SEED QUALITY ENHANCEMENT IN OKRA AND ORIENTAL PICKLING MELON WITH FILM COAT

By

RESHMA P. K.

(2016-11-083)

THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR -680 656

KERALA, INDIA

2018

DECLARATION

I, hereby declare that the thesis entitled **"seed quality enhancement in okra and oriental pickling melon with film coat"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other university or society.

Vellanikkara,

Reshma P. K.
(2016-11-083)

CERTIFICATE

Certified that the thesis entitled **"Seed quality enhancement in okra and oriental pickling melon with film coat"** is a record of research work done independently by Ms. **Reshma P. K. (2016-11-083)** 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 her.

Vellanikkara

Dr. Dijee Bastian
(Major Advisor)
Professor (Plant Breeding and Genetics)
Department of Seed Science and Technology.
College of Horticulture, Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of Ms. **Reshma P. K. (2016-11-083)** a candidate for the degree of **Master of Science in Agriculture**, with major field in Seed Science and Technology, agree that the thesis entitled **"**Seed quality enhancement in okra and oriental pickling melon with film coat**"** may be submitted by **Ms. Reshma P. K. (2016-11-083)**, in partial fulfilment of the requirement for the degree.

Dr. Dijee Bastian
(Chairman, Advisory committee)
Professor (Plant Breeding and Genetics)
Department of Seed Science and Technology
College of Horticulture, Vellanikkara

Dr. Rose Mary Francies
(Member, Advisory Committee)
Professor and Head
Department of Seed Science and Technology
College of Horticulture, Vellanikkara

Dr. Biju S.
(Member, Advisory Committee)
Assistant Professor
Department of Plant Breeding and Genetics
College of Horticulture, Vellanikkara

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

(External examiner)

Dr. R. JERLIN, Ph.D.,
Professor and Head,
Dept. of Seed Science & Technology,
Tamil Nadu Agricultural University,
Coimbatore - 641 003

ACKNOWLEDGEMENT

First and foremost I bow my head before the ***ALMIGHTY GOD*** *for showering grace on me to complete the work with good health, strength, enthusiasm, confidence and interest.*

My words cannot express my deep sense of gratitude and indebtedness to my beloved chairperson ***Dr. Dijee Bastian,*** *Professor of Plant Breeding and Genetics, Department of Seed Science and Technology for the esteemed advice, inspiring guidance, untiring interest, valuable suggestions, motherly approach ,whole hearted cooperation and immense help rendered throughout the course of this investigation and preparation of the thesis.*

I am extremely thankful to ***Dr. Rose Mary Francies,*** *Professor and Head, Department of Seed Science and Technology and member of my advisory committee for her unfailing support, valuable suggestions and guidance rendered to me for the completion of the research programme and preparation of the thesis.*

I am deeply obliged to ***Dr. S. Nirmala Devi,*** *Professor (Horticulture) and PI, AICRP on VC ,Vellanikkara and member of my advisory committee for her support and enthusiasm, relevant suggestions and constructive professional criticism and guidance rendered throughout the period of investigation and preparation of thesis.*

I sincerely thank ***Dr. Anita Cherian, K,*** *Professor and Head Department of Plant Pathology for her support, ever willing help, scholarly suggestions and expert advice and help in taking the observations on seed microflora and interpretation of results.*

I express my heartiest gratitude to ***Dr. Devadas V.S.,*** *Professor and Associate Director of Research (seeds) for his ever willing help, valuable guidance and creative suggestions throughout my study period.*

I take this opportunity to express my heartiest gratitude to ***Dr.Jiji joseph,*** *Professor and Head, Department of Plant Breeding and Genetics and* ***Dr.Biju, S*** *Assistant professor, Department of Plant Breeding and Genetics,* ***Dr. Sindhu mole P.*** *Assistant professor, Department of Plant Breeding and Genetics for their guidance and help accorded during this research work.*

I consider it as my privilege to express my deep felt gratitude to ***Sri. S. Krishnan,*** *Professor and Head, Department of Agricultural Statistics for his support, critical comments and valuable advice during the preparation of thesis.*

I would like to express my deep sense of gratitude to my course teachers ***Dr. S. Beena,*** *Professor, Department of plant pathology,* ***Dr. C. Beena,*** *Professor, Department of soil science and agricultural chemistry,* ***Dr. Berin pathrose,*** *Professor, Department of Agricultural Entomology and* ***Dr. M. R. Shylaja*** *Professor and Head, CPBMB, for their guidance throughout the period of course work.*

I take this opportunity to extend my profound gratitude to ***Dr. A. T. Francis,*** *Librarian, College of Horticulture, other library staff from college library as well as central library,* ***Aravind chettan*** *and* ***chechi*** *of computer club for the facilities offered.*

It gives me great pleasure in acknowledging the support and help of ***Ms. Simi,*** *Teaching Assistant, Department of soil science and agricultural chemistry, for their boundless help accorded during the laboratory work and help of all the non-teaching staff members of my department* ***Hitha chechi, Smitha chechi, Jeana chechi, Abhilash chettan and Krishnankutty chettan, Uthaman chettan, Indira aunty, Naveen chettan*** *whose constant help, love and support have helped me a lot to complete this venture successfully.*

I am particularly thankful for the heartfelt support and co-operation given by my classmates ***Athmaja S, Adersh S, Bennet Thomas, Megha L.M, Juby Baby, Anju. M. Job, Chakravarthi maari.***

I wish to express my sincere gratitude to my seniors especially ***Nishidha chechi, Navya chechi, Neethu chechi, Nagendra chettan, Vinodhini akka*** *and my lovable friends especially* ***Priya, Dhanya, Geethu, Athira, Lakshmi, Nayana and Haritha Jose*** *for their whole hearted support.*

I take this opportunity to thank all my M.Sc. colleagues and my juniors ***Athulya, Agina, Gayathry and Rosna*** *for their affection, support and encouragement.*

I am forever beholden to my father ***Sasikumar P. K.,*** *mother* ***Mrs. Parvathy P,*** *sister* ***Sabitha. P.*** *and brother* ***Sarath kumar P. K,*** *for their profound love, boundless affection, personal sacrifice, incessant inspiration and constant prayers, which supported me to stay on track.*

My word of apology to those I have not mentioned in person for the successful completion of this endeavour.

Reshma

Reshma P. K.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AOSA	-	Association of Official Seed Analysts
^0C	-	Degree Celsius
C. D.	-	Critical difference
cm	-	Centimeter
cv.	-	Cultivar
EC	-	Electrical conductivity
g	-	Gram
ha	-	Hectare
KAU	-	Kerala Agricultural University
kg	-	Kilogram
m	-	Meter
MAS	-	Months after storage
MSCS	-	Indian minimum seed certification standards
µS/m	-	Micro Siemens per meter
MSCS	-	Minimum Seed Certification Standards
OP- melon	-	Oriental pickling melon

Introduction

1. INTRODUCTION

Seeds have been considered as a symbol of beginning, wealth, and a source of beauty. It has been used in religious ceremonies from time immemorial. Seed quality is the cornerstone of Agriculture and its importance has been recognized since ancient times. It is mentioned in manusmriti as "*Subeejam Sukshetre Jayate Sampadyate*" which literally means "A good seed in a good field will win and prosper" (Poonia, 2013). Seed quality can be considered as a summation of all factors that contribute to seed performance and it is reported that quality seed alone can increase the crop yield by up to 20 per cent. Quality seed is one of the most strategic resources for higher yield.

Being a biological entity, seed undergoes natural ageing immediately after harvest and the extent of seed deterioration determines the plant stand of the subsequent crop. Storage of harvested seeds under ambient conditions, where high relative humidity and high temperature prevail, accelerates the process of deterioration and causes substantial yield loss. Storage under low temperature, low humidity conditions after drying back the seed to safe moisture limits is the most assured means for proper maintenance of seed quality (Jacob *et al.*, 2015).

Seed ageing and deterioration are irreversible, inexorable and inevitable process, but the rate of seed deterioration could be slowed down either by storing the seeds under controlled condition or by imposing seed treatment (Duan and Burries, 1997). Preservation of seeds under controlled conditions involves huge cost and is un feasible in developing countries like India. Under such a situation, seed treatment remains the best alternative approach to maintain seed quality.

Seed treatment refers to the application of certain physical, chemical or biological agents 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 treatments have played and are still playing a pivotal role in sustainable crop production which is also evidenced from the history of mankind. Surapala's *Vrikshayurvedha* an ancient Sanskrit text mentions that seeds steeped in milk and rubbed in cow dung, dried and then repeatedly rubbed in honey and mixed with vidanga (*Embelica aribis*) powder enhances yield. Ancient Chinese farmers coated rice seeds with mud balls to hasten germination in flooded paddy field which also eliminated the problem of seed drifting. The Greeks, presoaked cucumber seeds in milk or water for quick germination (Sadhale and Nalini, 1996). Both pelleted and coated seeds have been traced from Egyptian pyramids. Tull recorded that in England, while normal wheat crops were infected with bunt, seeds accidentally soaked in sea water gave a healthy yield. This led to the practice of treating wheat seeds with brine water (Vanagamudi *et al.*, 2010).

Seed treatments are the concept of 'seed vigour' and related to the management practice for maintenance of seed viability and vigour throughout the production cycle of the seed (Vanagamudi *et al.*, 2010). Many seed technological interventions have been successfully attempted for enhancing the seed quality of carry over seeds and polymer film coating is one such promising technology. Polymer film coating is a process of deposition of thin but uniform coating materials including seed protectants, nutrients, and hormones on the surface of the seed without altering its shape (Korishetter *et al.,* 2017).

As additives for agrochemicals, polymers and copolymers are promising candidates for seed coatings which are supposed to improve the adhesion and homogeneous distribution of the agrochemicals on the seeds and reduce dust formation (Silva *et al.*, 2013). Moreover, seed coating in pre-treatment result in less need of agrochemicals because of fewer losses when compared to spray application on the field (Knowles, 2008). An added advantage is that seed coating does not influence the activity of the active ingredient and the process of germination (Silva *et al.*, 2013).

There is a huge demand at present for precision seed quality enhancement technologies from the commercial seed sector dealing with high value low volume horticultural crops. Polymer film coating technique has provoked interest among seed industries, as it improves the marketability, retains brand identity and helps the farmers in easy identification of the crop and varieties. The practice of providing an exogenous colour coating to seed is only of recent interest in India. But, it is very much prevalent in developed countries for more than a decade. Thus, modern seed technology provides a wide opportunity that aims at translating a variety's genetic potential into improved harvest yield and seed quality (Vanagamudi *et al.*, 2010)

Vegetables play a vital role in human nutrition. They are the important sources of vitamins, minerals, dietary fibers and trace elements and are categorized as protective food. They are widely cultivated across the globe and forms a major portion of the agricultures sector. The demand for a particular type of vegetable varies from country to country, state to state and even form one locality to another. India has emerged as the second largest producer of vegetables next to China with an average productivity of 17.01 MT/Ha (NHB, 2017). The productivity levels of vegetables in India needs an upward shift and lack of supply of good quality seed suited to different regions intrigues till today. Vegetable seeds are high-value, low-volume crops, the high seed multiplication ratio and low seed rate often leads to huge quantity of carry over seeds which necessitates development of low cost technologies which can safeguard the viability of seeds for a longer periods of time.

Okra and oriental pickling melon are two important vegetable crops grown in Kerala. Okra [*Abelmoschus esculentus* (L.) Moench] is an economically important vegetable crop which plays an important role in human diet with potential health benefits. During 2016-17 the net cultivated area of okra in Kerala is 29.27 MT with a productivity of 9.74 MT (Indiastat, 2017). OP melon (*Cucumis melo.var.conomon)* is a summer vegetable crop in Kerala having its own cultural significance. It is commonly known as '*kanivellari*', the golden coloured attractive fruit is considered as a symbol

16

of prosperity and is an indispensable ingredient of '*vishukkani*', the auspicious first sight during the festival of '*vishu*'.

Kerala is blessed with heavy rain fall for most part of the year, which is detrimental for seed production in most vegetable crops and these climatic conditions do not permit year round seed production. Due to high humid condition, safe storage of seeds retaining its viability is also not much effective in Kerala. Kerala is a state which faces electricity problems, so storage of seed under controlled conditions is not feasible. Providing such technology requires heavy initial investments which is out of reach for small seed growers who form the majority of seed producers in the state .In this scenario, seed treatments assume great significance.

Among the different seed treatment methods, polymer film coating acts as an effective tool for enhancing seed performance, because it can act as moisture barrier that help to store seed safely for long periods (West *et al.*, 1985). Not much research has been done in the area of seed coating application and therefore it is important to focus on this technique.

Considering the above, the present study entitled 'Seed quality enhancement in okra and oriental pickling melon with film coat' was conducted at the Department of Seed Science and Technology, College of Horticulture, Vellanikkara with the following objectives.

1. To study the effect of different types of polymers on seed quality during storage
2. To standardize the optimum dose of polymer to be used in film coating
3. To study the effect of polymer film coat with plant protectants during storage
4. To standardize the effect of polymer film coating on seed microflora

Review of literature

2. REVIEW OF LITERATURE

Seed is the future source for foods and is the first link in the food chain and ultimate symbol of food security. Success of any crop production program depends on the quality of seed sown. Seeds undergo deterioration over storage and hence, maintenance of seed vigour and viability from harvest until planting is vital. Safe storage of seed is equally important as seed production. Several interventions to enhance the seed quality during storage have been attempted.

Seed treatment is a common practice in agriculture. It is essential for effective storage and preservation of seed and to reduce the rate of deterioration. Polymer film coating is one such seed invigoration technique which is associated with chemical seed treatment.

2.1 Seed viability and vigour

Seed vigour is highly complex; it is a sum of those properties that determine the activity and level of performance of seed lots of acceptable germination in a wide range of environments (Perry, 1978).

Viability and vigour are the two important factors to consider while judging seed quality. Seed vigour is defined as "seed properties that determines the potential for fast and uniform emergence, and development of seedlings under a wide range of field conditions" (AOSA, 1983).

According to Bhattacharyya (1985) viability of seeds can be defined as the germination capacity of a seed lot and is usually expressed as per cent of seeds that would germinate within a specified time. With the same seed lot, however, individuals may differ in their ability to germinate and this referred as vigour of the individual seed.

Viability of an individual seed is considered lost when the seed fails to attain physiological germination, simultaneously viability can be determined using tetrazolium chloride staining, which give a red stain in respiring tissues. (ISTA, 2003).

In any seed lot especially agricultural species, losses of seed vigour are related to a reduction in the ability of seeds to carry out all the physiological functions that allow them to perform (ISTA, 2009).

2.2 Seed deterioration and storability

According to Delouche (1973) seed deterioration is the summation of all physical, physiological and biochemical changes occurring in a seed which ultimately lead to loss of viability and seed death. Justice and Bass (1978) reported that relative humidity is an important factor that controls the longevity of seed in processing and storage.

Oxygen has been suggested to be an important factor regulating a series of physiological processes associated with seed deterioration. Ellis *et al.* (2008) reported that oxygen increased the respiration rate and accelerated seed deterioration at high temperatures.

It is the gradual loss of seed quality, viability and vigour due to the effect of adverse environmental factors during storage (Kapoor *et al.*, 2010). Seed deterioration is a natural process which involves cytological, physiological, biochemical and physical changes in seeds. It causes undesirable and detrimental effect in agriculture.

As seed deterioration increases, seed performance progressively decreases. Losses in seed quality occur during field weathering, harvesting and storage. The factors that causes seed deterioration are temperature, relative humidity, seed moisture content and invasion by microorganisms and insects, and their damage to the tissues (Jyoti and Malik, 2013).

High RH along with high temperature accelerates seed deterioration thereby causes aging. It is opined that low RH largely reduced the seed deterioration even with high storage temperature and RH might be more important than the storage temperature in determining the seed longevity (Suma *et al.*, 2013).

Lipid peroxidation, which is mainly triggered by reactive oxygen species (ROS) in plant cells, could interrupt plant metabolic functions and lead to cell death (Hussain *et al.,* 2016). Peroxidase and alpha amylase activity are the biochemical indicators to ascertain the rate of seed deterioration.

2.3 Seed quality enhancement

Any seed treatment method aims to improve the quality of seed, because nothing will work upon a poor quality seed, no matter how lavishly other inputs are spent on the crop to give a better crop stand. Seed treatment means the exposure of the seeds to certain physical, chemical, biological agents in order to enhance all quality aspects of seed.

Adding materials to seeds to improve crop production began more than 4,000 years ago. During 2000 BC to 100 AC, the first soaking technique of planting materials was introduced using onion or cypress sap in Egypt, Greece and Rome (Vanagamudi *et al.*, 2010).

A 6th century Chinese agricultural treatise narrated coating of seed grains with collagen of horse bones and aconite which is toxic alkaloid produced by the herb *Aconitum*. According to 17th century treatise, the aconite was grown in some parts of Szechwan for the sole purpose of treating seeds (Vanagamudi *et al.*, 2010).

In the early 1800s copper sulphate solution was found to be superior in controlling bunt and in1920s, copper carbonate dust replaced copper sulphate dips as it was more convenient and safe for both seed and handler (Mathre *et al.,* 2001).

According to Evanari (1980) soaking of seeds in moist cloth or water before sowing was a common practice among farmers. He also reported that repeated soaking and drying of seeds improves its resistance to drought and frost.

In 1930s, seed treatments with organic mercurial compounds achieved great success against a number of seed pathogens. It was abandoned in 1970 due to the risk of mercury poisoning. After World War II, number of organic and inorganic fungicides and insecticides were developed and during 1960s and 1970s, several groups of non systemic organic chemical fungicides and insecticides were produced. In the 1980s and 1990s, first biological seed treatments based on biocontrol with living microorganisms was developed (Mathre *et al.,* 2001).

Henckel (1964) introduced a technique 'Pre- sowing drought hardening' that involved soaking of seeds in water for about 48 hours at 10 – 15^0C and drying them back to original moisture level to induce drought tolerance in plants.

At present, in Indian agriculture different seed treatments are adopted on seeds for better field stand and productivity (Vanagamudi *et al.*, 2010).

2.4 Polymer film coating

Polymer film coating is a process of deposition of thin but uniform coating materials including seed protectants, nutrients, and hormones on the surface of the seed without altering its shape (Korishetter *et al.,* 2017).

Ester and Vogel (1994) reported that film coating had become a standard method for the application of fungicides and other ingredients to vegetable seeds.

According to Sherin and John (2003) film coating improves plant stand and seedling emergence and this technique is recommended for high value agricultural crops.

The polymer application act as an exterior shell that give the desired seed characteristics *viz*., identity to the seed, quick or delayed water uptake and enhanced germination that give rise to better emergence and crop establishment. (Taylor *et al.,* 1998).

2.4.1 Effect of dosage of polymer film coat on seedling performance

Baxter and Waters (1987) suggested that in sweet corn, seed treatment with hydrophilic polymer lock B at the rate of 2.3 and 4.6 g /kg of seed enhanced the crop stand establishment whereas the same coating in cowpea recorded deleterious effect on germination and crop stand establishment.

Bhatnagar and Porwal (1990) reported that chickpea seeds treated with super absorbent polymer @ 200g/ha recorded the highest yield (1.39 t/ha). Seed treatment with 0.2 per cent hydrophilic gel helped to retain moisture for rainfed pearl millet (Kaushik and Gautam, 1994).

Duan and Joseph (1997) opined that seed coating of sugar beet with polyvinyl polymer at 20 g/kg of seed showed significant reduction in germination.

According to Joshi *et al.* (1998) sorghum seeds coated with hydrophilic polymer @ 10 g/kg of seeds increased germination and emergence rate.

Chachalis and Smith (2001) reported that soybean seed coated with 24 mg of hydrophobic polymer per kg of seed regulated the rate of water uptake, decreased the imbibition damage and improved the germination per cent and seedling emergence. They also observed that coating the seed with hydrophobic polymer lowered the solute leakage in aged seeds.

Sherin *et al.* (2003) reported that maize seeds treated with polymer @ 3g per kg of seed diluted with 5 ml of water recorded higher germination per cent, seedling growth and dehydrogenase activity.

Geetharani *et al.* (2006) suggested that slurry coating of chilli seeds with polykote (3 g/ kg of seed) along with a combination of carbendazim (2g/kg of seed) and halogen mixture (3 g /kg of seed) enhanced germination and vigour index. They also observed that low seed infection in polymer treated seeds compared to control.

According to Vinitha (2006) seeds treated with 6 g white red polykote recorded higher germination per cent, root length, shoot length, and vigour index than untreated seeds.

According to Basavaraj *et al.* (2008), onion seeds treated with polymer coating along with a combination of fungicides resulted in improved in seed quality parameters over the storage period. The treatment polymer @ 12 ml per kg of seed + thiram @ 2g per kg of seed registered higher seed quality parameters compared to all other treatments and control.

Among the different seed treatment combinations in chilli seeds, seeds coated with polymer @ 7 g/kg and thiram @ 2.0g/kg had higher per cent of germination. Seedling vigour index and field emergence compared with the treatment polymer @ 5.0 g/kg and thiram 2.0g/kg of seed (Manjunatha *et al.,* 2008).

