. and Baipai, V. P. 2006. Selection of suitable growth regulator and spacing for seed yield and quality of okra (*Abelmoschus esculentus* (L.) Moench) cv. KS-404. *Seed Res.* **34**(1): 61-65.

Singh, P.V. and Kumar, J. 1998. Effect of gibberellic acid as a pre-sowing seed treatment and different levels of nitrogen on germination, growth, flowering and yield of Okra (*Abelmochus esculentus* (L.) Moench). *Indian J. Agric. Res.* **32**(1): 31-36.

Singh, R. K., Singh G. P. and Singh, V. K. 1999. Effect of plant growth regulator and green fruit picking on seed production of Bhindi [Abelmoschus esculentus (L.) Moench]. *J. Appli.Biol.* **9**(1):31-34.

Singh, R.P., Prasad, P.V. and Reddy, K.R., 2013. Impacts of changing climate and climate variability on seed production and seed industry. In *Adv. Agron.* **11(**8**)**: 49-110.

Sorte. P. N., Damke. M. M., Rafeekher. M., Goramnagar, H. B. and Bobade, P. M. 2001. Influence of GA and IAA on growth, yield and fruit quality of different varieties of brinjal. *J. Soils and Crops.***11**(1): 128-131.

Suganya, S. 2015. Halogenation of rice seeds to prolong storability. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 168p.

Sultana, W., Fattah, Q. A. and Islam, M. S. 2006. Yield and seed quality of chilli (*Capsicum annuum* L.) as affected by different growth regulators. *Bangladesh Journal of Botany,* **35**(2): 195-197.

Suryanarayana, V. and Subba Rao, K.V. S. 1981. Effect of growth regulators and nutrients sprays on the yield of okra. *Veg. Sci.* **8**(1): 12-14.

Thomson, T., Patel, G. S., Pandya, K. S., Dabhi, J. S. and Pawar, Y. 2015. Effect of plant growth substances and antioxidants on growth, flowering, yield and economics of garden pea, *Pisum sativum* L cv. Bonneville. *International Journal of Farm Sciences,* **5**(1): 8-13.

Tyagi, V. (2012). IndIa's agriculture: Challenges for growth & development in present scenario. *IJPSS*, **2**(5): 116- 128.

Vanangamudi, K. 1988. Storability of soybean sees as influenced by the variety seed size and storage container. *Seed Res.***16** (1): 81- 87.

Vijayaraghavan, H. 2000. Effect of seed treatment with plant growth regulators on bhendi (*Abelmoschus esculentus* L.) grown under sodic soil conditions. *Madras Agric. J.* **86** (4-6): 247-249.

Vijaykumar, A., Dharmalingam, C. and Sambandamurthi, S. 1988. Effect of pre-sowing treatment on seed yield and quality in bhendi. *South Indian Hortic.*, **36**(3): 118-120.

Yadav, G. L., Kumawat, P. D. and Singh, M. 2004. Effect of thiourea seed treatment and foliar spray pray on yield of cluster bean. *Haryana J. Agron.* 20: 18-20.

Yogananda, D. K., Vyakarnahal, B. S. and Shekhargouda, M. 2004. Effect of seed invigoration with growth regulations and micronutrients on germination and seedling vigour of bell pepper cv. California Wonder. *Karnataka J. Agric. Sci.* **17**(4): 811-813.

Appendices

Monthly meteorological data from May 2017 to July 2018

Months	Temperature		Relative humidity (%)	Rainfall (mm)
	Mean Maximum	Mean minimum		
May-17	34.26	24.89	85.68	167.50
Jun-17	30.48	23.55	94.63	640.20
Jul-17	30.47	22.78	93.81	384.40
Aug-17	29.92	23.39	95.90	478.00
Sep-17	31.20	22.98	94.47	413,90
Oct-17	31.46	22.40	92.77	183.20
Nov-17	32.74	21.79	86.93	58.30
Dec-17	32.55	21.11	78.06	00.00
Jan-17	32.87	23.76	69.52	00.00
Feb-17	34.65	23.65	71.18	00.00
Mar-17	36.70	24.00	59.00	33.20
Apr-17	36.10	24.80	69.00	28.90
May-17	33.20	22.60	79.00	483.60
June-17	29.80	23.20	89.00	730.00
July-17	29.60	22.50	88.00	793.20