According to Kaushik *et al.* (2014), maize seeds (variety MH7) treated with polymer @ 9 ml per kg of seed + thiram @ 2 g per kg of seed recorded significantly higher seed quality parameters such as germination, seedling length, vigour index, fresh weight than the seeds treated with polymer 6 ml + thiram @ 2 g per kg of seed.

An experiment was conducted by Rajeshwari *et al.* (2016) to standardize the polymer coating in rice. The observations made on different seed quality parameters indicated that seeds coated with polymer @ 4 ml per kg of seeds recorded higher germination per cent, shoot length, root length, speed of germination, seedling dry weight and seedling vigour.

Chilli seeds were subjected to seed coating at different doses of polymers *viz.*, 3, 5, 7 ml along with fungicide thiram @ 2 g per kg of seeds by Manoharapaladagu *et al.* (2017). Among the different treatments, germination per cent, seedling length and seedling vigour were significantly higher in seed treated with polymer @ 7 ml + thiram @ 2 g per kg of seed.

2.4.2 Effect of polymer film coating on longevity and storability of seed

Differences in seed vigour and viability is reflected in seed longevity. A seed lot with high vigour has good storage potential and maintains the germination over storage, whereas low vigour seed lot has poor storage potential and may observed with decline in germination (Delouche and Baskin, 1973).

Polymer film coating help to further improve the seed storage potential. It prolongs the shelf life of seed and retain the germination health during storage (Vanagamudi *et al.,* 2010).

Polymer treatment along with vitavax 200 @ 2g per kg of seed retained viability and storability up to eighth month of storage in soybean (Verma and verma, 2014).

Chickpea cv. Pusa-256 seeds were treated with polymer in combination with fungicide (Bavistin @ 2g/kg), insecticide (imidachloprid @ 2.5 ml/kg) and bioagent (*Pseudomonas fluorescens*) and stored in polythene bags (700 gauge) for six months. Among the treatments, polymer + bavistin + imidacloprid +*Pseudomonas fluorescens* recorded high germination (Basavaraj and Rai, 2016).

2.4.3 Effect of polymer coating on seed quality parameters

2.4.3.1 Germination (%)

Crop	Polymers used	Experimental details	Reference
Vegetables			
Snap bean	SB 2000 Polymer	Under stress test, the polymer coated snap bean seeds registered increased germination per cent.	Kim *et al.* (2004)
Tomato	Polykote	Tomato seeds treated with pink polymer @ 3 g per kg recorded higher germination per cent.	Ramya (2003)
Brinjal	Polykote	Brinjal hybrid seeds (COBH-1) treated with polymer and halogen mixture expressed higher germination under different water holding capacities.	Rajasekaran (2004)
Tomato	Polykote	Tomato seeds coated with 6 g white red polykote + carbendazim @ 2g + dimethoate @ 5 ml per kg of seed and stored in aluminium pouches retained higher germination per cent.	Vinitha (2006)
Onion	Polymer clear (Polykote)	Onion seeds variety Bellary red were coated with polycot at various doses *viz.*, 6 ml, 9 ml, 12 ml per kg of seeds with and without fungicides and stored for ten months. Seed treated with polymer alone and the combination of fungicide retained MSCS (Minimum Seed Certification Standards) for germination up to the tenth month of storage.	Basavaraj *et al.* (2008)

Cluster bean	Polykote	Seeds of cluster bean cv. Pusji Navbhagar exposed to polymer coating along with fungicides and halogens were subjected to accelerated ageing at 40 ^{0}C and 100 per cent RH up to ten days. It was noticed that film coated seed along with bavistin recorded higher germination per cent even at tenth day of accelerated ageing.	Renugadevi *et al.* (2008)
Cowpea	Polykote	Seeds of vegetable cowpea variety Bhagyalakshmi was subjected to different doses of dry and wet method of film coat application. Initial germination was high in treatment 5 ml film coat per kg (77.33 %) followed by 10 ml film coat per kg (72.67%) in dry method whereas 5 ml film coat per kg (74.67 %) and 15 ml film coat per (78.67 %) kg recorded higher per cent of germination in wet method.	Thontadarya *et al.* (2010)
Cucumber	Hydroxypropyl Methyl cellulose	Hybrid cucumber seeds were treated with hydroxypropyl methylcellulose polymer along with additives. Among the treatments, the untreated seeds recorded a greatest decline of 41 per cent in germination at sixth month of storage while only 21 per cent, reduction in germination occurred in the polymer coated seeds along with pesticide at eighth month after storage.	Keawkham *et al.* (2014)
Coriander	Polykote	Seeds of coriander cv.CO4 were imposed to polymer coating with a combination of biofertilizer (*Azospirillum. spp* and *T.viride),* fungicides (Imidachloprid) and halogens (KH_2PO_4). It was observed that the storage potential had extended with the treatments and among the treatments higher per cent of germination was noticed in seeds fortified with KH_2PO_4.	Issac and Vjayakumar (2014)

Okra	Polykote	Hydroprimed okra seeds were subjected to polymer coating along with a combination of imidachloprid and stored for 12 months. The interaction effects due to the treatment hydropriming + polymer + Imidachloprid recorded higher germination per cent at twelfth month of storage.	Thakur (2016)
Tomato	Disco clear	Seeds of tomato cultivar Pusa Rohini were treated with commercial hydrophilic polymer Disco Clear were stored for a period of one year under ambient and low temperature low humidity (LTLH) conditions. Seed quality parameters were evaluated at an interval of 3 months. High germination rate and seedling emergence were observed in polymer treated seeds.	Jacob *et al.* (2015)
Cowpea	Polykote	Cowpea seeds of two varieties Kashi Kanchana and Kashi Unnati were exposed to various polymer treatments along with combinations of insecticide, fungicide and biofertilizer. Among the treatments, seed treated with polymer along with, imidachloprid, moncozeb, phosphorous solubilising bacteria recorded high per cent of germination for both varieties.	Ma *et al.* (2017)
Field crops			
Maize	Polykote	The seeds of maize cv. Co1 were subjected to different doses of polymer coating as dry dressing and slurry formulations. It is reported that seeds slurry coated with polykote, carbendazim, imidacloprid and micronutrient gave higher germination (99%) and enhanced seedling growth.	John *et al.* (2005)

Pearlmillet	Polykote	Pearmillet (cv. ICMV-221) seeds were subjected to hydropriming for 8 hours. Hydroprimed seeds were exposed to polymer treatment along with different combinations of fungicides, insecticides and halogen mixtures. Among the treatments, hydropriming + polymer coating + Thiram 2.5 g per kg seed + malathion 5 % recorded highest germination per cent (83.45 %) at the end of the storage period.	Chandravathi (2008)
Rice	Synthetic polymer	Hybrid rice (KRH 2) seeds treated with synthetic polymer and in combination with fungicide were stored in cloth bags and polythene bags for four months. Among the treatment, the seeds treated with polymer along with thiram recorded higher germination per cent in both containers of storage.	Rettinassababady *et al.* (2012)
Maize	Synthetic polymer	Maize (Variety – MH7) seeds treated with various doses of synthetic polymer (@ 3, 6, 9 ml per kg of seeds), and their combination with fungicide- thiram 2 g per kg of seeds. Treatment, Polymer @ 6 ml + thiram 2g per kg recorded highest germination percent compared to untreated seeds.	Kaushik *et al.* (2014)
Wheat	Polykote	The seeds of two wheat genotype were subjected to seed coating along with various combinations of insecticide, bio-agent and natural fillers at different doses. Treatment polymer + *T.viride* + insecticide + Neem oil recorded high germination per cent and other seed quality parameters.	Tiwari *et al.* (2015)

Blackgram	Polycote	Breeder seed of blackgram var. ADT 3 was subjected to seed treatment using polymers, combination of fungicides (Imidacloprid, carbendazim), halogen mixtures ($CaCl_2$, $CaCO_3$; 1:1 ratio), rhizome powder of turmeric (*Curcuma longa*) and vasambu (*Acorus calamus*) and stored for a period of nine months in cloth bags and polythene bags. Treatment polymer @ 3ml per kg + imidacloprid @ 2ml per kg + carbendazim @ 2g per kg maintained germination per cent of 88 and 90 in cloth bags and polythene bags respectively at the end of storage period.	Malarkodi and Ananthi (2017)
Pigeon pea	Disco agro red polymer	Seeds of pigeonpea cv. TS-3R exposed to different seed treatments using polymer, along with the various doses of nanoparticles of Zn and Fe and their bulk solutions of $ZnSO_4$ and $FeSO_4$ and stored for ten months. Among the different seed treatments, seed polymer coating with Zn and Fe nanoparticles recorded significantly higher germination per cent throughout the storage period. At the end of storage period, highest germination per cent (61.67 %) was observed in Zn NPs at 750 ppm.	Korishettar *et al.* (2017)
Groundnut	1. Synthetic polymer I, II, III 2.Commercial biopolymer 3.Chitosan	Groundnut seeds were treated five different polymer namely Synthetic polymer I, II, III, commercial biopolymer and a natural biopolymer (Chitosan) to evaluate their effect on seed quality characters. Highest germination per cent (91.80 %) noticed in seed treated with chitosan, at the concentration of 0.25%.	Rakesh *et al.* (2017)

Castor	1.Synthetic polymer I, II, III 2.Commercial bipolymer 3. Chitosan	The result revealed that biopolymers were superior in enhancing the seed quality parameters over the synthetic polymers. Among the treatments, seeds coated with natural biopolymer chitosan at 0.25 % recorded higher germination per cent (97.40 %).	Rakesh *et al.* (2017)
Rice	Polykote	Three rice varieties were exposed to polymer coating along with fungicides and subjected to adverse atmospheric conditions of 40-45^0 C temperature and 100% RH (accelerated ageing) for different duration. Among the treatments the fungicide combination with seed coating resulted in higher germination.	Tiwari *et al.* (2018)

2.4.3.2 Seedling length (cm)

Crop	**Polymers used**	**Experimental details**	**Reference**
Vegetables			
Onion	Polymer clear (Polykote)	Seeds of onion variety Bellary red were film coated with polykot at various doses *viz.,* 6 ml, 9 ml, 12 ml per kg of seeds with and without fungicides (Thiram 2 g per kg of seeds) and stored for ten months. Seed treated with polymer along with a combination of fungicide recorded higher seedling shoot length at tenth month after storage.	Basavaraj *et al.* (2008)

Chilli	Polykote	Among the polymer treatments, significantly high seedling length (14.28 cm) was recorded in the treatment polymer @7 g per kg + thiram 2 g per kg seed followed by polymer @ 5 g per kg + thiram 2 g per kg (13.62 cm) compared to control.	Manjunatha *et al.* (2008)
Brinjal	Polykote	Brinjal seeds fortified with 2% KNO_3 and polymer coated along with bavistin and imidachloprid recorded high seedling length.	Vijayalakshmi *et al.* (2013)
Okra	Polykote	Hydroprimed okra seeds were subjected to polymer coating along with a combination of imidachloprid and stored for 12 months. At the 12^{th} month of storage, polymer coating + Imidachloprid recorded maximum seedling length.	Dhiman (2015)
Cowpea	Polykote	Seed treatment with, polymer along with phosphorous solubilising bacteria (PSB) recorded higher values for shoot length and root length.	Ma *et al.* (2017)
Field crops			
Pearlmillet	Polykot	Pearlmillet (cv. ICMV-221) seeds were subjected to hydropriming for 8 hours. Hydroprimed seeds were used for polymer treatment along with different combinations of fungicides, insecticides and halogen mixtures. Among the treatments, higher seedling shoot length (8.21 cm) and root length (17.40 cm) were noticed in the treatment hydropriming + polymer coating + thiram 2.5 g per kg seed + malathion 5 %.	Chandravathi (2008)

Maize	Polykote	Maize (Variety – MH7) seeds were treated with different doses of synthetic polymer (@3, 6, 9 ml per kg of seeds), in combination with thiram 2 g per kg of seeds. Treatment, T7 (Polymer @ 9 ml + thiram 2g per kg) recorded higher shoot length and root length (7.80 and 13.90 cm respectively).	Kaushik *et al.* (2014)
Pigeonpea	Disco agro red	Seeds of pigeonpea cv. TS-3R were subjected to polymer coating along with various doses of nanoparticles (Zn and Fe) and their bulk form ($ZnSO_4$ and $FeSO_4$) and stored for ten months. Seed polymer coating with the Zn and Fe NPs had significantly high seedling growth characteristics. Treatment polymer + Zn NPs at 750 ppm recorded higher value for seedling length (18.6 cm) followed by the treatment Polymer + Fe NPs at 500 ppm (18.06 cm).	Korishettar *et al.* (2017)
Castor	1.Synthetic polymer I, II, III 2.Commercial biopolymer 3.Chitosan	Castor seeds coated with natural biopolymer chitosan at 0.25% recorded higher value in root length (18.76 cm) and shoot length (14.76 cm) compared to other synthetic polymers and commercial biopolymer treatments.	Rakesh *et al.* (2017)

2.4.3.3 Seedling dry weight (g)

Crop	Polymers used	Experimental details	Reference
Vegetables			
Cowpea	Polykote	Seeds of vegetable cowpea variety Bhagyalakshmi subjected to dry and wet method of film coat application. The seedling dry weight was significantly high for film coated cowpea seeds.	Thontadarya *et al.* (2010)
Tomato	Disco clear	Seeds of tomato cultivar Pusa Rohini treated with commercial hydrophilic polymer Disco Clear, and stored for a period of one year under ambient and low temperature- low humidity (LTLH) conditions. Seed quality parameters were evaluated at 3 months intervals. Polymer coated seedlings recorded high dry matter content.	Jacob *et al.* (2015)
Chilli	Yellow polymer coating	Chilli cv. K 2 seeds were subjected to different seed treatments. Initially seeds were bioprimed with liquid formulation of *B. amyloliquefaciens* and *P. fluorescens* at 6 and 8 per cent concentrations respectively followed by hydropriming for 12 hr and polymer coating (10 ml kg^{-1} of seed). Among the treatments, biopriming with 6 % *B. amyloliquefaciens* VB7 + yellow polymer coating @ 10 ml kg-1 of seed recorded high dry matter content.	Sathya (2016)

Chilli	Polykote	Chilli seeds (Cv. Byadagi Dabbi) subjected to seed coating with different doses of polymers *viz.,* 3, 5, 7 ml along with fungicide thiram @ 2 g per kg of seeds and stored. Among the treatments, higher seedling dry weight was noticed in treatment polymer @ 7ml + thiram @ 2g/kg of seeds.	Manoharapaladagu *et al.* (2017)
Field crops			
Sunflower	Polykote	Sunflower seeds treated with polymer seed coating @ 5ml/kg of seeds + Vitavax (Carboxin 37.5% + thiram 37.5%) @ 2 g/kg of seeds, recorded high seedling dry weight.	Shakuntala *et al.* (2009)
Maize	Polykote	Maize (Variety – MH7) seeds treated with various doses of synthetic polymer (@3, 6, 9 ml per kg of seeds), in combination with thiram 2 g per kg of seeds. The results revealed that the combined effect of seed treatment with polymer dye and fungicide stored recorded significantly high dry weight after six months of storage.	Kaushik *et al.* (2014)
Chickpea	Polykote	Seeds treated with bavistin + imidacloprid + *Pseudomonas fluorescens* recorded highest seedling dry weight at the sixth month of storage.	Basavaraj and Rai (2016)
Blackgram	Polykote	Breeder seed of blackgram var. ADT 3 were subjected to different pre- storage treatment using the polymer and combinations with fungicides, halogen mixtures and rhizome powders of turmeric and vasambu and stored for a period of 9 months. Treatment polymer @ 3ml kg^{-1} + imidacloprid @ 2ml kg-1 + carbendazim @ 2g kg^{-1} recorded highest seedling dry weight.	Malarkodi and Ananthi (2017)

2.4.3.4 Seedling vigor indices

Crop	Polymers used	Experimental details	Reference
Vegetables			
Chilli	Polykote	Chilli seeds treated with polykote as slurry treatment along with carbendazim and halogen mixtures expressed high vigour and germination.	Geetharani *et al.* (2006)
Onion	Polymer clear (Polykote)	Onion seeds treated with polymer 12 ml per kg + thiram 2 g per kg recorded higher value for vigour index I compared to all other treatments.	Basavaraj *et al.* (2008)
Cluster bean	Polykote	Cluster bean seeds coated with polymer as slurry treatment along with bavistin after ten days accelerated ageing retained high seedling vigour.	Renugadevi *et al.* (2008)
Chilli	Polykote	Chilli seeds fortified with 200 ppm salicylic acid and exposed to polymer coating along with bavistin and imidacloprid recorded high vigour index.	Vijayalakshmi *et al.* (2013)
Okra	Polykote	Hydroprimed okra seeds were subjected to polymer coating along with a combination of imidachloprid and stored for 12 months. Among the treatments higher vigour index was obtained in the treatment hydropriming + polymer and imidachloprid at twelve months after storage.	Dhiman (2015)

Field crops			
Sorghum	Polykote	Sorghum seeds treated with polymer as slurry coating recorded high seedling vigour compared to untreated seeds.	Devi (2004)
Maize	Polykote	The polymer treatment of maize seeds cv. Co1 as 3g slurry with the dilution of 5 ml water recorded higher seedling vigour index I	John *et al.* (2005)
Sunflower	Polykote	To evaluate the seed and field parameters of sunflower hybrid RSFH-130, the seeds were treated with polymer along with a combination of chemicals. Among the treatments Polymer seed coating @ 5 ml/kg of seeds + Vitavax @ 2 g/kg of seeds + Imidachloprid @ 5 g/kg of seeds was found to be significantly superior in terms of seedling vigour.	Shakuntala *et al.* (2009)
Maize	Polykote	Higher VI (1840.70) was recorded in treatment, polymer @ 9 ml + thiram 2g per kg and lower VI was noticed (1199.39) in control at the end of the storage.	Kaushik *et al.* (2014)
Cotton	Polykote	Cotton seed (Hybrid NHH-44) subjected to polymer treatments along with plant protection chemicals. Polykote @ 3 ml + vitavax 200 @ 2ml/kg recorded high vigour index I and II compared to untreated seeds at tenth month of storage.	Badiger *et al.* (2014)
Wheat	Polykote	Seeds treated with polymer + insecticide + Neem oil recorded higher values for vigour index II compared to other treatments.	Tiwari *et al.* (2015)

Chickpea	Polykote	**C**hickpea cv. Pusa-256 seeds treated with polymer in combination with fungicide (Bavistin @ 2g/kg), insecticide (imidachloprid @2.5 ml/kg) and bioagent (*Pseudomonas fluorescens*) were stored for six months. Among the treatments, polymer + bavistin + imidacloprid + *Pseudomonas fluorescens* recorded higher vigour indices.	Basavaraj and Rai (2016)
Pigeon pea	Disco agro red polymer	Seeds of pigeonpea cv. TS-3R were subjected to polymer coating combined with various doses of Zn and Fe nanoparticles and their bulk solutions (ZnSO4 and FeSO4), and stored for ten months. Polymer + nano- Zn at 750 ppm and Fe at 500 ppm recorded significantly higher seedling vigour index compared to other treatments throughout the storage period.	Korishettar *et al.* (2017)
Groundnut	1.Synthetic polymer I, II, III 2.Commercial biopolymer 3.Chitosan	Seeds were subjected to seed coating using five different polymers namely synthetic polymer I, II, III, commercial biopolymer and natural bio polymer (chitosan). Among the treatments, seed coated with natural biopolymer chitosan at 0.25 % recorded higher seedling vigour index I (2620.4) and among the synthetic polymer vigour index I noticed in seeds treated with synthetic polymer II at 0.3 % followed by synthetic polymer II at 4 % (1801.00)	Rakesh *et al.* (2017)

2.4.3.5 Electrical conductivity

Crop	Polymers used	Experimental details	Reference
Vegetables			
Chilli	Polymer	Chilli seeds (cv. Byadgi kaddi) subjected to polymer treatment with combinations of fungicide, thiram. Treatment polymer @7 g per kg + thiram 2 g per kg seed recorded significantly lower electrical conductivity (2.023 dSm^{1}) whereas untreated control recorded higher values (2.19 dSm-1) for this character at twelve months after storage.	Manjunatha *et al.* (2008)
Tomato	Disco clear	Seeds of tomato cultivar Pusa Rohini treated with commercial hydrophilic polymer Disco Clear, were dried and packed in paper bags and aluminium pouches and stored for a period of one year under ambient and low temperature-low humidity (LTLH) conditions. The seeds stored in paper bags under ambient condition showed increase in EC value compared to seeds stored in aluminium pouches in LTLH conditions.	Jacob *et al.* (2015)
Tomato	Polykote	Tomato seeds of variety Pusa Ruby were coated with polymer in combination with fungicides, botanicals, and micronutrients and untreated seeds were maintained as control. Lowest value for electrical conductivity was noticed in seeds treated with Vitavax + polymer @ 6 ml per kg of seed packed in aluminium foil pouches.	Dheeraj (2018)

Field crops			
Pearlmillet	Polykot	Among the hydroprimed and polymer treated seeds of pearlmillet, treatment hydropriming + polymer coating + thiram 2.5 g per kg seed + malathion 5 % recorded lowest seed leachate (0.718 dS/m) over the untreated seeds.	Chandravathi (2008)
Maize	Polykote	Maize seeds were treated with polymer along with fungicides and stored up to eight months. Lowest seed leachate was noticed in the treatment polykote @ 3 ml / kg seed diluted with 5 ml of water + Vitavax 200 @ 2.0 g / kg seed.	Mohammad (2012)
Soybean	Polykote	Soybean seeds were subjected to film coating along with a combination of fungicide and insecticides. Minimum EC of seed leachates was observed in seeds treated with polymer + thiram + imidacloprid + *T.viride.*	Devi (2014)

2.4.3.6 Dehydrogenase enzyme activity

Crop	Polymers used	Experimental details	Reference
Maize	Polykote	Maize seeds cv. CO 1 subjected to polymer coating as slurry formulation with various seed treatment chemicals (fungicides, insecticide and micro nutrients). Seeds coated with pink polykote @ 3g+ carbendazim @ 2g + imidacloprid @ 1ml dissolved in 5 ml of water kg^{-1} seed recorded highest dehydrogenase enzyme activity.	John *et al.* (2005)
Maize	Polykote	Maize seeds were treated with polymer along with fungicides and stored up to eight months. Among the treatments, polykote @ 3 ml/kg + vitavax 200 recorded higher value for this character.	Mohammad (2012)
Pigeon pea	Disco agro red polymer	Among the treatments, polymer coating with Zn and Fe NPs observed with high value in dehydrogenase enzyme activity at second, sixth, tenth month of storage.	Korishettar *et al.* (2017)

2.5 Seed microflora

Since seed is an efficient media for survival and dissemination of pathogens, in order to reduce the losses due to the pathogens and to maintain viability, it is advisable to treat seeds with plant protection agents before storage.

Seed coating is used for protection against seed-borne fungi, which simultaneously enhanced the shelf life of seeds [Delouche and Baskin, (1973); Dadlani *et al.* (1992)]

Chilli seeds coated with polymer combined with fungicide had minimal pathogen infection (Geetharani *et al.,* 2006). Seed coating with synthetic polymer along with vitavax 200 maintained good storability with lesser pathogen infection (Rettinassababady *et al.*, 2012).

Nutritional value of groundnut and other oilseeds is affected by seedborne fungi. It was reported that fat content in groundnut and soybean reduced due to *Aspergillus flavus* and it causes deteriorative changes during storage (Chavan, 2011).

The fungicide seed treatments are the most commonly used traditional method to protect the seeds and young seedlings from many seed-and soil-borne pathogens. According to Bharathi *et al.* (2015) poly coat seed treatment was the next best in maintaining seed quality leading to maximum suppression of fungi.

2.5.1 Microorganisms observed in seed

Crop	Organisms observed	Reference
Paddy	*Curvularia spp., Fusarium spp., Heliminthosporium oryzae, Nigrospora oryzae, Pyricularia oryzae*	Neergard and Saad (1962)
	Curvulariasp, Drechslera sp, Nigrospora sp Trichothecium sp, Fusarium sp. Aspergillus sp, Penicillium sp	Ali and Deka (1996)
	Drechslera oryzae, Fusarium spp., Curvularia spp., Aspergillus spp. Rhizopus spp	Sharma and Chaudhary (1986)
	Alternaria sp, Heliminthosporium, Rhizopus sp. and Aspergillus sp.	Suganya (2015)
Maize	*Fusarium moniliforme*, *Ceplasporium acremonium*, *Aspergillu s*sp., *Penicillium* sp. *Rhizopus* sp.	Yap and Kulshreshta (1975)
Cowpea	*Rhizopus* sp. and *Aspergillus* sp.	Aswathi (2015)
Chilli	*Aspergillus, Penicilium, Rhizophous, Alternaria* sp., *Colletotrichum* sp.,	Manjunatha *et al.* (2008)

	Aspergillus niger, A.flavus, Pencillium sp., *Fusarium* sp., *Pencillium* sp., *Fusarium* sp.	Navya (2016)
	Aspergillus niger, Aspergillus flavus, Pencillium sp., Alternaria sp.	Sandhya (2016)
Okra	*Aspergillus niger, Aspergillus flavus, A. alternata, C. globosum, F. oxysporum, Rhizoctonia* spp., *R. nigricans, Trichoderma spp., C. lunata*	Ahmad *et al.* (2017)
Oriental pickling melon	*Aspergillus niger, Aspergillus flavus*	Nagendra (2017)
Cucumber	*Aspergillus niger, Aspergillus. fumigatus, Aspergillus flavus, Bipolaris* spp., *P.camemberti, Rhizoctonia* spp., *Stemphylium* spp.,	Ahmad *et al.* (2017)
Tomato	*Aspergillus flavus, Aspergillus niger, Fusarium, Alternaria, Cladosporium, Penicillium spp.*	Patekar (2017)
Brinjal	*Aspergillus flavus, Aspegillu sniger, Fusarium, Rhizopus spp., Cladosporium.*	Patekar (2017)
Sunflower	*Aspergillus flavus, Fusarium oxysporum, Rhizopus stolonifer.*	Patil (2017)

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on 'Study on seed quality enhancement in okra and oriental pickling melon with film coat', was undertaken at the Department of Seed Science and Technology, College of Horticulture, Vellanikkara, Kerala Agricultural University, Thrissur during the year 2016-2018. The details of materials used and techniques utilized during the course of study are described hereunder.

3.1 Location and Climate

The experiment was conducted under ambient conditions in the Department of Seed Science and Technology, College of Horticulture, Kerala Agricultural University (KAU), Vellanikkara, Thrissur, which is located 40 m above MSL at 10° 54' North latitude and 76° 28' East longitude. Vellanikkara experiences humid tropical climate where the relative humidity remains 80 to 96 per cent for most part of the year. During the period of study, the maximum temperature was experienced in the month of March (36.03°C) and minimum in December 2017 (21.11°C), month the corresponding relative humidity was 84.81 and 78.06 per cent respectively.

3.2. Experimental materials

Freshly harvested and processed seeds of okra, variety Arka Anamika and oriental pickling melon, variety Mudicode local obtained from Central nursery, Kerala Agricultural University were used as the experimental materials. The initial seed quality parameters were assessed before the start of study.

3.3 Experimental details

Seeds of okra variety Arka Anamika and Oriental pickling melon variety Mudicode local were treated separately with two polymers namely Polykot and Hitron either with or without seed protectants and packaged.

3.3.1 Treatment details

The experiment was conducted as a completely randomized design with three replications as per following treatments.

Table 1: Treatments

T_1	Polykote (5ml)
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)
T_3	Polykote (5ml) + *Trichoderma viride* (4g)
T_4	Polykote (10 ml)
T_5	Polykote (10ml) + carbendazim- mancozeb (2g) +bifenthrin (0.1%)
T_6	Polykote (10ml) + *Trichoderma viride* (4g)
T_7	Hitron (5ml)
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)
T_9	Hitron (5ml) + *Trichoderma viride* (4g)
T_{10}	Hitron (10ml)
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)
T_{12}	Hitron (10ml) + *Trichoderma viride* (4g)
T_{13}	Untreated control

3.3.2. Seed treatment procedure

The freshly harvested seeds of okra and oriental pickling melon were treated separately. Seed taken in polythene bag were treated with the plant protection chemicals as per the treatment combinations and polymers added according to the dosage (Plate 1). The polythene bag was closed tightly and shaken till the seeds were uniformly coated. The treated seeds were shade dried back to less than or equal to original moisture content (Plate 2 and Plate 3).

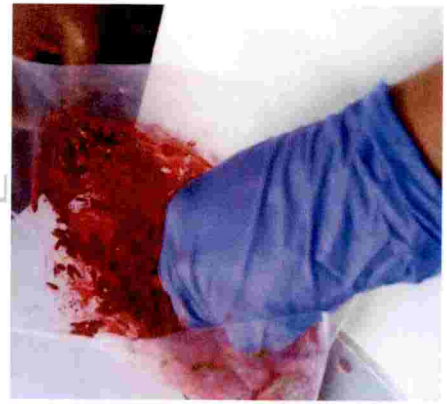
Plate 1: Procedure for treating seeds with polymers

Seed before treatment

Polymers

Measuring required dosage

Polymer adding to the seed



Mixing with seed

Seed after treatment

Plate 2: Polymer treated seeds of okra

T_1: Polykote (5 ml)

T_2: Polykote (5 ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%)

T_3: Polykote (5 ml) + *Trichoderma viride* (4g)

T_4: Polykote (10 ml)

T_5: Polykote (10 ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)

T_6: Polykote (10 ml) + *Trichoderma viride* (4g)

T_7: Hitron (5 ml)

T_8: Hitron (5 ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)

T_9: Hitron (5 ml) + *Trichoderma viride* (4g)

T_{10}: (Hitron 10 ml)

T_{11}: Hitron (10 ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%)

T_{12}: Hitron (10 ml) + *Trichoderma viride* (4g)

T_{13}: Untreated control

Plate 3: Polymer treated seeds of oriental pickling melon

T_1: Polykote (5ml)

T_2: Polykote (5ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%)

T_3: Polykote (5ml) + *Trichoderma viride* (4g)

T_4: Polykote (10 ml)

T_5: Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)

T_6: Polykote (10ml) + *Trichoderma viride* (4g)

T_7: Hitron (5ml)

T_8: Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin

T_9: Hitron (5ml) + *Trichoderma viride* (4g)

T_{10}: Hitron (10ml)

T_{11}: Hitron (10ml) + carbendazim-mancozeb (2g)

T_{12}: Hitron (10ml) + *Trichoderma viride* (4g)

T_{13}: Untreated control

The treated seeds were packed into separate lots with 700 gauge polythene bags and stored under ambient conditions for sixteen months.

3.3.3 Method of storage

The treated seeds of okra and oriental pickling melon along with the control were packed in 700 gauge polyethylene bags. The bags were heat sealed and stored under ambient conditions and observations recorded at bimonthly intervals for a period of sixteen months.

3.4 Observations

The required quantity of seed was drawn randomly from each replication of each treatment at bimonthly intervals for taking observations on seed quality parameters. Observation on seed microflora and seed moisture were recorded at the start and end of storage period. Seed quality parameters enumerated below were recorded in all the experiments.

3.4.1 Germination (%)

Germination test was conducted as per ISTA standards using sand medium. Four replicates of 100 seeds each were germinated in a germination room maintained at 25±2°C temperature and 90±3% RH. At the end of germination period, the number of normal seedlings in each replication was counted and the germination was calculated and expressed in per cent (Plate 4).

3.4.2 Seedling shoot length (cm)

Ten normal seedlings were selected randomly from each replication of the treatment at the end of the germination test and the shoot length was measured from the base of primary leaf to the collar region. The mean shoot length was expressed in centimeter.

Plate 4: Germination test- Sand method

3.4.3 Seedling root length (cm)

The ten seedlings used for measuring the shoot length were used to record the root length. The root length of each seedling was measured from collar region to the tip of primary root. The mean root length was expressed in centimeter.

3.4.4 Seedling dry weight (g)

Ten seedlings used for measuring shoot and root length, were dried in a hot air oven maintained at 85 ± 1°C for 24 hours as per ISTA (2007). The seedlings were then removed and allowed to cool in desiccators for 30 minutes and weighed using a digital balance and expressed in gram.

3.4.5 Vigour index I

The seedling vigour index was computed by adopting the formula suggested by Abdul-Baki and Anderson (1973).

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

3.4.6 Vigour index II

The seedling vigour index was computed by adopting the formula suggested by Abdul-Baki and Anderson (1973).

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

3.4.7 Electrical conductivity of seed leachate (µS/m)

The observation on electrical conductivity of seed leachate (EC) was recorded using 50 seeds from each replication in both crops. The seeds were soaked in 50ml distilled water. After 24 hour of incubation, leachate was collected in a beaker. The EC of the seed leachate was recorded with EUTECHCON-510 digital conductivity meter with a cell constant of 0.1 and expressed in micro Siemons per meter (µS/m).

3.4.8 Time taken for 50% germination

The time to reach 50% germination (T50) was calculated according to Coolbear *et al.* (1984) modified by Farooq *et al.* (2005):

$$T50 = ti + [(N / 2 - ni) (ti - tj)] / ni - nj$$

Where,

N = final number of emergence

ni, nj cumulative number of seeds germinated by adjacent counts at times ti and tj, respectively when ni< N / 2 <nj.

3.4.9 Mean time to germination (days)

Mean germination time (MGT) was calculated according to the equation of Ellis and Roberts (1981):

$$\text{Mean germination time (MGT)} = \frac{\Sigma Dn}{\Sigma n}$$

Where,

n = number of seeds, which were germinated on day D

D = number of days counted from the beginning of germination

3.4.8 Dehydrogenase activity (OD value)

3.4.8.1 Dehydrogenase activity for okra

Twenty five seeds in three replicates were soaked in water for 16 h at 25^0C. The seed coat was carefully removed from the seeds with the help of sharp blade and needle without damaging the cotyledon and the embryo. After removing the seed coat, the seeds were immersed in 10 ml of 1% solution of 2-3-5-triphenyl tetrazolium chloride (TZ) prepared in 0.067 M phosphate buffer of pH 7, for 2 h at 37^0C for staining. After incubation, the excess solution was decanted and the embryos were thoroughly washed with distilled water and surface dried with blotters. The formazon was eluted by

soaking the stained embryos in 5 ml of Methyl cellosolve (2 methoxy ethanol) overnight and the optical density was measured using spectrophotometer at 470 nm (Kittock and Law, 1968).

3.4.8.2 Dehydrogenase activity for oriental pickling melon

The total dehydrogenase activity was determined by the method described by Perl *et al.* (1978) with slight modifications. Ten seeds were selected randomly from each replication and pre conditioned by imbibing the seeds for 24 hours. After removing the seed coat, the cotyledons, and the embryonic axis were soaked in 0.5 per cent Tetrazolium solution at $30^0 \pm 1^0$C for a period of 24 hours. Then they were washed thoroughly with distilled water. The red colour (formazan) was eluted from the stained embryos by soaking in 5 ml of 2-methoxy ethanol for 6 to 8 hours in airtight vials. The extract was decanted and the colour intensity was measured at 480 nm using spectrophotometer. The total dehydrogenase activity was expressed in terms of absorbance at 480nm.

3.4.9 Seed moisture content (%)

Five gram of seed material from two replication were taken for determining the moisture content through high constant temperature method as per procedure advocated by ISTA (1985). The seeds were ground to coarse powder using grinding mill. The powdered seed material was placed in a weighed air tight aluminium cup with lid. The seed material was placed in hot air oven maintained at 103 ± 2°C and allowed to dry for 17 ± 1 hour after removing the lid. Then, the lid was replaced after the drying period and so the contents were cooled in a dessicator for thirty minutes and weighed in an electronic balance. The moisture content was worked out using the following formula and expressed as per cent (ISTA, 1999).

$$\text{Moisture content (\%)} = \frac{M2-M3}{M2-M1} \times 100$$

Where,

M1 = weight of the aluminium cup with lid alone

M2 = weight of the aluminium cup with lid + sample before drying

M3 = weight of the aluminium cup with lid + sample after drying

3.4.10 Seed microflora (%)

3.4.10.1 Blotter method

Storage fungi present on seeds were detected using Blotter method as prescribed by ISTA (1999). Ten seeds were placed equidistantly on three layered moistened blotter taken in sterilized petriplates. Three replications were kept for each treatment. They were incubated at 20°C for seven days with an alternate cycle of twelve hour near ultra violet range and for remaining twelve hours in dark. On the eighth day, the plates were examined under stereo binocular microscope for the presence of seed borne fungi. The number of infected seeds were counted and expressed in per cent. The slides were prepared using the fungal growth on seeds and observed under light microscope for identification (Plate 5 and 6).

3.4.10.2 Agar plate method

Three replications of ten seeds each per treatment was used in the agar plate method. Seeds were surface sterilized using 0.1 per cent mercuric chloride and placed in a Potato Dextrose Agar media equidistantly under the laminar air flow chamber. The petriplates were packed in a polyethylene cover and kept under the bell jar for incubation. The fungal growth was examined under the stereo binocular microscope.

3.5 Statistical analysis

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

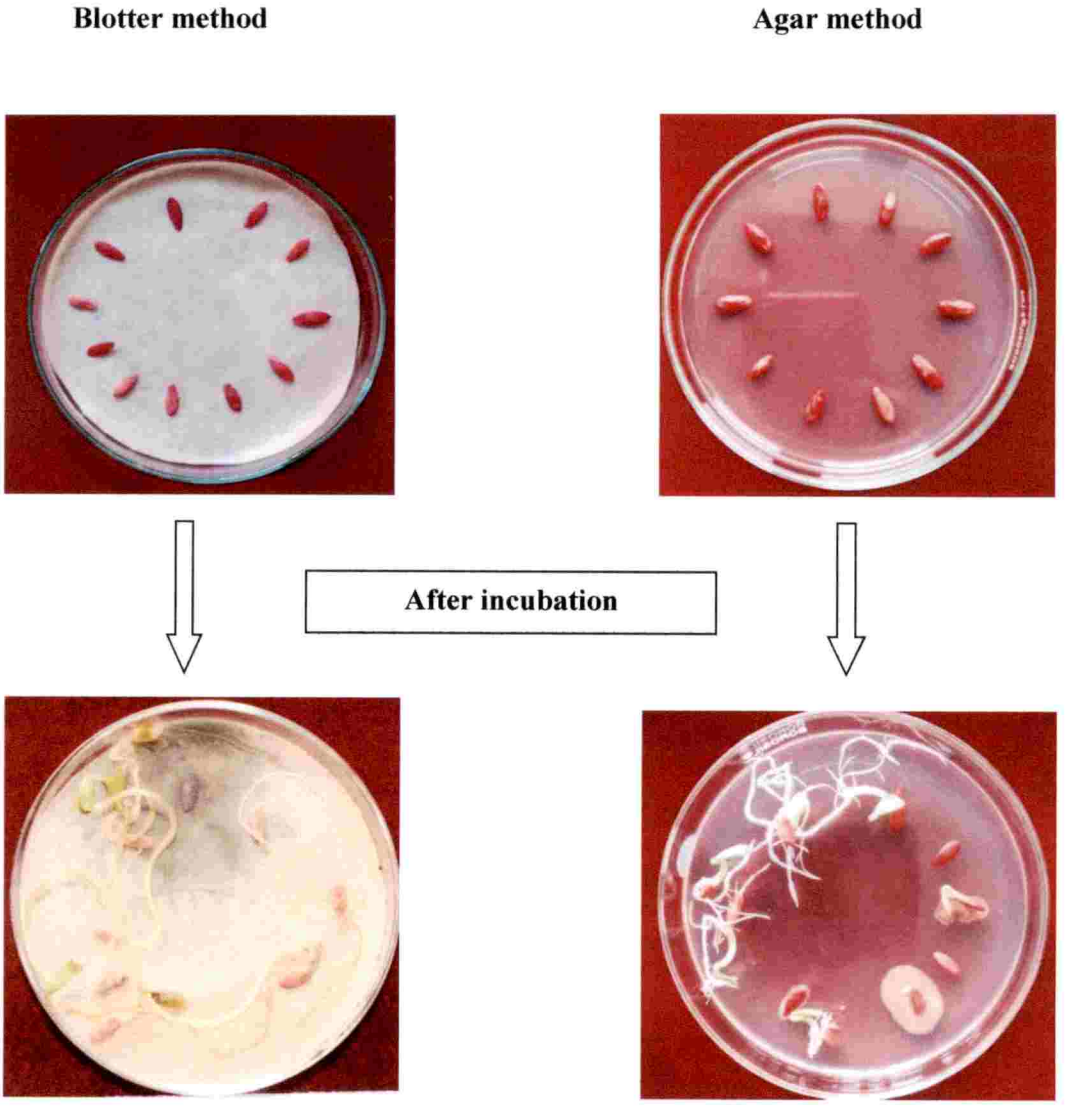
Plate 5: Seed microflora in okra

Blotter method

Agar method

After incubation

Plate 6: Seed microflora in oriental pickling melon



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).

3.5.1 ANOVA for completely randomized design

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	SST_o		

Where,

t – treatments

MSE – error sum of squares

MST – treatment sum of squares

n – number of observations

3.5.2. 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-

significantis 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 are followed for ranking the data (Gomez and Gomez, 1976).

Step 1: All 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 s_d value was computed following the appropriate procedure

$$s_d = \sqrt{\frac{2s^2}{r}}$$

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

$$R_p = \frac{(r_p)(s_d)}{\sqrt{2}} \text{for } p = 2, 3,...,t$$

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: According to the ranking to present the test result alphabet notations were used.

Results

4. RESULTS

The present study on 'Seed quality enhancement in okra and oriental pickling melon with film coat' was undertaken at the Department of Seed Science and Technology, College of Horticulture, Vellanikkara. The results obtained for the various seed quality parameters *viz.,* germination, shoot length, root length, seedling dry weight, vigour indices, electrical conductivity of seed leachate, mean germination time, time taken for 50% germination, dehydrogenase enzyme activity, seed moisture and seed microflora are presented in this chapter.