Benefit Cost ratio for the best seed treatments with growth regulators in okra

Total cost (acre)				Gibberellic acid (GA_3)	Naphthalene acetic acid (NAA)	Thiourea
Parameters		**Quantity**	**Rate (Rs.)**			
Seed		3.5 kg@ 1400	4900			
Manure		12 tonnes@5/kg	60,000			
Tractor		12 hrs@600/hr	7,200			
Fertilizer	Urea	100 kg@ 6/kg	600			
	Rock phosphate	100 kg@ 17/kg	1,700			
	MOP	50 kg@16/kg	800			
Field labour	Seed treatment	2 man@ 600		1200	1200	1200
	Land preparation and sowing	26 men@ 600	15,600			
	Weeding and roguing	22 women@ 600	13,200			
	Plant protection	10 men@ 600	6,000			
	Fertilizer application and earthing up	28 women@ 600	16,800			
Post-harvest operations	Harvest and seed extraction.	25 women	15,000			
	Cleaning and drying	14 woman	8,400			
	Removal of shrivelled seeds and hard seeds	8 women	7200			
	Seed packing	10 women	6000			
Transportation			10,000			
Gibberellic acid (GA_3)		10g @ 1088/10g		1088		
Naphthalene acetic acid (NAA)		10g @ 850/10g			850	
Thiourea		50g @ 2026				2026
Total			1,73,400	1,75.688	1,75,450	1,76,626
Saleable seed (kg/acre)			198,752 (248.44kg/acre)	3,25,272 (406.59kg/acre)	3,28,328 (410.41kg/acre)	3,42,760 (428.45kg/acre)
B:C ratio			**1.15**	**1.85**	**1.87**	**1.94**

EFFECT OF SEED TREATMENT ON GROWTH, SEED YIELD AND QUALITY IN OKRA (*Abelmoschus esculentus* L. Moench)

By

ADERSH S.

(2016-11-060)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA

2018

Abstract

The research work 'Effect of seed treatments on growth, seed yield and quality in okra (*Abelmoschus esculentus* L. Moench)', was conducted in the Department of Seed Science and Technology, College of Horticulture, Vellanikkara, during 2017-18 with an objective to find the effect of seed treatment with growth regulators on growth, seed yield and quality in okra and to delineate their effect on seed quality and longevity.

Two separate experiments were conducted. Freshly harvested okra seeds of variety Arka Anamika, were treated with different concentrations of growth regulators namely GA_3, IAA, NAA, Cycocel, Maleic hydrazide and Thiourea for two different time period (12 hours and 24 hours) and used to conduct the field experiment (Experiment 1) immediately. The experiment uses the treated seeds was laid out in Randomised Block Design with three replication and twenty five treatments including control. Observations on growth and yield parameters were recorded at appropriate stages.

The results revealed that seed treatment with different plant growth regulators exhibited significant differences for all the characters studied. Growth characters like plant height, internode length, number of fruits per plant and seed yield per plant were found to be high in T_{24} (Thiourea 1000 ppm for 24 hours), while T_{16} (CCC at 150 ppm for 24 hours) and T_{14} (CCC at 150ppm for 12 hours) registered higher values for nodes per plant and branches per plant respectively. Among the treatments T_3 (GA_3 50 ppm for 24 hours) flowered early at 36.26 days. Higher values for fruit length and seeds per fruit were recorded in GA_3 100 ppm for 24 hours (T_4) and fruit weight was found to be higher in NAA 100 ppm for 24 hours (T_{11}).

The seeds obtained under the field experiment were used to conduct the seed storage studies (Experiment II). The seeds from each treatment of experiment I were dried separately to a moisture content of less than 8 per cent and packed in 700G polythene covers and sealed. Seeds were stored under ambient conditions and seed

quality parameters evaluated at monthly intervals for a period of seven months. Experiment II was laid out following a Completely Randomized Design (CRD) with twenty five treatments (T_0 to T_{25}) as in experiment I and three replications.

Significant differences existed among the treatments for all seed quality parameters studied except time taken for 50% germination, seed moisture and seed microflora. It was clearly evident from the storage study that, as storage period increases the seed quality decreases irrespective of the treatments. In case of germination, all treatments including the control maintained the Minimum Seed Certification Standard (MSCS) of 65 percent up to fifth month of storage. At the end of the storage period (7 MAS) only two treatments (T_{11} –NAA 50ppm for 24 hours and T_3 – GA_3 50ppm for 24 hours) retained MSCS (65%). Vigour index I and II had higher values in T_{11} which was statistically on par with T_{12}, T_{10}, T_3 and T_4. Seed quality parameters such as germination, vigour indices and seedling dry weight decreased with the advancement of storage period, whereas EC of seed leachate, germination time, time taken for 50% germination increases over the storage period.

The effect of growth regulators on seed microflora was found to be non-significant at the start and the end of the storage period. But the per cent of seed infection by seed microflora increased at the end of storage period, irrespective of the treatments.

Ranking of characters in experiment I along with germination percent and vigour index I of experiment II was undertaken to identify the superior treatments. Based on the total score obtained GA_3 at 50 ppm for 24 hours (T_3) was adjudged as the best treatment followed by NAA at 50 ppm for 24 hours (T_{11}).

Hence it is concluded that soaking seeds with GA_3 at 50 ppm and NAA at 50 ppm effectively enhances the growth, fruit and seed yield, seed quality and longevity in okra.