4.1 OKRA

4.1.1 Analysis of variance

Analysis of variance of the observations recorded at bimonthly intervals for sixteen months of storage revealed that, there existed significant differences among the various treatments for seed quality parameters like germination per cent, seedling shoot and root length, seedling dry weight, seedling vigour index I and II, mean germination time, time taken for 50% germination, electrical conductivity of seed leachate, dehydrogenase activity and seed infection per cent.

4.1.2 Initial seed quality of okra

The initial seed quality parameters were ascertained at the start of the experiment and presented in Table 2. The seeds of okra had recorded an initial germination of 94 per cent. The seedling shoot length, root length and dry weight were 20.42 cm, 10.14 cm and 0.04 g respectively. The initial vigour index I was 2819 and vigour index II 3.20. The electrical conductivity of the seed leachate was 112.4 while the dehydrogenase enzyme activity was 0.198. The seed moisture content was 7.00 per cent. The seeds were free from seed microflora infestation.

Table 2: Initial seed quality parameters of okra

Parameter	Value
Germination (%)	94.00
Seedling shoot length (cm)	20.42
Seedling root length (cm)	10.14
Seedling dry weight (g)	0.04
Vigour index I	2819
Vigour index II	3.20
Electrical conductivity of seed leachate (μSm^{-1})	112.40
Dehydrogenase activity	0.198
Seed infection (%)	0.00
Moisture content (%)	7.00

4.1.3 Germination (%)

The effect of polymer film coating on seed germination of okra is presented in Table 3. Significant differences were observed in germination from the sixth to sixteenth month of storage. At the end of the storage period all the treatments were found to be superior over control.

Irrespective of the seed treatment the germination per cent declined gradually with the advancement of storage period. Highest germination per cent was recorded during second month of storage in T_8 [Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] (95.33 %) followed by T_5 [Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] (94.67 %) and T_2 [Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] (94.67%).

At the end of the storage period, T_5 recorded the highest germination per cent (60.67 %) while, lower values were recorded in T_{13} (untreated control) (28.67%) and T_4 [Polykote (10ml/kg seed)] (33.33%).

All the treatments except untreated control maintained MSCS (Minimum Seed Certification Standards) of 65 per cent germination up to ten months of storage. Treatments such as T_2 [Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed], T_4 [Polykote (10ml/kg seed)], T_5 [Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed],T_7 [Hitron (5ml/kg seed)], T_{11} [Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] retained germination per cent above MSCS up to twelve months of storage whereas, T_5 maintained MSCS up to fourteen months of storage.

Table 3: Effect of polymer coating on germination during storage in okra

Treatments		Germination (%)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	88.00 (9.38)	84.00 (9.17)	82.00^{bc} (9.06)	79.33^{bcd} (8.91)	75.33^{a} (8.69)	64.67^{cd} (8.04)	52.67^{d} (7.26)	37.33^{ef} (6.11)
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	94.67 (9.73)	86.00 (9.27)	82.67^{bc} (9.09)	78.67^{cde} (8.87)	72.00^{ab} (8.49)	71.33^{b} (8.45)	63.33^{b} (7.96)	40.67^{d} (6.38)
T_3	Polykote (5ml) + *T. viride* (4g)	92.00 (9.59)	86.00 (9.27)	77.33^{d} (8.79)	77.33^{de} (8.79)	72.00^{ab} (8.48)	61.33^{de} (7.83)	64.00^{b} (7.99)	40.67^{d} (6.38)
T_4	Polykote (10 ml)	93.33 (9.66)	85.33 (9.23)	82.67^{bc} (9.09)	82.67^{ab} (9.09)	75.33^{a} (8.68)	66.67^{c} (8.16)	36.00^{f} (5.99)	33.33^{g} (5.77)
T_5	Polykote (10ml) + carbendazim- mancozeb (2g) + bifenthrin (0.1%)	94.67 (9.73)	85.33 (9.23)	86.67^{a} (9.31)	85.33^{a} (9.24)	76.00^{a} (8.72)	76.00^{a} (8.71)	73.33^{a} (8.56)	60.67^{a} (7.79)
T_6	Polykote (10ml) + *T. viride* (4g)	90.67 (9.52)	84.00 (9.16)	84.00^{abc} (9.16)	82.00^{abc} (9.05)	75.33^{a} (8.68)	58.00^{ef} (7.62)	48.00^{e} (6.93)	39.33^{de} (6.27)
T_7	Hitron (5ml)	92.00 (9.59)	82.00 (9.05)	83.33^{abc} (9.13)	75.33^{e} (8.68)	66.67^{cd} (8.16)	52.67^{gh} (7.26)	44.67^{e} (6.68)	40.00^{de} (6.32)
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	95.33 (9.76)	86.67 (9.30)	84.67^{ab} (9.2)	84.67^{a} (9.20)	74.00^{ab} (8.60)	56.00^{fg} (7.48)	58.00^{c} (7.61)	54.00^{b} (7.35)
T_9	Hitron (5ml) + *T .viride* (4g)	94.00 (9.69)	85.33 (9.23)	83.33^{abc} (9.13)	82.00^{abc} (9.06)	76.00^{a} (8.71)	50.00^{h} (7.07)	46.67^{e} (6.83)	34.67^{fg} (5.89)
T_{10}	Hitron (10ml)	92.00 (9.59)	82.00 (9.05)	83.33^{abc} (9.13)	75.33^{e} (8.68)	66.67^{cd} (8.16)	52.67^{gh} (7.26)	44.67^{e} (6.68)	40.00^{de} (6.32)
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	90.67 (9.52)	84.00 (9.16)	83.33^{abc} (9.13)	78.00^{de} (8.83)	70.00^{bc} (8.37)	66.00^{c} (8.12)	60.00^{bc} (7.74)	46.67^{c} (6.83)
T_{12}	Hitron (10ml) + *T. viride* (4g)	93.33 (9.66)	81.33 (9.02)	84.67^{ab} (9.20)	83.33^{a} (9.13)	70.67^{bc} (8.41)	50.67^{h} (7.11)	53.33^{d} (7.30)	38.00^{de} (6.16)
T_{13}	Untreated control	92.00 (9.59)	82.00 (9.06)	78.00^{d} (8.83)	78.67^{cde} (8.87)	66.67^{cd} (8.16)	44.67^{i} (6.68)	34.67^{f} (5.88)	28.67^{h} (5.35)
	SEm	6.256	8.308	4.410	4.410	6.970	7.282	6.051	3.179
	CD	NS	NS	3.525	3.525	4.430	4.530	4.130	2.993

*Values in parentheses are square root transformed values ** M- Months of storage ***NS- Non significant **** *T. viride* - *Trichoderma viride*

At the end of the storage period the germination per cent in all treatments declined below MSCS, the values ranging from 33.33in T_4 to 60.67per cent, in T_5 and untreated control recorded 28.67 per cent at sixteen months of storage.

4.1.4 Seedling shoot length (cm)

Seedling shoot length showed significant differences among the treatments throughout the storage period (Table 4). Initial seedling shoot length ranged between 19.92 and 21.41 cm. At the end of the storage, T_4 recorded the highest shoot length of 14.45 cm followed by T_6 (14.41 cm) and they were on par with each other. The untreated control recorded 12.05 cm.

4.1.5 Seedling root length (cm)

The seedling root length values obtained for the thirteen treatments over sixteen months of storage are presented in Table 5. There was a gradual significant decline in the seedling root length over the period of storage in all treatments.

Twelve month after storage it was observed that treatment T_{11} recorded a seedling root length of 6.10 cm followed by T_5 (6.06 cm) and T_8 (5.75 cm). At the end of the storage period T_5 recorded the highest seedling root length of 4.67 cm and the treatment are on par with T_8 (3.94 cm), T_{10} (4.21 cm), T_1 (3.68 cm) while the treatment T_9 (1.77 cm) recorded the least value for the character.

4.1.6 Seedling dry weight (g)

There was a gradual decline in the seedling dry weight over the period of storage (Table 6). Significant differences among the treatments were observed throughout the storage period. Higher seedling dry weight was recorded in treatments T_3 and T_5 (0.039 and 0.037g respectively) at the second month of storage.

Table 4: Effect of polymer coating on seedling shoot length during storage in okra

Treatments		Seedling shoot length (cm)							
		M2	**M4**	**M6**	**M8**	**M10**	**M12**	**M14**	**M16**
T_1	Polykote (5ml)	21.47^{a}	21.90^{ab}	16.24^{bcd}	16.30^{abc}	15.36^{bcde}	14.88^{cde}	14.37^{cde}	13.32^{ab}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	20.57^{bcde}	19.74^{cde}	16.20^{bcd}	16.08^{abc}	15.83^{abc}	15.05^{bcde}	14.33^{cde}	14.21^{ab}
T_3	Polykote (5ml) + *T. viride* (4g)	21.07^{abcd}	21.21^{b}	16.06^{cd}	15.84^{bcd}	15.45^{bcde}	15.22^{bcde}	14.27^{cde}	13.98^{ab}
T_4	Polykote (10 ml)	21.14^{abc}	21.41^{b}	17.02^{ab}	15.63^{cd}	15.51^{ab}	15.62^{abc}	14.48^{cde}	14.45^{a}
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	20.56^{bcde}	22.96^{a}	16.49^{abcd}	16.44^{ab}	16.46^{a}	15.85^{ab}	15.54^{ab}	13.94^{ab}
T_6	Polykote (10ml) + *T. viride* (4g)	21.33^{ab}	21.01^{bc}	16.40^{abcd}	15.93^{bcd}	15.54^{bcde}	15.47^{abc}	15.18^{abc}	14.41^{a}
T_7	Hitron (5ml)	20.34^{cde}	20.94^{bcd}	16.77^{abc}	16.34^{ab}	16.02^{ab}	15.18^{bcde}	14.66^{bcd}	10.52^{d}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	20.00^{e}	19.55^{de}	16.90^{ab}	15.80^{bcd}	15.79^{abcd}	15.82^{abc}	15.82^{a}	13.98^{ab}
T_9	Hitron (5ml) + *T. viride* (4g)	19.92^{e}	17.98^{f}	17.11^{a}	16.72^{a}	16.48^{a}	16.33^{a}	15.45^{ab}	13.44^{ab}
T_{10}	Hitron (10ml)	20.54^{bcde}	21.87^{ab}	15.85^{d}	15.28^{d}	15.02^{de}	14.34^{e}	14.29^{cde}	13.14^{bc}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	21.41^{a}	19.10^{ef}	16.88^{abc}	16.72^{a}	15.36^{bcde}	15.82^{abc}	14.08^{de}	13.92^{ab}
T_{12}	Hitron (10ml) + *T. viride* (4g)	20.30^{de}	19.67^{cde}	15.78^{d}	16.15^{abc}	15.13^{cde}	14.48^{de}	13.52^{e}	13.81^{ab}
T_{13}	Untreated control	20.21^{e}	19.62^{cde}	15.86^{d}	15.61^{cd}	14.95^{e}	15.44^{abcde}	14.15^{de}	12.05^{c}
	SEm	0.242	0.719	0.244	0.177	0.215	0.326	0.314	0.494
	CD	0.826	1.424	0.830	0.705	0.778	0.958	0.940	1.180

* M- Months of storage ** *T.viride - Trichoderma viride*

Table 5: Effect of polymer coating on seedling root length during storage in okra

Treatments		Seedling root length (cm)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	11.72^{a}	10.37	7.48^{a}	6.66^{a}	5.86^{abc}	4.42^{d}	4.17^{cde}	3.68^{abc}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	9.64^{ef}	10.83	6.41^{cd}	5.85^{d}	5.07^{cd}	5.21^{abcd}	4.38^{bcde}	3.26^{bc}
T_3	Polykote (5ml) + *T.viride* (4g)	9.94^{def}	10.33	6.63^{bcd}	6.40^{ab}	5.97^{ab}	5.19^{bcd}	5.14^{ab}	3.49^{bc}
T_4	Polykote (10 ml)	10.55^{bcdef}	10.31	6.40^{cd}	6.34^{ab}	6.32^{a}	5.73^{abc}	4.58^{bcd}	2.80^{cd}
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	10.58^{bcde}	10.50	7.12^{ab}	6.34^{ab}	6.23^{a}	6.06^{ab}	5.57^{a}	4.64^{a}
T_6	Polykote (10ml) + *T.viride* (4g)	11.20^{ab}	10.42	6.40^{cd}	6.62^{ab}	5.87^{abc}	5.68^{abc}	4.70^{abcd}	2.74^{cd}
T_7	Hitron (5ml)	11.13^{abc}	10.11	7.09^{abc}	5.38^{cd}	5.36^{bcd}	4.90^{cd}	3.88^{de}	3.74^{abc}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	10.77^{abcd}	10.52	7.03^{abc}	6.69^{a}	5.64^{abc}	5.75^{abc}	5.04^{abc}	3.94^{ab}
T_9	Hitron (5ml) + *T.viride* (4g)	10.26^{bcdef}	11.61	6.21^{d}	6.61^{ab}	5.69^{abc}	5.58^{abc}	5.20^{ab}	1.77^{d}
T_{10}	Hitron (10ml)	10.29^{bcdef}	10.09	7.47^{a}	6.14^{b}	6.05^{ab}	5.31^{abcd}	4.48^{bcd}	4.21^{ab}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	10.09^{cdef}	10.75	6.58^{bcd}	6.50^{ab}	5.29^{bcd}	6.10^{a}	4.14^{de}	3.47^{bc}
T_{12}	Hitron (10ml) + *T.viride* (4g)	9.86^{def}	10.32	6.33^{d}	5.53^{c}	5.35^{bcd}	4.85^{cd}	3.84^{de}	3.47^{bc}
T_{13}	Untreated control	9.49^{f}	8.87	6.64^{bcd}	5.35^{c}	4.73^{d}	5.36^{abcd}	3.56^{e}	3.51^{bc}
	SEm	0.414	0.798	0.171	0.091	0.264	0.336	0.286	0.401
	CD	1.080	NS	0.694	0.506	0.863	0.973	0.898	1.063

* M- Months of storage **NS- Non significant *** *T.viride* - *Trichoderma viride*

Table 6: Effect of polymer coating on seedling dry weight during storage in okra

Treatments		Seedling dry weight (g)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	0.034	0.023^{bc}	0.021	0.018^{bcde}	0.017	0.017	0.016^{abc}	0.014^{b}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.034	0.023^{bc}	0.027	0.018^{bcde}	0.016	0.018	0.017^{ab}	0.013^{b}
T_3	Polykote (5ml) + *T viride* (4g)	0.039	0.021^{c}	0.021	0.018^{abcd}	0.017	0.019	0.017^{ab}	0.013^{b}
T_4	Polykote (10 ml)	0.035	0.023^{bc}	0.026	0.017^{bcde}	0.018	0.018	0.018^{a}	0.013^{b}
T_5	Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.037	0.020^{c}	0.023	0.021^{a}	0.019	0.020	0.018^{a}	0.016^{a}
T_6	Polykote (10ml) + *T. viride* (4g)	0.034	0.021^{c}	0.020	0.016^{de}	0.018	0.018	0.017^{ab}	0.014^{b}
T_7	Hitron (5ml)	0.032	0.019^{c}	0.025	0.020^{ab}	0.016	0.018	0.014^{cd}	0.013^{b}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.034	0.022^{c}	0.018	0.020^{ab}	0.014	0.017	0.016^{abc}	0.013^{b}
T_9	Hitron (5ml) + *T. viride* (4g)	0.034	0.021^{c}	0.020	0.019^{abc}	0.018	0.021	0.013^{d}	0.013^{b}
T_{10}	Hitron (10ml)	0.032	0.019^{c}	0.023	0.015^{e}	0.017	0.017	0.016^{abc}	0.014^{b}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.025	0.021^{c}	0.020	0.016^{cde}	0.015	0.021	0.014^{bcd}	0.012^{b}
T_{12}	Hitron (10ml) + *T .viride* (4g)	0.026	0.027^{ab}	0.022	0.019^{abc}	0.015	0.015	0.014^{bcd}	0.012^{b}
T_{13}	Untreated control	0.024	0.029^{a}	0.019	0.020^{ab}	0.015	0.018	0.014^{bcd}	0.012^{b}
	SEm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	CD	NS	0.005	NS	0.003	NS	NS	0.003	0.002

** M- Months of storage ***NS- Non significant **** *T.viride - Trichoderma viride*

At the end of the storage period T_5 (0.016 g) recorded highest value in seedling dry weight and the least (0.012) was recorded in T_{11}, T_{12} and untreated control.

4.1.7 Seedling vigour index I

Irrespective of the treatments, the seedling vigour index I declined gradually with the advancement in storage period. Throughout the storage period the treated seed were superior over untreated control. A significant difference was noticed among the treatments for this parameter (Table 7) throughout the storage period.

Treatment T_5 recorded significant higher values for this character from the fourth month (2850) onwards till the end of the storage period (1126). At twelve months after storage the highest seedling vigour index I was noticed in T_5 (1664) followed by T_2 (1445) and T_{11} (1446).

4.1.8 Seedling vigour index II

Vigour index II was calculated for all the treatments and presented in Table 8. During the initial four months of storage and at tenth month of storage there were no significant differences among the treatments for this parameter but towards the end of storage the treatments were found to be significantly different for seedling vigour index II.

Vigour index II of the treatment declined over the storage period. At the end of storage all the treatments were found to be superior over the control and T_5 maintained high vigour index II (1.77) followed by T_{11} (1.12).

At twelve months after storage higher vigour index II values were observed for T_5 (1.53), T_{11} (1.39), and T_7 (1.23)

Table 7: Effect of polymer coating on seedling vigour index I during storage in okra

Treatments		Seedling vigour index I							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	2919^{d}	2710^{b}	1944^{d}	1822^{e}	1596^{d}	1246^{e}	974^{f}	634^{h}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2856^{f}	2628^{e}	1867^{i}	1646^{j}	1504^{g}	1445^{b}	1183^{d}	710^{d}
T_3	Polykote (5ml) + *T. viride* (4g)	2852^{g}	2709^{b}	1753^{j}	1718^{i}	1540^{b}	1244^{e}	1241^{b}	710^{d}
T_4	Polykote (10 ml)	2955^{a}	2705^{c}	1934^{e}	1815^{f}	1686^{b}	1422^{c}	677.73^{l}	572^{i}
T_5	Polykote (10ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2946^{b}	2850^{a}	2045^{a}	1935^{a}	1724^{a}	1664^{a}	1547^{a}	1126^{a}
T_6	Polykote (10ml) + *T. viride* (4g)	2949^{b}	2636^{d}	1915^{g}	1846^{d}	1612^{c}	1226^{f}	953^{h}	674^{f}
T_7	Hitron (5ml/kg seeds)	2894^{e}	2585^{h}	1924^{f}	1804^{h}	1581^{e}	1335^{d}	865^{j}	637^{h}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2935^{c}	2605^{g}	2024^{b}	1904^{c}	1585^{e}	1207^{g}	1209^{c}	967^{b}
T_9	Hitron (5ml) + *T. viride* (4g)	2836^{h}	2523^{i}	1943^{d}	1912^{b}	1684^{b}	1094^{h}	963^{g}	525^{j}
T_{10}	Hitron (10ml)	2835^{h}	2620^{f}	1943^{d}	1613^{k}	1404^{i}	1033^{i}	836^{k}	693^{e}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2856^{f}	2506^{j}	1954^{c}	1810^{fg}	1446^{h}	1447^{b}	1092^{e}	811^{c}
T_{12}	Hitron (10ml) + *T. viride* (4g)	2813^{i}	2438^{k}	1872^{h}	1805^{gh}	1445^{h}	975^{j}	924^{i}	656^{g}
T_{13}	Untreated control	2732^{j}	2335^{l}	1754^{j}	1649^{j}	1256^{j}	926^{k}	611^{m}	446^{k}
	SEm	3.818	5.352	7.033	9.170	7.338	6.960	6.992	8.114
	CD	3.280	3.884	4.452	5.084	4.547	4.429	4.439	4.782

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

Table 8: Effect of polymer coating on seedling vigour index II during storage in okra

Treatments		Seedling vigour index II							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	2.99	1.96	1.43^{c}	1.39^{cdef}	1.26	1.13^{cde}	0.85^{cd}	0.90^{cd}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.27	1.98	1.50^{abc}	1.39^{cdef}	1.14	1.29^{bc}	1.07^{b}	0.77^{cde}
T_3	Polykote (5ml) + *T.viride* (4g)	3.59	1.81	1.45^{c}	1.41^{bcdef}	1.20	1.15^{cde}	1.07^{b}	0.86^{cd}
T_4	Polykote (10 ml)	3.27	1.95	1.50^{abc}	1.40^{bcdef}	1.33	1.21^{bcd}	0.66^{efg}	0.71^{de}
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	3.47	1.72	1.74^{ab}	1.78^{a}	1.44	1.53^{a}	1.35^{a}	1.77^{a}
T_6	Polykote (10ml) + *T. viride* (4g)	3.05	1.77	1.47^{bc}	1.34^{def}	1.32	1.02^{defg}	0.80^{cde}	0.76^{cde}
T_7	Hitron (5ml/kg seeds)	2.94	1.59	1.48^{bc}	1.65^{abc}	1.17	1.23^{bcd}	0.64^{efg}	0.64^{e}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.25	1.91	1.42^{c}	1.68^{ab}	1.07	0.94^{efgh}	0.94^{bc}	0.95^{bc}
T_9	Hitron (5ml) + *T. viride* (4g)	3.22	1.84	1.73^{ab}	1.60^{abcd}	1.33	1.03^{def}	0.59^{fg}	0.64^{e}
T_{10}	Hitron (10ml)	2.91	1.58	1.43^{c}	1.14^{f}	1.12	0.90^{fgh}	0.72^{def}	0.88^{cd}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2.27	1.81	1.75^{a}	1.28^{ef}	1.07	1.39^{ab}	0.84^{cd}	1.12^{b}
T_{12}	Hitron (10ml) + *T. viride* (4g)	2.44	2.21	1.31^{c}	1.62^{abc}	1.03	0.78^{h}	0.75^{def}	0.91^{bcd}
T_{13}	Untreated control	2.23	2.35	1.42^{c}	1.54^{abcde}	0.97	0.81^{gh}	0.49^{g}	0.57^{e}
	SEm	0.335	0.070	0.026	0.028	0.039	0.017	0.01	0.016
	CD	NS	NS	.269	0.283	NS	0.217	0.164	0.214

* M- Months of storage **NS- Non significant *** *T.viride- Trichoderma viride*

4.1.9 Mean germination time (days)

The results on mean germination time for different seed treatments under storage are presented in Table 9. Progressive increase in mean germination time was observed in all the treatments with advancement in storage period. Mean germination time was found to be significant during twelve and fourteen months of storage. At twelve months after storage T_8 recorded lower mean germination time of 3 days which are on par with T_9 (3.04), T_3 (3.05), T_{10} (3.11) and higher value for this parameter recorded by T_7 (3.39) and T_1 (3.39).

At the end of storage period the lowest value in mean germination time was noticed in T_{11} (3.371 days) followed by T_8 (3.47 days) and highest value in T_7 (3.97 days).

4.1.10 Time taken for 50 % germination (days)

The results pertaining to time taken for 50 per cent germination are given in Table 10. Generally, a progressive increase for time taken for 50 per cent germination was observed in all treatments and treatments were found to be significantly different from the tenth month onwards.

During the entire storage period, the mean value for time taken for 50 per cent germination ranged from 3.84 to 4.30 days. The treatments were found to be significantly different from tenth month onwards. The untreated seeds have highest value (6.44 days) at the end of storage while lowest value was recorded in treatments T_8 (4.46) which are on par with T_{11} (4.88), T_5 (4.89), T_2 (4.95) and T_3 (4.94).

4.1.11 Electrical conductivity (µS/m)

The electrical conductivity of seed leachate is presented in Table 11. Irrespective of the treatments electrical conductivity of seed leachate was found to

Table 9: Effect of polymer coating on mean germination time (days) of okra during storage

Treatments		Mean germination time (days)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	3.02	3.10	3.17	3.20	3.27	3.39^{a}	3.47^{ab}	3.80
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.10	3.23	3.17	3.20	3.21	3.22^{abcd}	3.33^{bc}	3.72
T_3	Polykote (5ml) + *T. viride* (4g)	3.12	3.22	3.19	3.21	3.26	3.05^{cd}	3.36^{bc}	3.51
T_4	Polykote (10 ml)	3.10	3.28	3.03	3.19	3.28	3.32^{ab}	3.28^{bc}	3.47
T_5	Polykote (10ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.12	3.11	3.10	3.18	3.17	3.24^{abc}	3.21^{c}	3.65
T_6	Polykote (10ml) + *T. viride* (4g)	3.04	3.11	3.23	3.28	3.36	3.26^{abc}	3.28^{bc}	3.49
T_7	Hitron (5ml/kg seeds)	3.17	3.20	3.03	3.13	3.29	3.39^{a}	3.23^{c}	3.97
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.04	3.19	3.01	3.11	3.29	3.00^{d}	3.37^{bc}	3.47
T_9	Hitron (5ml) + *T. viride* (4g)	3.10	3.14	3.13	3.11	3.30	3.04^{cd}	3.27^{bc}	3.73
T_{10}	Hitron (10ml)	3.03	3.26	3.16	3.10	3.16	3.11^{bcd}	3.31^{bc}	3.73
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.10	3.02	3.09	3.00	3.03	3.13^{bcd}	3.21^{c}	3.37
T_{12}	Hitron (10ml) + *T. viride* (4g)	3.09	3.18	3.06	3.03	3.03	3.22^{abcd}	3.32^{bc}	3.61
T_{13}	Untreated control	3.01	3.22	3.20	3.25	3.17	3.13^{bcd}	3.63^{a}	3.74
	SEm	0.009	0.008	0.008	0.021	0.017	0.018	0.017	0.047
	CD	NS	NS	NS	NS	NS	0.228	0.221	NS

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

Table 10: Effect of polymer coating on time taken for 50 % germination (days) during storage in okra

Treatments			Time taken for 50 % germination						
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	3.56	3.63	3.60	3.66^{c}	3.78	3.94^{efg}	4.52^{b}	5.35^{bc}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.58	3.67	3.66	3.67^{c}	3.81	3.86^{g}	4.24^{bc}	4.95^{cd}
T_3	Polykote (5ml) + *T. viride* (4g)	3.59	3.64	3.71	3.70^{bc}	3.89	3.95^{efg}	4.44^{bc}	4.94^{cd}
T_4	Polykote (10 ml)	3.59	3.67	3.61	3.66^{c}	3.78	4.05^{def}	4.87^{a}	5.22^{bc}
T_5	Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.53	3.61	3.62	3.66^{c}	3.74	3.82^{g}	3.82^{d}	4.89^{cd}
T_6	Polykote (10ml) + *T. viride* (4g)	3.55	3.65	3.59	3.68^{bc}	3.92	4.14^{bcd}	4.21^{bc}	5.08^{cd}
T_7	Hitron (5ml/kg seeds)	3.59	3.66	3.65	3.66^{c}	3.83	3.97^{defg}	4.37^{bc}	5.11^{bcd}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.55	3.62	3.59	3.67^{c}	3.80	3.95^{efg}	4.29^{bc}	4.46^{d}
T_9	Hitron (5ml) + *T. viride* (4g)	3.55	3.64	3.63	3.68^{c}	3.85	4.08^{cde}	4.28^{bc}	5.82^{ab}
T_{10}	Hitron (10ml)	3.61	3.69	3.60	3.80^{a}	3.85	4.24^{bc}	4.38^{bc}	5.56^{bc}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	3.53	3.63	3.62	3.73^{abc}	3.74	3.87^{fg}	4.10^{cd}	4.88^{cd}
T_{12}	Hitron (10ml) + *T. viride* (4g)	3.59	3.69	3.60	3.72^{abc}	3.79	4.28^{ab}	4.35^{bc}	5.25^{bc}
T_{13}	Untreated control	3.57	3.69	3.61	3.76^{ab}	3.85	4.44^{a}	4.99^{a}	6.44^{a}
	SEm	0.001	0.001	0.002	0.002	0.005	0.012	0.042	0.186
	CD	NS	NS	NS	0.079	NS	0.182	0.343	0.724

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

increase gradually with the advancement of storage period. Treatments were significantly different from fourth to sixteen months of storage.

In storage the mean value for electrical conductivity of seed leachate varied from 266.90 to 356.97μS/m. It is evident that treated seeds had lower values for electrical conductivity of seed leachate compared to control. Untreated seeds exhibited the highest value of this character.

At twelve months of storage, the highest value for electrical conductivity of seed leachate was noticed in untreated control (398.33 μS/m) followed by T_6 (426.67 μS/m) and T_7 (387.00 μS/m) and among the treatments T_5 recorded the least value (324.97 μS/m) for this parameter.

4.1.12 Dehydrogenase enzyme activity (O D value)

The results for dehydrogenase enzyme activity of the various treatments over storage are depicted in Table 12. A gradual decline in dehydrogenase enzyme activity was observed in all treatments throughout the storage period.

At fourteenth month of storage T_5 was found to be superior over all other treatments with a dehydrogenase activity of 0.158. Treatments T_1 (0.153), T_3 (0.156) T_6 (0.151), and T_8 (0.155) were on par with T_5. At the end of the storage period all other treatments were found to be superior over untreated control.

4.1.13 Seed moisture (%)

Seed moisture content was not influenced by the seed treatments as well as the storage period. Seed moisture content varied marginally and it was not significantly different among treatments (Table 13).

Table 11: Effect of polymer coating on electrical conductivity during storage in okra

Treatments		Electrical conductivity (µS/m)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	115.82	156.20^{e}	310.40^{c}	323.00^{e}	346.33^{e}	364.60^{d}	397.83^{ef}	455.17^{d}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	114.60	197.33^{b}	284.83^{e}	318.13^{ef}	337.57^{f}	362.90^{d}	398.00^{ef}	435.83^{f}
T_3	Polykote (5ml) + *T. viride* (4g)	117.07	168.30^{d}	286.13^{e}	308.27^{gh}	343.00^{e}	365.33^{d}	376.43^{h}	438.33^{f}
T_4	Polykote (10 ml)	116.23	155.23^{e}	324.43^{b}	347.13^{d}	363.67^{c}	376.90^{c}	394.53^{f}	445.00^{e}
T_5	Polykote (10ml) + carbendazim- mancozeb (2g) + bifenthrin (0.1%)	114.43	127.17^{g}	215.13^{h}	285.90^{j}	310.40^{h}	324.97^{g}	355.67^{i}	401.53^{h}
T_6	Polykote (10ml) + *T. viride* (4g)	115.80	187.13^{c}	266.05^{f}	299.00^{i}	332.67^{g}	341.73^{f}	426.67^{b}	439.00^{f}
T_7	Hitron (5ml)	116.87	135.77^{f}	324.67^{b}	363.50^{b}	356.00^{d}	387.00^{b}	412.67^{d}	435.80^{f}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + Bifenthrin (0.1%)	115.00	156.73^{e}	294.27^{d}	312.67^{fg}	343.67^{e}	355.33^{e}	386.07^{g}	424.67^{g}
T_9	Hitron (5ml) + *T. viride* (4g)	113.07	153.53^{e}	308.30^{c}	304.37^{hi}	356.00^{d}	366.00^{d}	401.60^{e}	437.33^{f}
T_{10}	Hitron (10ml)	114.73	165.27^{d}	268.90^{f}	354.57^{c}	386.67^{b}	360.33^{de}	415.97^{cd}	484.00^{b}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	115.13	155.63^{e}	226.83^{g}	321.70^{e}	335.00^{fg}	344.00^{f}	385.47^{g}	435.00^{f}
T_{12}	Hitron (10ml) + *T. viride* (4g)	117.73	197.00^{b}	286.10^{e}	342.40^{d}	355.00^{d}	374.47^{c}	417.67^{c}	466.73^{c}
T_{13}	Untreated control	114.40	208.40^{a}	366.73^{a}	412.77^{a}	411.00^{a}	398.33^{a}	433.00^{a}	511.13^{a}
	SEm	5.077	3.956	16.927	15.403	5.362	14.216	6.966	6.824
	CD	NS	3.339	6.907	6.588	3.887	6.239	4.431	4.385

* M- Months of storage **NS- Non significant *** *T.viride- Trichoderma viride*

Table 12: Effect of polymer coating on dehydrogenase enzyme activity during storage in okra

	Treatments	Dehydrogenase enzyme activity (OD value)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	0.198^{bcd}	0.193	0.178^{ab}	0.172^{abc}	0.167^{ab}	0.164^{abcd}	0.153^{abc}	0.130
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.196^{d}	0.189	0.176^{abc}	0.172^{abc}	0.164^{abcd}	0.162^{bcd}	0.145^{def}	0.131
T_3	Polykote (5ml) + *T. viride* (4g)	0.197^{cd}	0.191	0.177^{ab}	0.173^{ab}	0.166^{ab}	0.165^{abc}	0.156^{ab}	0.139
T_4	Polykote (10 ml)	0.199^{bcd}	0.192	0.177^{ab}	0.170^{bcd}	0.162^{bcd}	0.162^{bcd}	0.15^{bcde}	0.134
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	0.216^{a}	0.195	0.179^{a}	0.175^{a}	0.168^{a}	0.168^{a}	0.158^{a}	0.135
T_6	Polykote (10ml) + *T .viride* (4g)	0.198^{bcd}	0.194	0.172^{d}	0.168^{cd}	0.160^{de}	0.160^{de}	0.151^{abcd}	0.137
T_7	Hitron (5ml)	0.196^{d}	0.193	0.177^{ab}	0.170^{bcd}	$0.161c^{de}$	0.161^{cde}	0.147^{cdef}	0.135
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.207^{abc}	0.193	0.175^{abcd}	0.173^{ab}	0.165^{abc}	0.165^{abc}	0.155^{ab}	0.139
T_9	Hitron (5ml) + *T. viride* (4g)	0.205^{bcd}	0.193	0.176^{abc}	0.172^{abc}	0.165^{abcd}	0.165^{abcd}	0.147^{cdef}	0.128
T_{10}	Hitron (10ml)	0.209^{ab}	0.194	0.178^{ab}	0.173^{ab}	0.163^{bcd}	0.163^{bcd}	0.146^{def}	0.131
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.196^{d}	0.193	0.178^{ab}	0.173^{ab}	0.166^{ab}	0.166^{ab}	0.147^{cdef}	0.134
T_{12}	Hitron (10ml) + *T. viride* (4g)	0.195^{d}	0.193	0.173^{cd}	0.167^{d}	0.164^{abcd}	0.164^{abcd}	0.142^{f}	0.125
T_{13}	Untreated control	0.198^{cd}	0.192	0.175^{bcd}	0.168^{cd}	0.157^{e}	0.157^{e}	$0.143e^{f}$	0.122
	SEm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	CD	0.011	NS	0.004	0.004	0.005	0.005	0.007	NS

* M- Months of storage **NS- Non significant*** *T.viride* - *Trichoderma viride*

4.1.14 Seed microflora

Irrespective of the treatments seed infection by microflora increased as storage period advanced (Table 14). The seed treatment on seed microflora was found to be significant at the end of the storage period. The presence of storage fungi on seeds was observed in all the treatments.

In both methods the untreated control showed high percentage of infection compared to other treatments. Comparatively less infection was noticed in blotter method.

In blotter method, the lowest per cent infection was noticed in T_5 [Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] and T_{11} [Hitron (10ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%) per kg seed (13.33%)] Higher percentage of infection (30.00%) was observed in untreated seeds followed by T_1: [Polykote (5ml/kg seed)] (23.33%), T_3: [Polykote (10ml/kg seed)] (23.33) and T_{10} [Hitron (10ml/kg seed)] (23.33%). Whereas, lowest infection percentage was noticed in T_5 and T_{11}.It was evident that the pathogen infection less in seeds treated with polymers along with a combination of insecticide and fungicides.

In agar plate method higher infection (36.67%) was noticed in untreated seeds followed by T_7 (33.33%), T_1 [Polykote (5ml/kg seed)] (30.00%) and T_{10} [Hitron (10ml/kg seed)] (30.0%). Among the treatments lower percentage of infection noticed in T_5 (16.67%) followed by T_{11} (20.00%).

All treatments showed higher percentage of infection in agar plate method whereasT_4 [Polykote (10 ml/kg seed)] recorded same level of infection in both methods. The pathogens detected on seeds of okra were *Aspergillus flavus* and *Aspergillu sniger* and *Rhizopus sp.*

Table 13: Effect of polymer coating on seed moisture content at the end of storage period in okra

Treatments		Seed moisture (%)
T_1	Polykote (5ml)	7.10
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	7.17
T_3	Polykote (5ml) + *T. viride* (4g)	7.06
T_4	Polykote (10 ml)	7.19
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	7.04
T_6	Polykote (10ml) + *T. viride* (4g)	7.02
T_7	Hitron (5ml)	7.19
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	7.02
T_9	Hitron (5ml) + *T .viride* (4g)	7.07
T_{10}	Hitron (10ml)	7.26
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	7.01
T_{12}	Hitron (10ml) + *T. viride* (4g)	7.06
T_{13}	Untreated control	7.14
	SEm	0.188
	CD	NS

Table 14: Effect of polymer coating on seed microflora at the end of storage period in okra

Treatments		Seed infection (%)	
		Blotter method	**Agar method**
T_1	Polykote (5ml)	23.33	30.00
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	16.67	20.00
T_3	Polykote (5ml) + *T. viride* (4g)	16.67	23.33
T_4	Polykote (10 ml)	23.33	23.33
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	13.33	16.67
T_6	Polykote (10ml) + *T. viride* (4g)	16.67	26.67
T_7	Hitron (5ml)	20.00	33.33
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	16.67	23.33
T_9	Hitron (5ml) + *T.viride* (4g)	16.67	23.33
T_{10}	Hitron (10ml)	23.33	30.00
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	13.33	20.00
T_{12}	Hitron (10ml) + *T. viride* (4g)	16.67	26.67
T_{13}	Untreated control	30.00	36.67

4.2 ORIENTAL PICKLING MELON

4.2.1 Analysis of variance

Analysis of variance of the observations recorded at bimonthly intervals for sixteen months of storage revealed that, there existed significant differences among the various treatments for seed quality parameters like germination per cent, seedling shoot and root length, seedling dry weight, seedling vigour index I and II, mean germination time, time taken for 50% germination, electrical conductivity of seed leachate, dehydrogenase activity and seed infection per cent for most part of storage period.

4.2.2 Initial seed quality of oriental pickling melon

The initial seed quality parameters were assessed at the start of the experiment and presented in Table 15. The seeds of oriental pickling melon had recorded an initial germination of 98.00 per cent. The seedling shoot length, root length and dry weight were 18.51cm, 9.8 cm and 0.019 g respectively. The initial vigour index I was 2676 and vigour index II 1.81. The electrical conductivity of the seed leachate was 12.5 and dehydrogenase enzyme activity 0.581. The seed moisture content was 6.00 per cent. The seeds were free from seed microflora infestation.

4.2.3. Germination (%)

The data recorded on germination per cent as influenced by seed treatment and storage period are given in Table 16. Treatments were significantly different for germination per cent except at second and sixteen months after storage. At the end of the storage period all the treatments were found to be superior over control.

Irrespective of the seed treatment the germination per cent declined gradually with the advancement of storage period. Highest germination per cent was recorded during second month of storage in T_1 [Polykote (5ml/kg seed)] (98.00 %) followed by

Table 15: Initial seed quality parameters of oriental pickling melon

Parameter	Value
Germination (%)	98.00
Seedling shoot length (cm)	18.51
Seedling root length (cm)	9.80
Seedling dry weight (g)	0.019
Vigour index I	2676
Vigour index II	1.81
Electrical conductivity of seed leachate (μSm^{-1})	12.5
Dehydrogenase activity (O D value)	0.581
Seed infection (%)	0.00
Moisture content (%)	6.00

T_3 [Polykote (5ml) + *Trichoderma viride* (4g) per kg seed] (97.33%) and T_5 [Polykote (10ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed (97.33 %)

All the treatments maintained MSCS (Minimum Seed Certification Standards) of 60 per cent germination up to the tenth month of storage. T_{10} [[Hitron (10ml/kg seed)] was the first treatment to lose the germination below 60 per cent after twelve months of storage. Treatments T_5 [Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] and T_8 [Hitron (5ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] retained MSCS up to fourteen months.

At the end of the storage period, T_5 recorded the highest germination per cent (57.33. %) followed by T_8 (52.67%) and T_{11} [(Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed)] (52.00 %) while, the lowest value (24.67%) was recorded in T_4 [Polykote (10ml/kg seed)] followed by T_{13} [(untreated control)] (26.00%).

4.2.4 Seedling shoot length (cm)

Seedling shoot length showed significant differences during storage except at four and sixteen months after storage, results are exhibited in Table 17. Initial seedling shoot length ranged between 16.32 and 18.83 cm.

At fourteen months of storage the highest value for seedling shoot length was noticed in T_5 (16.60 cm) which was found to be on par with T6 [Polykote (10ml) + *Trichoderma viride* (4g) per kg seed] (16.20 cm), T9 [Hitron (5ml) + *Trichoderma viride* (4g) per kg seed] (15.77 cm) T_{11} [(Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin(0.1%) per kg seed)] (15.63) and untreated control (15.43 cm).

At the end of the storage period, T_5 showed highest value (15.39 cm) in shoot length followed by T_4 (15.31) and T_{10} [Hitron (10ml/kg seed)] (15.04), while lowest value for shoot length was recorded by T_{12} [Hitron (10ml) + *Trichoderma viride* (4g) per kg seed] (12.72 cm) and T_{11} (13.46 cm) followed by untreated control (13.48 cm).

Table 16: Effect of polymer coating on germination during storage in oriental pickling melon

Treatments		Germination (%)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	98.00^{a} (9.89)	97.33 (9.87)	84.67^{de} (9.20)	84.67^{bcd} (9.20)	72.67^{fg} (8.53)	66.00^{bc} (8.12)	37.33^{ef} (6.11)	38.00^{d} (6.16)
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	94.00^{bcd} (9.69)	94.66 (9.73)	90.67^{a} (9.52)	89.33^{ab} (9.45)	76.00^{def} (8.72)	66.00^{bc} (8.12)	34.00^{fg} (5.83)	32.67^{de} (5.71)
T_3	Polykote (5ml) + *T. viride* (4g)	97.33^{ab} (9.86)	96.66 (9.83)	90.67^{ab} (9.52)	90.00^{ab} (9.49)	80.67^{ab} (8.98)	69.33^{ab} (8.33)	31.33^{g} (5.59)	29.33^{ef} (5.38)
T_4	Polykote (10 ml)	94.66^{abcd} (9.73)	95.33 (9.76)	90.00^{ab} (9.49)	86.00^{bcd} (9.27)	72.67^{fg} (8.52)	66.00^{bc} (8.12)	40.00^{e} (6.31)	24.67^{f} (4.96)
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	97.33^{ab} (9.87)	96.66 (9.83)	90.67^{a} (9.52)	92.67^{a} (9.62)	84.00^{a} (9.17)	72.67^{a} (8.52)	65.33^{a} (8.08)	57.33^{a} (7.57)
T_6	Polykote (10ml) + *T.viride* (4g)	93.33^{ab} (9.66)	92.00 (9.59)	88.67^{abc} (9.42)	88.00^{ab} (9.38)	80.00^{bc} (8.94)	66.00^{bc} (8.12)	58.00^{bc} (7.61)	45.33^{bc} (6.73)
T_7	Hitron (5ml)	94.66^{abcd} (9.73)	91.33 (9.56)	86.00^{cd} (9.27)	82.00^{cd} (9.06)	74.67^{defg} (8.64)	62.00^{de} (7.87)	47.33^{d} (6.88)	44.67^{c} (6.68)
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	96.66^{abc} (9.83)	92.00 (9.59)	88.00^{abcd} (9.38)	88.67^{ab} (9.41)	72.00^{g} (8.49)	68.00^{b} (8.25)	63.33^{ab} (7.95)	52.67^{a} (7.25)
T_9	Hitron (5ml) + *T. viride* (4g)	96.66^{abc} (9.63)	96.66 (9.83)	86.00^{cd} (9.28)	85.33^{bcd} (9.24)	78.00^{bcd} (8.83)	62.00^{de} (7.87)	58.00^{bc} (7.61)	28.00^{ef} (5.29)
T_{10}	Hitron (10ml)	96.66^{abc} (9.83)	96.00 (9.79)	82.00^{e} (9.06)	74.67^{defg} (8.64)	60.00^{e} (7.74)	54.00^{c} (7.35)	54.00^{c} (7.35)	51.33^{ab} (7.16)
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	93.33^{cd} (9.66)	96.00 (9.79)	86.00^{cd} (9.27)	88.67^{ab} (9.41)	76.67^{cde} (8.75)	68.67^{b} (8.28)	58.67^{bc} (7.66)	52.00^{a} (7.21)
T_{12}	Hitron (10ml) + *T. viride* (4g)	95.33^{abcd} (9.76)	96.00 (9.79)	86.67^{bcd} (9.30)	86.67^{bc} (9.31)	74.67^{defg} (8.64)	67.33^{bc} (8.20)	34.00^{fg} (5.83)	28.00^{ef} (5.29)
T_{13}	Untreated control	94.00^{bcd} (9.69)	94.00 (9.69)	85.33^{cde} (9.27)	82.00^{cd} (9.06)	74.00^{efg} (8.60)	64.00^{cd} (7.99)	32.67^{fg} (5.71)	26.00^{f} (5.09)
	SEm	4.103	5.949	4.410	11.897	5.330	5.641	12.410	14.050
	CD	3.400	NS	3.520	5.790	3.870	3.987	5.910	6.290

*Values in parentheses are square root transformed values ** M- Months of storage *** NS- Non significant **** *T.viride - Trichoderma viride*

Table 17: Effect of polymer coating on seedling shoot length during storage in oriental pickling melon

Treatments		seedling shoot length (cm)							
		M2	**M4**	**M6**	**M8**	**M10**	**M12**	**M14**	**M16**
T_1	Polykote (5ml)	16.96^{cde}	16.88	15.03^{f}	14.76^{fg}	14.78^{fg}	14.93^{cd}	14.61^{cd}	14.51
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	17.41^{bcd}	16.61	14.79^{g}	14.63^{fg}	14.46^{g}	14.32^{cd}	14.53^{cd}	14.76
T_3	Polykote (5ml) + *T. viride* (4g)	17.35^{bcde}	17.09	16.37^{d}	16.31^{cd}	15.27^{ef}	14.50^{d}	14.95^{bcd}	14.75
T_4	Polykote (10 ml)	16.32^{e}	17.57	17.65^{b}	16.52^{bc}	16.25^{cd}	15.49^{d}	15.33^{bcd}	15.31
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	17.14^{bcde}	17.40	19.22^{a}	19.27^{a}	17.51^{a}	17.35^{a}	16.60^{a}	15.39
T_6	Polykote (10ml) + *T. viride* (4g)	17.17^{bcde}	17.59	17.54^{cd}	17.39^{b}	17.79^{a}	16.86^{ab}	16.20^{ab}	14.89
T_7	Hitron (5ml)	17.91^{abc}	17.49	16.96^{de}	16.23^{cd}	15.67^{cde}	16.43^{ab}	15.07^{bcd}	14.16
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	17.58^{bcd}	17.53	19.20^{a}	17.41^{b}	16.34^{bc}	14.61^{d}	14.40^{d}	14.15
T_9	Hitron (5ml) + *T. viride* (4g)	18.16^{ab}	17.52	17.02^{bc}	18.56^{a}	17.09^{ab}	16.44^{ab}	15.77^{abc}	14.99
T_{10}	Hitron (10ml)	16.63^{de}	17.23	15.96^{f}	15.45^{def}	16.00^{cde}	15.31^{cd}	14.69^{cd}	13.04
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	18.83^{a}	16.58	15.12^{f}	14.44^{g}	15.54^{def}	15.96^{bc}	15.63^{abcd}	13.46
T_{12}	Hitron (10ml) + *T. viride* (4g)	17.84^{abc}	17.37	15.17^{ef}	14.96^{efg}	15.83^{cde}	14.67^{d}	15.01^{bcd}	12.72
T_{13}	Untreated control	17.70^{bcd}	17.41	16.34^{cd}	15.88^{cde}	15.51^{def}	14.73^{d}	15.43^{abcd}	13.48
	SEm	0.410	0.204	0.243	0.315	0.225	0.385	0.563	1.916
	CD	1.070	NS	0.827	0.942	0.796	1.042	1.260	NS

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

4.2.5 Seedling root length (cm)

The seedling root length values obtained for the thirteen treatments over sixteen months of storage are presented in Table 18. There was a gradual significant decline in the seedling root length over the period of storage in all treatments. Treatments were significantly different for this parameter at second, sixth and tenth months of storage.

After ten months of storage, it was observed that treatment T_5 recorded a highest seedling root length of 6.66 cm which are on par with T_{11} (6.32 cm) and T_6 (6.29 cm). At the end of storage period, T_6 recorded the highest seedling root length of 4.63 cm while the treatment T_4 recorded the least value for the character (2.47 cm).

4.2.6 Seedling dry weight (g)

There was a gradual decline in the seedling dry weight over the period of storage (Table 19). Significant difference among the treatments for dry weight was observed during the storage period. Highest seedling dry weight was recorded in treatments T_1 and T_8 (0.029 and 0.029g respectively) at the fourth month of storage.

At the end of the storage period T_5 (0.019g) recorded highest value in seedling dry weight and the least was recorded inT10 (0.012 g). The mean seedling dry weight over storage ranged from 0.017 to 0.02 g.

4.2.7 Vigour index I

Irrespective of the treatments, the seedling vigour index I declined gradually with advancement in the storage period. A significant difference was noticed among the treatments for this parameter (Table 20) throughout the storage period.

Table 18: Effect of polymer coating on seedling root length during storage in oriental pickling melon

Treatments		Seedling root length (cm)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	6.83^{cdef}	7.22	6.35^{abc}	4.94	4.71^{ef}	4.93	4.80	3.19
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	7.41^{bcd}	8.21	5.09^{e}	4.49	4.57^{f}	5.01	3.66	4.15
T_3	Polykote (5ml) + *T. viride* (4g)	6.54^{ef}	7.09	5.49^{de}	5.23	5.42^{cdef}	5.47	4.72	3.84
T_4	Polykote (10 ml)	8.39^{a}	6.76	5.48^{de}	5.32	4.92^{def}	4.87	3.74	2.47
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	6.92^{bcdef}	7.50	6.66^{a}	5.77	6.66^{a}	6.03	6.15	3.41
T_6	Polykote (10ml) + *T. viride* (4g)	7.68^{ab}	7.07	5.09^{e}	5.45	6.29^{ab}	6.64	4.37	4.63
T_7	Hitron (5ml/kg seeds)	6.72^{def}	8.19	6.55^{ab}	5.99	5.56^{bcde}	5.17	4.34	4.25
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	6.68^{def}	7.67	6.36^{abc}	5.99	5.73^{bcd}	4.61	4.16	2.83
T_9	Hitron (5ml) + *T. viride* (4g)	6.99^{bcdef}	6.66	6.51^{ab}	5.32	5.72^{bcd}	5.46	3.76	3.85
T_{10}	Hitron (10ml)	7.52^{bc}	6.94	6.89^{a}	6.12	5.86^{abc}	5.37	4.25	4.36
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	6.32^{f}	7.90	6.87^{bcd}	6.17	6.32^{ab}	5.85	3.70	3.22
T_{12}	Hitron (10ml) + *T. viride* (4g)	6.67^{def}	6.91	6.77^{cde}	6.42	5.86^{abc}	5.19	4.33	3.91
T_{13}	Untreated control	7.17^{bcde}	7.20	5.45^{de}	5.65	5.87^{abc}	4.53	3.97	3.41
	SEm	0.214	0.650	0.172	0.607	0.269	0.586	0.866	0.709
	CD	0.777	NS	0.695	NS	0.871	NS	NS	NS

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

Table 19: Effect of polymer coating on seedling dry weight during storage in oriental pickling melon

Treatments		Seedling dry weight (g)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	0.018	0.029	0.015	0.017	0.017	0.018	0.017	0.016
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.017	0.025	0.015	0.015	0.015	0.015	0.013	0.015
T_3	Polykote (5ml) + *T. viride* (4g)	0.022	0.021	0.020	0.017	0.016	0.015	0.015	0.016
T_4	Polykote (10 ml)	0.023	0.023	0.019	0.021	0.016	0.020	0.014	0.016
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	0.022	0.025	0.021	0.022	0.019	0.018	0.015	0.019
T_6	Polykote (10ml) + *T. viride* (4g)	0.017	0.024	0.022	0.017	0.016	0.017	0.016	0.015
T_7	Hitron (5ml)	0.022	0.018	0.019	0.019	0.016	0.019	0.018	0.015
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.020	0.029	0.017	0.017	0.016	0.017	0.017	0.014
T_9	Hitron (5ml) + *T. viride* (4g)	0.017	0.024	0.016	0.017	0.015	0.018	0.013	0.013
T_{10}	Hitron (10ml)	0.026	0.023	0.019	0.019	0.017	0.016	0.015	0.012
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.020	0.022	0.018	0.018	0.014	0.015	0.015	0.013
T_{12}	Hitron (10ml) + *T. viride* (4g)	0.019	0.014	0.016	0.016	0.018	0.018	0.012	0.015
T_{13}	Untreated control	0.021	0.018	0.016	0.017	0.019	0.021	0.014	0.015
	SEm	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	CD	NS	NS	NS	NS	NS	NS	NS	NS

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

Table 20: Effect of polymer coating on seedling vigour index I during storage in oriental pickling melon

Treatments		Seedling vigour index I							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	2331^{cd}	2340^{cd}	1810^{ij}	1624^{m}	1417^{j}	1413^{h}	724^{i}	665^{g}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2335^{bcd}	2354^{b}	1712^{l}	1708^{l}	1446^{i}	1405^{i}	617^{l}	614^{h}
T_3	Polykote (5ml) + *T. viride* (4g)	2336^{bc}	2349^{c}	1962^{e}	1938^{e}	1636^{e}	1463^{g}	610^{m}	524^{i}
T_4	Polykote (10 ml)	2338^{c}	2341^{cd}	2087^{c}	1878^{f}	1537^{h}	1419^{h}	752^{h}	445^{k}
T_5	Polykote (10ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2337^{bc}	2400^{a}	2346^{a}	2318^{a}	2029^{a}	1928^{a}	1484^{a}	1076^{a}
T_6	Polykote (10ml) + *T. viride* (4g)	2315^{e}	2225^{h}	1904^{g}	2010^{d}	1926^{b}	1754^{b}	1187^{b}	882^{d}
T_7	Hitron (5ml/kg seeds)	2334^{bcd}	2315^{e}	1935^{f}	1822^{h}	1583^{g}	1536^{d}	916^{g}	822^{f}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2353^{a}	2318^{e}	2246^{b}	2067^{b}	1589^{g}	1280^{j}	1174^{c}	914^{c}
T_9	Hitron (5ml) + *T. viride* (4g)	2334^{bcd}	2336^{d}	2026^{d}	2029^{c}	1779^{c}	1560^{c}	1117^{e}	521^{i}
T_{10}	Hitron (10ml)	2335^{bcd}	2241^{g}	1797^{k}	1746^{k}	1631^{e}	1225^{l}	956^{f}	994^{b}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	2352^{a}	2341^{cd}	1804^{j}	1816^{i}	1676^{d}	1507^{e}	1134^{d}	865^{e}
T_{12}	Hitron (10ml) + *T. viride* (4g)	2329^{d}	2337^{d}	1814^{i}	1859^{g}	1618^{f}	1496^{f}	656^{j}	464^{j}
T_{13}	Untreated control	2337^{b}	2307^{f}	1863^{h}	1765^{j}	1580^{g}	1244^{k}	633^{k}	437^{l}
	SEm	14.155	12.535	21.344	8.553	28.370	21.770	14.225	5.346
	CD	6.316	5.943	7.756	4.904	8.940	7.830	6.331	3.882

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

Treatment T_5 recorded higher values for this character from the second month (2400) onwards till the end of the storage period (1076). At fourteen months after storage the highest seedling vigour index I was noticed in T_5 (1484) followed by T_6 (1187) and T_8 (1175). The mean value for vigour index I ranged from 1520 (T_{13}: Untreated control) to 1990 (T_5) over the storage.

4.2.8 Vigour index II

Vigour index II was calculated for all the treatments and presented in Table 21. During the storage period up to twelve months of storage there were no significant differences among the treatments for this parameter but towards the end of storage the treatments were found to be significantly different for seedling vigour index II.

Vigour index II of the treatment declined over the storage period. At the end of storage all the treatments were found to be superior over the control and T_5 maintained highest vigour index II (1.06) followed by T_8 (0.72).

At ten months after storage higher vigour index II values were observed for T_5 (1.55), T_2 (1.27), and T_6 (1.26).

4.2.9 Mean germination time (days)

The results on mean germination time for different seed treatment under storage are presented in Table 22. Progressive increase in mean germination time was observed in all the treatments with advancement in storage period.

Mean germination time was found to be significant at twelve months after storage during storage period.

At twelfth month after storage T_5 recorded a mean germination time of 6.88 days which were on par with T_6 (6.88 days) and T_7 (6.79 days) while T_9 recorded highest mean germination time of 7.7 days.

Table 21: Effect of polymer coating on seedling vigour index II during storage in oriental pickling melon

Treatments		Seedling vigour index II							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	1.72	2.79	1.31	1.40	1.23	1.22	0.64^{cde}	0.61^{bcd}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	1.62	2.39	1.39	1.36	1.15	0.99	0.45^{ef}	0.50^{cde}
T_3	Polykote (5ml) + *T. viride* (4g)	2.12	1.99	1.83	1.52	1.27	1.04	0.48^{ef}	0.46^{de}
T_4	Polykote (10 ml)	2.15	2.22	1.72	1.83	1.17	1.29	0.54^{def}	0.40^{e}
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	2.16	2.42	1.92	2.08	1.55	1.34	0.97^{ab}	1.06^{a}
T_6	Polykote (10ml) + *T. viride* (4g)	1.60	2.26	1.99	1.51	1.26	1.13	0.93^{ab}	0.69^{b}
T_7	Hitron (5ml)	2.10	1.62	1.67	1.59	1.15	1.15	0.84^{abc}	0.64^{bc}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + Bifenthrin (0.1%)	1.92	2.65	1.47	1.50	1.13	1.15	1.09^{a}	0.72^{b}
T_9	Hitron (5ml) + *T.viride* (4g)	1.60	2.30	1.36	1.44	1.19	1.12	0.77^{bcd}	0.37^{e}
T_{10}	Hitron (10ml)	2.56	2.17	1.55	1.50	1.25	1.16	0.81^{bc}	0.62^{bc}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	1.86	2.13	1.51	1.58	1.06	1.02	0.87^{abc}	0.70^{b}
T_{12}	Hitron (10ml) + *T. viride* (4g)	1.85	1.35	1.40	1.38	1.31	1.25	0.42^{ef}	0.42^{e}
T_{13}	Untreated control	1.96	1.66	1.36	1.38	1.36	1.15	0.36^{f}	0.39^{e}
	SEm	0.188	0.306	0.078	0.062	0.024	0.055	0.021	0.009
	CD	NS	NS	NS	NS	NS	NS	0.244	0.157

* M- Months of storage **NS- Non significant *** *T.viride* - *Trichoderma viride*

Table 22: Effect of polymer coating on mean germination time (days) during storage in oriental pickling melon

Treatments		Mean germination time (days)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	6.46	6.56	6.10	6.81	6.82	7.40^{ab}	6.77	7.56
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + Bifenthrin (0.1%)	6.36	6.46	6.49	6.58	6.96	6.40^{de}	7.00	8.82
T_3	Polykote (5ml) + *T. viride* (4g)	6.69	6.68	6.80	7.01	7.67	7.14^{abc}	8.10	8.68
T_4	Polykote (10 ml)	6.26	6.42	6.64	6.57	6.63	6.56^{cde}	7.42	8.79
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	6.40	6.27	6.46	7.22	6.67	6.88^{bcd}	7.54	7.83
T_6	Polykote (10ml) + *T.viride* (4g)	6.19	6.14	6.36	6.61	6.65	6.88^{bcd}	7.84	7.89
T_7	Hitron (5ml)	6.40	6.15	6.31	6.37	6.80	6.79^{bcd}	7.64	7.65
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + Bifenthrin (0.1%)	6.88	6.35	6.48	6.83	6.81	6.01^{e}	6.90	7.09
T_9	Hitron (5ml) + *T. viride* (4g)	5.86	6.78	6.51	6.59	6.22	7.70^{a}	8.52	7.38
T_{10}	Hitron (10ml)	6.68	6.63	6.01	6.01	6.78	7.14^{abc}	8.21	7.22
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	6.01	6.48	6.64	6.90	6.99	7.15^{abc}	7.96	7.56
T_{12}	Hitron (10ml) + *T. viride* (4g)	6.17	6.54	6.62	6.62	6.70	7.16^{abc}	7.98	7.93
T_{13}	Untreated control	6.44	6.48	6.40	6.16	6.73	6.16^{e}	7.07	7.42
	SEm	0.189	0.064	0.084	0.216	0.958	0.135	0.509	0.573
	CD	NS	NS	NS	NS	NS	0.617	NS	NS

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

At the end of storage period the lowest value in mean germination time was noticed in T_8 (7.09 days) followed by T_{10} (7.22 days) and highest value in T_2 (8.82 days).

4.2.10 Time taken for 50 % germination (days)

The results pertaining to time taken for 50 per cent germination are given in Table 23. Generally a progressive increase for time taken for 50 per cent germination was observed in all treatments and treatments were found to be significantly different during eighth, tenth and twelfth month after storage.

During the entire storage period, the mean value for time taken for 50 per cent germination ranged from 5.36 to 6.27 days. Treatment T_4 has highest value (9.33 days) at the end of storage while lowest value was recorded in treatments T_6 (7.67 days) and T_{12} (7.67 days).

4.2.11 Electrical conductivity (µS/m)

The electrical conductivity of seed leachate were significant throughout the storage period and presented in Table 24. Irrespective of the treatments electrical conductivity of seed leachate was found to increase gradually with the advancement of the storage period.

It is evident that treated seed had lower values for electrical conductivity of seed leachate compared to control. Untreated seed exhibited the highest value for this parameter.

At twelve months after storage the highest value for electrical conductivity of seed leachate was noticed in untreated control (56.13 µS/m) followed by T_{11} (49.07 µS/m) and T_7 (64.83 µS/m)

Table 23: Effect of polymer coating on time taken for 50 % germination (days) during storage in oriental pickling melon

Treatments		Time taken for 50 % germination (days)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	4.23	4.22	5.09	6.06^{a}	7.42^{a}	6.89^{bc}	8.01	7.92
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	4.29	4.29	4.63	4.71^{de}	4.84^{c}	6.24^{bc}	8.89	8.11
T_3	Polykote (5ml) + *T. viride* (4g)	4.23	4.18	4.75	5.24^{b}	6.11^{b}	7.78^{ab}	7.58	7.83
T_4	Polykote (10 ml)	4.17	4.31	4.56	5.13^{bc}	6.11^{b}	7.43^{bc}	7.28	9.33
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	4.19	4.19	4.22	4.67^{de}	5.74^{bc}	6.67^{bc}	8.08	8.56
T_6	Polykote (10ml) + *T. viride* (4g)	4.12	4.12	4.31	4.76^{cde}	5.47^{bc}	7.17^{bc}	7.35	7.67
T_7	Hitron (5ml)	4.21	4.21	4.66	5.09^{bcd}	5.82^{bc}	9.69^{a}	7.67	8.81
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	4.24	4.17	4.66	4.90^{bcde}	5.83^{bc}	7.78^{ab}	7.77	7.92
T_9	Hitron (5ml) + *T. viride* (4g)	4.02	4.02	4.64	4.71^{de}	5.36^{bc}	6.66^{bc}	7.28	8.36
T_{10}	Hitron (10ml)	4.21	4.21	4.67	4.67^{de}	5.14^{bc}	6.51^{bc}	7.45	8.00
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	4.08	4.04	4.88	4.81^{cde}	5.61^{bc}	6.07^{bc}	7.56	7.92
T_{12}	Hitron (10ml) + *T. viride* (4g)	4.08	4.08	4.62	4.62^{e}	5.22^{bc}	5.55^{c}	7.00	7.67
T_{13}	Untreated control	4.18	4.26	4.70	4.81^{cde}	5.30^{bc}	7.27^{bc}	8.47	8.44
	SEm	0.012	0.019	0.073	0.062	0.481	1.368	0.966	0.682
	CD	NS	NS	NS	0.417	1.165	1.964	NS	NS

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

Table 24: Effect of polymer coating on electrical conductivity during storage in oriental pickling melon

Treatments		Electrical conductivity (µS/m)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	17.03^{bcde}	17.63^{cde}	22.50^{efg}	28.80^{bc}	43.97^{b}	43.10^{de}	62.17^{b}	86.90^{b}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	13.67^{def}	16.83^{de}	24.45^{cdef}	28.90^{bc}	40.63^{bc}	45.23^{cd}	57.27^{c}	76.53^{de}
T_3	Polykote (5ml) + *T viride* (4g)	19.37^{b}	27.20^{a}	30.50^{ab}	27.37^{cde}	37.17^{cde}	36.53^{gh}	62.10^{b}	77.90^{d}
T_4	Polykote (10 ml)	18.60^{bc}	19.27^{c}	28.27^{abc}	28.85^{bc}	38.93^{cd}	39.67^{efg}	65.10^{ab}	76.67^{de}
T_5	Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%)	13.23^{ef}	17.08^{cde}	19.57^{g}	23.47^{f}	30.77^{f}	32.90^{h}	50.13^{d}	67.10^{f}
T_6	Polykote (10ml) + *T viride* (4g)	18.00^{bcd}	18.87^{cd}	31.13^{a}	26.31^{cdef}	35.93^{de}	39.30^{fg}	54.90^{c}	76.53^{de}
T_7	Hitron (5ml/kg seeds)	12.01^{f}	16.83^{de}	26.45^{cde}	24.78^{def}	37.27^{cde}	47.33^{bc}	56.20^{c}	85.27^{bc}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	14.77^{bcdef}	19.03^{cd}	22.97^{defg}	23.63^{ef}	34.33^{ef}	42.33^{def}	54.63^{c}	75.27^{de}
T_9	Hitron (5ml) + *T. viride* (4g)	14.43^{cdef}	18.37^{cde}	27.85^{abc}	31.77^{b}	40.50^{bc}	45.43^{bcd}	55.23^{c}	85.13^{bc}
T_{10}	Hitron (10ml)	13.18^{ef}	16.10^{e}	25.80^{cde}	29.53^{bc}	33.40^{ef}	45.50^{bcd}	56.90^{c}	82.50^{c}
T_{11}	Hitron (10ml) + carbendzim-mancozeb (2g) + bifenthrin (0.1%)	14.33^{cdef}	$16.93d^{e}$	21.00^{fg}	27.30^{cde}	36.33^{de}	42.09^{def}	54.37^{c}	74.07^{e}
T_{12}	Hitron (10ml) + *T. viride* (4g)	12.92^{ef}	17.90^{cde}	27.52^{abc}	27.83^{cd}	44.43^{ab}	49.07^{b}	64.83^{ab}	87.57^{b}
T_{13}	Untreated control	24.70^{a}	24.54^{b}	26.61^{bcd}	36.77^{a}	48.27^{a}	56.13^{a}	66.50^{a}	93.03^{a}
	SEm	7.61	1.905	5.709	5.15	5.84	5.008	3.312	3.667
	CD	4.63	2.317	4.011	3.81	4.05	3.757	3.055	3.215

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

At the end of the storage period treatment T_5 recorded lowest value in electrical conductivity of seed leachate (67.10µS/m) followed by T8 (75.27µS/m) and T_6 (76.53 µS/m).

4.2.12 Dehydrogenase enzyme activity (OD value)

The results for dehydrogenase enzyme activity of the various treatments over storage are depicted in Table 25. A gradual decline in dehydrogenase enzyme activity was observed in all treatments throughout the storage period.

At the end of the storage period all other treatments were found to be superior over, untreated control and high value for dehydrogenase enzyme activity was recorded in T_5 (0.333) followed by T_8 (0.312). Treatments T_{11} (0.312), and T_1 (0.308) were on par with T_8.

4.2.13 Seed moisture (%)

Seed moisture content was not influenced by the seed treatment and throughout the storage period seed moisture content varied marginally and it was not significantly different among treatments (Table 26).

4.2.14 Seed microflora (%)

The effect of polymer film coating on seed infection is presented in Table 27. Significant difference in the percentage of seed infection was noticed in both agar and blotter method. Comparatively less infection was noticed in blotter method than agar method. In both methods the untreated control showed high percentage of infection compared to other treatments.

In blotter method, higher percentage of infection (10.00%) was observed in untreated seeds, T_7 and T_{10}. Whereas, no infection was recorded in T_3, T_5, T_8 and T_{12}.

Table 25: Effect of polymer coating on dehydrogenase enzyme activity during storage in oriental pickling melon

Treatments		Dehydrogenase enzyme activity (OD value)							
		M2	M4	M6	M8	M10	M12	M14	M16
T_1	Polykote (5ml)	0.550	0.509^{ab}	0.325^{d}	0.320^{c}	0.310^{d}	0.309^{cde}	0.309^{cd}	0.308^{bc}
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.569	0.511^{ab}	0.423^{ab}	0.408^{a}	0.334^{bc}	0.309^{cde}	0.308^{cd}	0.304^{cde}
T_3	Polykote (5ml) + *T. viride* (4g)	0.532	0.484^{bc}	0.422^{ab}	0.413^{a}	0.352^{ab}	0.303^{e}	0.302^{d}	0.298^{de}
T_4	Polykote (10 ml)	0.505	0.517^{ab}	0.413^{b}	0.329^{bc}	0.325^{cd}	0.310^{cde}	0.309^{cd}	0.305^{cde}
T_5	Polykote (10ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.550	0.521^{a}	0.469^{a}	0.432^{a}	0.358^{a}	0.345^{a}	0.344^{a}	0.333^{a}
T_6	Polykote (10ml) + *T. viride* (4g)	0.520	0.453^{c}	0.411^{b}	0.361^{b}	0.317^{cd}	0.314^{bcd}	0.313^{bc}	0.309^{bc}
T_7	Hitron (5ml)	0.525	0.416^{d}	0.358^{cd}	0.321^{c}	0.318^{cd}	0.312^{bcde}	0.311^{bcd}	0.307^{bcd}
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.523	0.513^{ab}	0.397^{bc}	0.403^{a}	0.318^{cd}	0.321^{b}	0.32^{b}	0.316^{b}
T_9	Hitron (5ml) + *T .viride* (4g)	0.547	0.516^{ab}	0.362^{cd}	0.323^{c}	0.323^{cd}	0.314^{bcd}	0.31^{bcd}	0.306^{cde}
T_{10}	Hitron (10ml)	0.566	0.511^{ab}	0.323^{d}	0.311^{c}	0.311^{d}	0.312^{bcde}	0.311^{bcd}	0.307^{bcd}
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.560	0.514^{ab}	0.339^{d}	0.362^{b}	0.328^{cd}	0.317^{bc}	0.316^{bc}	0.312^{bc}
T_{12}	Hitron (10ml) + *T. viride* (4g)	0.542	0.512^{ab}	0.352^{cd}	0.336^{bc}	0.313^{d}	0.308^{cde}	0.307^{cd}	0.303^{cde}
T_{13}	Untreated control	0.545	0.514^{ab}	0.325^{d}	0.319^{c}	0.308^{d}	0.305^{de}	0.302^{d}	0.298^{e}
	SEm	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000
	CD	NS	0.035	0.048	0.037	0.021	0.01	0.010	0.009

* M- Months of storage **NS- Non significant *** *T.viride - Trichoderma viride*

Similar trend was observed in agar plate method. Higher per cent of infection (16.67%) was noticed in untreated seeds followed by T_9 (16.67%), T_{10} (13.33%) and T_{10} (30.0%). Among the treatments lower percentage of infection was noticed in T_5 (3.33%) followed by T_8 and T_{12}.All treatments showed higher percentage of infection in agar plate method whereas T_1, T_2, T_7, T_{11}, T_4 maintained same level of infection in both methods. The pathogens detected on seeds of oriental pickling melon through the identification methods are *Aspergillus flavus* and *Aspergillus niger*.

Table 26: Effect of polymer coating on seed moisture content at the end of storage period in oriental pickling melon

Treatments		Seed moisture (%)
T_1	Polykote (5ml)	6.11
T_2	Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	6.12
T_3	Polykote (5ml) + *T. viride* (4g)	6.11
T_4	Polykote (10 ml)	6.12
T_5	Polykote (10ml) + carbendazim- mancozeb (2g) + bifenthrin (0.1%)	6.12
T_6	Polykote (10ml) + *T. viride* (4g)	6.12
T_7	Hitron (5ml)	6.12
T_8	Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	6.15
T_9	Hitron (5ml) + *T.viride* (4g)	6.13
T_{10}	Hitron (10ml)	6.13
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	6.14
T_{12}	Hitron (10ml) + *T. viride* (4g)	6.12
T_{13}	Untreated control	6.12
	SEm	0.00
	CD	NS

Table 27: Effect of polymer coating on seed microflora at the end of storage period in oriental pickling melon

Treatments		Seed infection (%)	
		Blotter method	Agar method
T_1	Polykote (5ml)	6.67	6.67
T_2	Polykote (5ml) +carbendazim-mancozeb (2g) +bifenthrin (0.1%)	6.67	6.67
T_3	Polykote (5ml) + *T. viride* (4g)	0.00	6.67
T_4	Polykote (10 ml)	3.33	6.67
T_5	Polykote (10ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.00	3.33
T_6	Polykote (10ml) + *T. viride* (4g)	6.67	10.00
T_7	Hitron (5ml)	10.00	10.00
T_8	Hitron (5ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%)	0.00	3.33
T_9	Hitron (5ml) + *T .viride* (4g)	10.00	16.67
T_{10}	Hitron (10ml)	6.67	13.33
T_{11}	Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)	6.67	6.67
T_{12}	Hitron (10ml) + *T. viride* (4g)	0.00	3.33
T_{13}	Untreated control	10.00	16.67

Discussion

5. DISCUSSION

Since time immemorial, seed has played a crucial role in agriculture. It is the most essential and basic input which decides the performance and commercial success of the crop. Being a living entity seed undergoes natural ageing and senescence. The loss of seed vigour and viability is inevitable but it can be reduced to some extent by adopting proper management practices.

Seed treatment refers to the exposure of seeds to certain physical, chemical, biological agents in order to enhance all aspects of seed quality. Many seed technological interventions have been successfully attempted for enhancing the seed quality of carry over seeds; polymer film coating is one such promising technology.

Polymer coating technology is a sophisticated process that allows precise distribution of active ingredients along with a liquid material directly on to the seed surface without altering its shape and causing a total seed weight gain of up to 1 to 2 per cent. Polymer coating acts as physical barrier which has been reported to reduce the leaching of inhibitors from seed covering. Therefore, it is one of the best alternative approach to maintain seed quality during storage.

Coated seed has several benefits. It is an effective delivery system for agrochemicals, providing uniform and precise chemical placement on the seed which is dust free, reduced dust-off during disinfestation, safer for the applicator, visible in the soil, ensures brand identity and is ecofriendly.

The results of the present study on 'Seed quality enhancement in okra and oriental pickling melon with film coat', 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.

105

5.1 Germination (%)

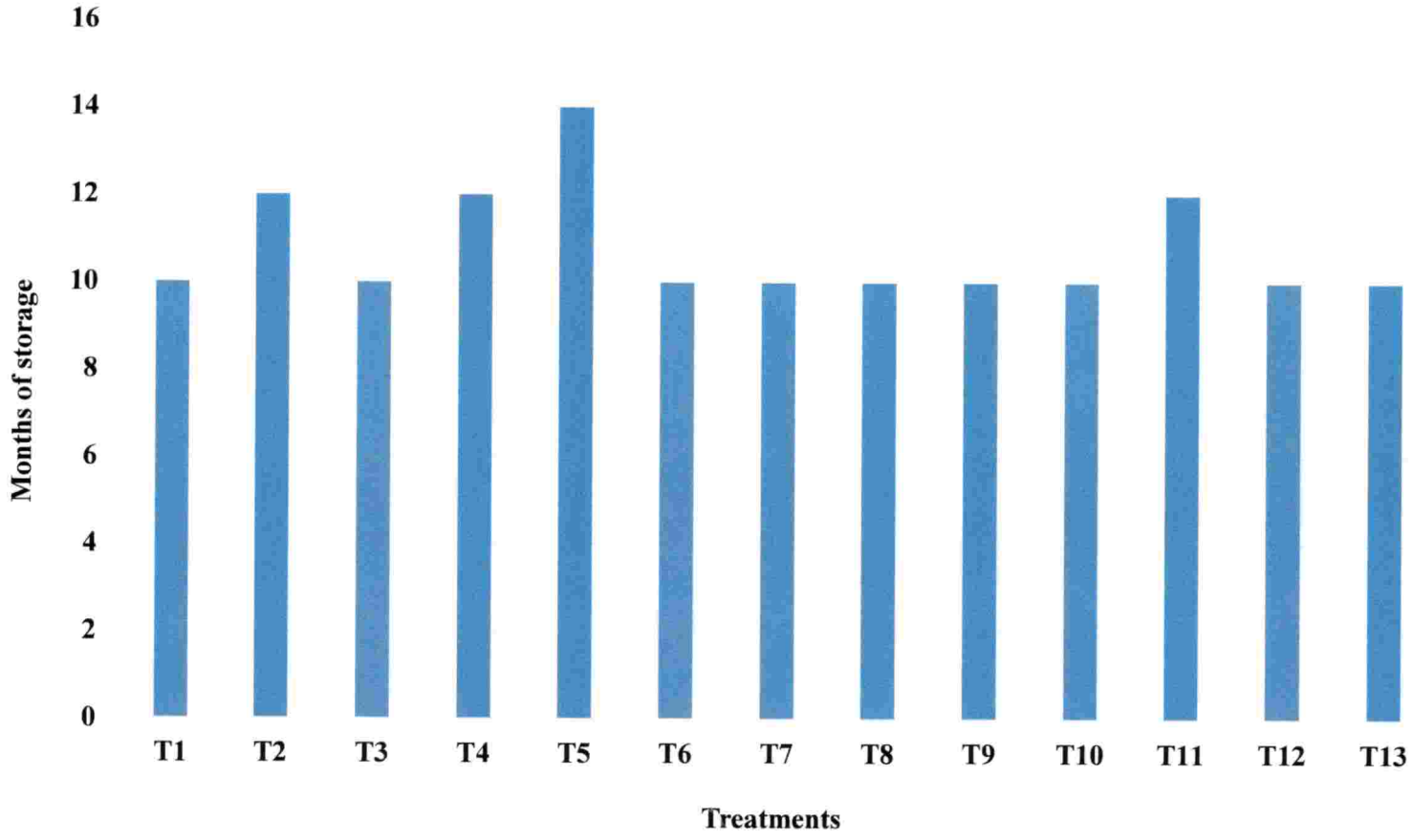
Germination is the basic requirement and key indicator of good quality seed. Loss of seed germination is directly proportional to rate of deterioration and it is increases with ageing.

Higher per cent of germination was observed during the initial months of storage in both okra and oriental pickling melon. In storage, germination per cent declined with increase in storage period irrespective of treatments and storage conditions, as reported by several pioneer workers, in vegetables such as cowpea (Aswathi, 2015 and Antony, 2016), chillies (Navya, 2016, Sandhya, 2016), ash gourd (Shobha, 2016),oriental pickling melon (Nagendra, 2017), and in field crops such as wheat (Tiwari *et al.*,2015) and cotton (Kaushik *et al.*, 2014, Mahantesh *et al.*, 2017, Rathinavel, 2015).

The rate of reduction in germination per cent from the initial to final months of storage was slower in polymer coated seed compared to untreated seed. Similar results were reported by Manjunatha *et al.* (2008) and Kumari *et al.* (2014) in chilli; Basavaraj *et al.* (2008) in onion; Keawkham *et al.* (2014) in cucumber and Dhiman (2015) in okra.

In okra, variety Arka Anamika, while considering the MSCS, the treatment T_5: Polykote (10ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%) per kg seeds retained viability up to fourteen months of storage (Fig. 1). The enhanced germination and viability of polymer treated seeds along with fungicide and insecticide may be due to the combined positive action of these chemicals with polymers. According to Basavaraj and Rai (2016) the polymer coated chickpea seeds treated with chemicals and biological agents had superiority in seed quality throughout the storage period. Similar reports have been obtained in onion by Basavaraj *et al.* (2008), Manjunath *et al.* (2008) and Sushma (2013) in chilli.

Fig. 1: Effect of polymer coating on retention of seed viability in okra



Among the two polymers used, Polykote was found to perform better. However, both polymers along with plant protection chemicals were effective in seed quality enhancement. According to Basavaraj *et al.* (2008) by encasing the seed within a thin film of bio degradable polymer, the adherence of seed treatment to the seed can be improved, ensuring dust free handling. This makes the technology both useful and environment friendly in addition it makes sowing operation easier due to the smooth flow of seeds.

In okra, the untreated control lost viability at the twelfth month of storage with a germination per cent of 44.67 while the best treatment polykote (10 ml) along with carbendazim–mancozeb and bifenthrin retained a germination per cent of 76.00.

In oriental pickling melon variety Mudicode local, the untreated seeds declined in germination below MSCS at fourteen months of storage whereas the best treatment T_5: Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seeds recorded a germination per cent of 65.33 (Fig. 2).

Both in okra and oriental pickling melon, treatments T_5: Polykote (10ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%) per kg seeds, T_8: Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seeds and T_{11}: Hitron(10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seeds retained higher germination per cent at sixteen months of storage compared to other treatments including control (Fig. 3).

Manjunatha *et al.* (2008) suggested that chilli seeds coated with polymer @ 7.0 g per kg and thiram @ 2.0 g per kg remained viable up to twelve months of storage. Similarly, the studies by Renugadevi *et al.* (2008) in cluster bean seeds reported that inclusion of plant protection chemicals in poly coating resulted in 9 per cent improvement in germination compared to control. Similar finding were also reported by Thontadarya *et al.* (2010) in cowpea; Vijayalakshmi *et al.* (2013) in tomato; Vijayalakshmi *et al.* (2013) and Manoharapaladagu *et al.* (2017) in chili; Chaubey *et*

Fig. 2: Effect of polymer coating on retention of seed viability in oriental pickling melon

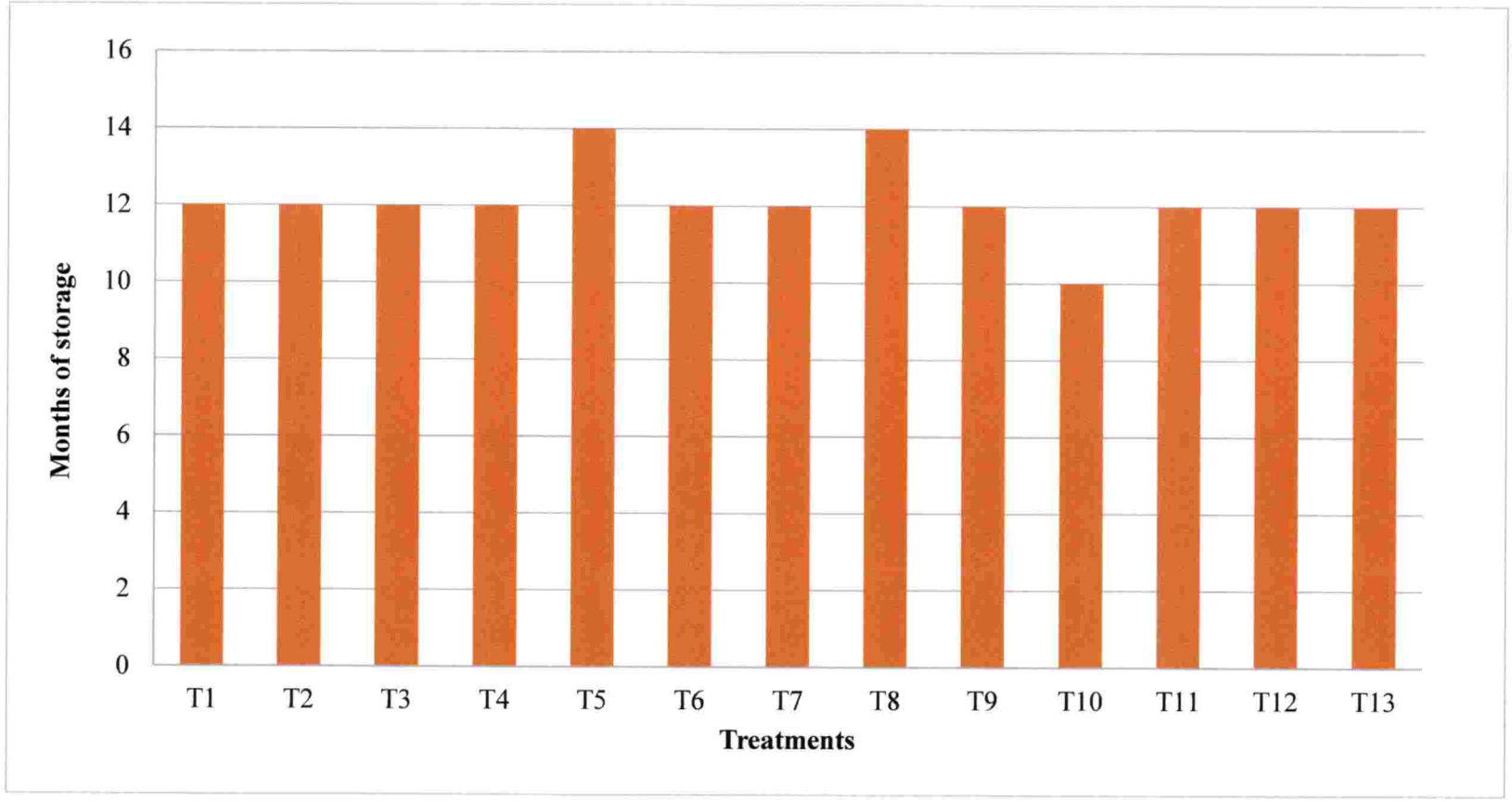
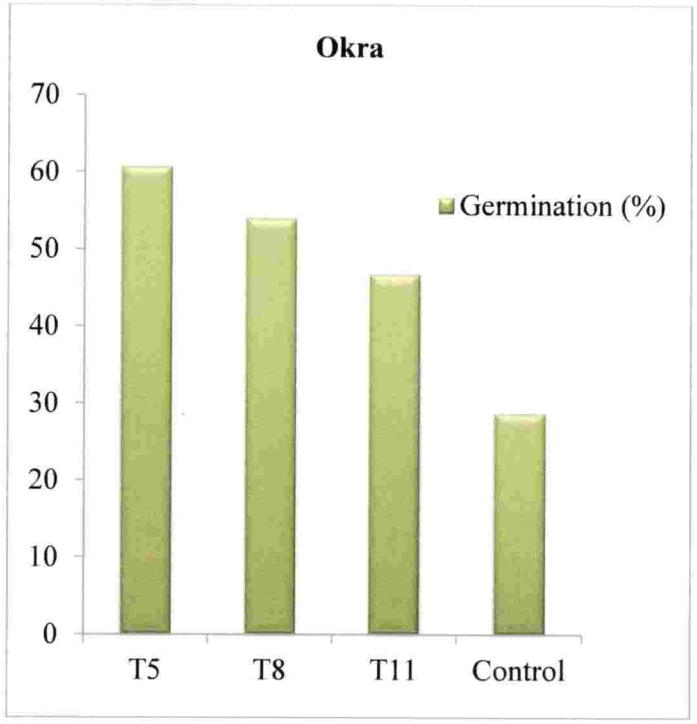
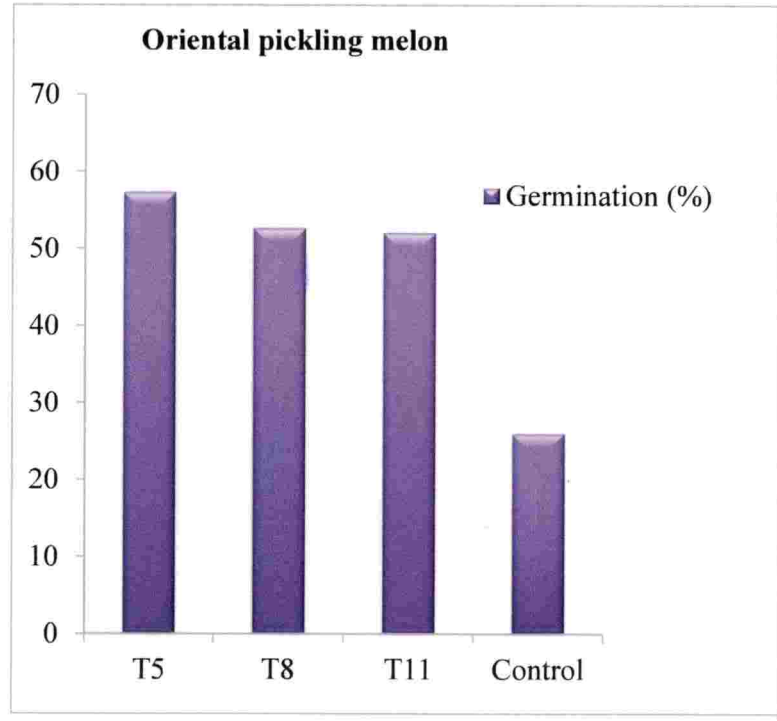


Fig. 3: Superior polymer treatments in okra and oriental pickling melon





al. (2014) in broccoli ;Verma and Verma (2014) in soybean, Ghosh *et al.* (2016) and Rajeshwari *et al.* (2016) in rice;

In both crops, polymer treatments exhibited superiority over control for germination per cent. This may be due to the easy absorption of moisture during germination. Manjunatha *et al.* (2008) opined that higher germination of polymer coated seeds may be due to increase in the rate of imbibition where the fine particles in the coating act as a moisture attractant. According to Vanagamudi *et al.* (2010), the increase in germination of polymer coated seeds is due to its hydrophyllic nature which improves the imbibition rate in turn leading to the increased enzyme activity of cells accelerating the biochemical reactions aiding germination.

5.2 Seedling shoot length (cm)

A gradual decline in seedling shoot length was observed with the advancement in storage period although the responses varied among the treatments. T_5 (Polykote (10ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%) per kg seeds) recording higher seedling shoot length. The results are in concurrence with the findings of Aswathy (2015) and Antony (2016) in cowpea; Navya (2016) and Sandhya (2016) in chilli.

In okra, at tenth months of storage T_9: Hitron (5ml) + *Trichoderma viride* (4g) per kg of seed recorded highest seedling shoot length and found to be on par with T_5: Polykote (10ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%) per kg seed. The seedling shoot length gradually decreasing over the storage period. The decline in seedling shoot length is might be due to loss of vigour and age induced reduction in germination.

In OP melon, at twelve months of storage (the month where most of treatments retained MSCS of germination) T_5: Polykote (10ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%) per kg seed recorded higher seedling shoot length and which is on

par with the treatments T_6 : Polykote (10 ml) + *Trichoderma viride* (4g) , T_9 : Hitron (5ml) + *Trichoderma viride* (4g). The results for variations in seedling shoot length agree with the results recorded by Basavaraj *et al.* (2016) in onion; Chandravathi (2008) in pearlmillet; Devi *et al.* (2014) in soybean; Kaushik *et al.* (2014) in wheat and Rakesh *et al.* (2017) in castor.

5.3 Seedling root length (cm)

Irrespective of the treatments a gradual significant decline in the seedling root length was observed over the period of storage. The results were similar with the findings by Sandhya (2016) in chilli.

In okra, the highest value for seedling root length was recorded in T_5: Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seeds followed by T_{10}: Hitron (10ml/kg seeds) and T_8: Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seeds.

In OP melon, the highest value for seedling root length was recorded in Polykote (10ml) + *Trichoderma viride* (4g) per kg seeds at twelve months of storage. In both crops, polymer coating along with the plant protection agents recorded higher values for seedling root length.

The reason for decline in root length and seedling length may be attributed to reduction in germination and vigour and also due to the increased number of abnormal seedlings over the storage period (Mohammad, 2012). Similar results were reported by Basavaraj (2007) in onion, Devi *et al.* (2014) in soybean, Ma *et al.,* 2017 in cowpea, Rakesh *et al.* (2017) in castor.

5.4 Seedling dry weight (g)

The dry matter content of seedlings is the result of physiological vigour. Seedling vigour index II is usually measured by the seedling weight after a period of

storage and this is essentially a physiological phenomenon regulated by the metabolites, enzyme activities and growth regulators (Qualls and Cooper, 1968).

In okra, the seedling dry weight value of the best treatment [T_5: Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] ranges from 0.037 g to 0.016 g and in all treatments the value decreasing as storage period advanced.

In OP melon, it was observed that seedling dry weight decreased with increase in storage period. Treatment T_5: Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed initially recorded a seedling dry weight of 0.022 g that gradually reduced to 0.019 g at sixteen months of storage. Similar results were observed by Nagendra (2017) in oriental pickling melon.

Seeds treated with polymer, fungicide, insecticide and bioagent showed higher seedling dry weight which indicates that there is a positive effect of seed coating polymer on seedling dry weight in storage. These results agree with the findings of Basavaraj (2007) in onion; Manjunatha *et al.* (2008), Vijayalakshmi *et al.* (2013) and Satyabhama *et al.* (2016) in chilli; Siddaraju *et al.* (2015) in maize and Rajeshwari *et al.* (2017) in rice.

5.5 Seedling vigour indices

An important factor related to seed viability is the seed vigour. Manifestation of germination alone may not reveal the real potential of a seed lot the assessment of seedling vigour indices is also more important for judging the quality of seed.

Adbul-Baki and Anderson (1973) assessed the seed vigour by multiplying seedling length or dry weight with germination percentage. The seedling vigour index based on seedling length is well correlated with seedling vigour index based on seedling dry weight.

Polymer coating along with the additives were found superior over untreated control for seedling vigour indices in both okra and OP melon. Irrespective of the treatments seedling vigour indices gradually decreasing over storage period.

In okra, it is evident that among the various polymer treatments the highest vigour indices were noticed in seeds with polymer (10 ml) along with carbendazim – mancozeb and bifenthrin, which is in conformity with the findings of Dhiman (2015) (Fig. 4).

In OP melon, highest seedling vigour indices were recorded in T_5: Polykote (10ml) + carbendzim-mancozeb (2g) + bifenthrin (0.1%) per kg seeds at the end of storage (Fig. 5).

A study conducted by Manoharapaladagu *et al.* (2017) revealed that seedling vigour index I and II were significantly higher in chilli seeds coated with polymer @ 7ml/kg of seed along with thiram @ 2g/kg of seed and stored for six months. The effect of polymer coating on seedling vigour indices has been reported by several workers, Vijayalakshmi *et al.* (2013) in brinjal; Badiger *et al.* (2014) and Rathinavel (2015) and in cotton; Sushma (2013) and Basavaraj and Rai (2016) in chickpea; Ghosh *et al.* (2016) in rice.

5.6 Mean germination time (days)

Progressive increase in mean germination time was observed in all the treatments with advancement in storage period. According to Shobha (2016) mean time germination was negatively correlated with germination in ash gourd.

Mean germination time was found to be non significant during the initial months of storage. In both crops, the mean germination time recorded lower values during the initial months of storage which may be due to high vigour and viability of the seed lot that leading to quick germination of seed.

Fig. 4: Influence of polymer coating on seedling vigour indices on okra

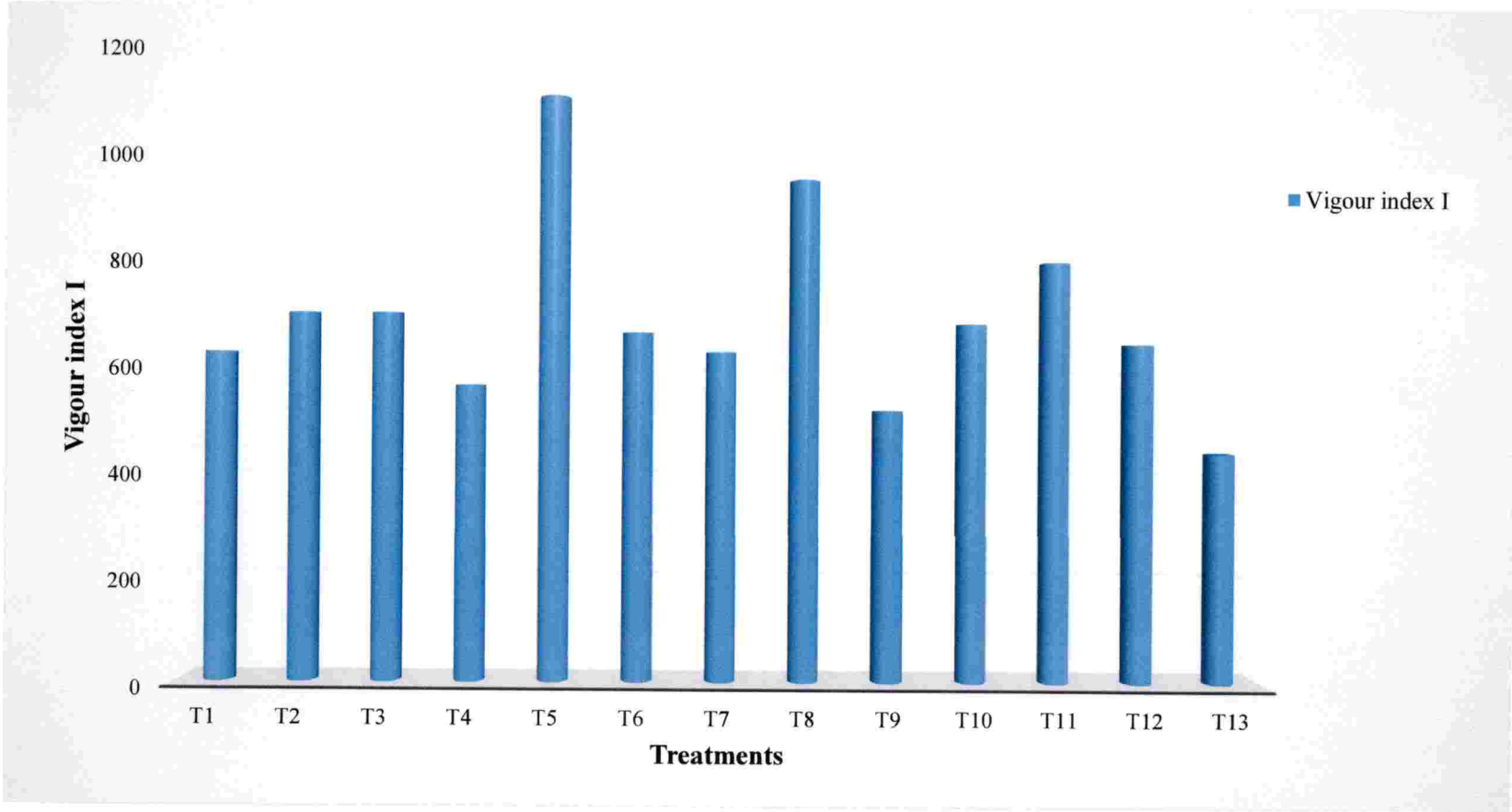
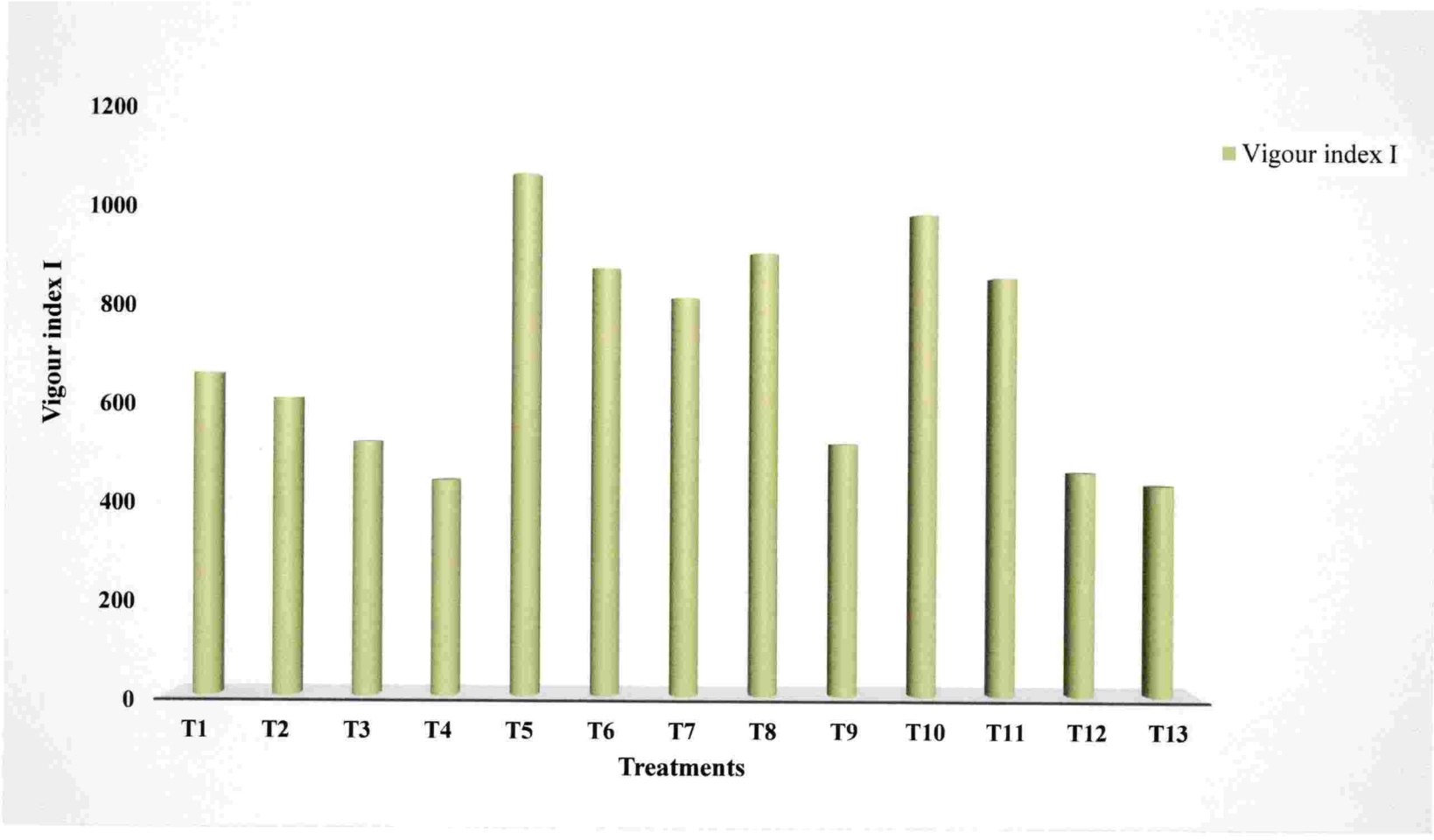


Fig. 5: Influence of polymer coating on seedling vigour indices in oriental pickling melon



A good viable seed germinates quickly which requires lesser time to germinate therefor we prefer least value for mean germination time. In okra, T_8 [Hitron (5ml) + carbendazim-mancozeb (2g) +bifenthrin (0.1%) per kg seed] recorded lower value for this character at twelve months of storage.

In OP melon, among the treatments T_9: Hitron (5ml) + *Trichoderma viride* (4g) per kg of seed observed with lower mean germination time. Nagendra (2017) reported that seed with good germination and vigour required with less time to germinate in OP melon.

5.7 Time taken for 50 per cent germination (days)

The results for time taken for 50 per cent germination also follows same trend as that of mean germination time. Progressive rise was observed in all treatments for this parameter with increase in storage period. Such gradual rise in this trait was also reported by Nagendra (2017) in oriental pickling melon.

In storage polymer coated seeds observed lower value for this character. The reason might be that polymer coating can enhance the absorption of water, gas and nutrients to the seeds during imbibition that lead to further quick action of hormones and enzymes which results in rapid and easy seedling emergence (Sujatha and Ambika, 2016).

5.8 Electrical conductivity (µS/m)

Electrical conductivity of seed leachate indicates the membrane integrity and permeability of seed and it is negatively correlated with seed quality (Basavaraj *et al.*, 2007). It is one of the bio-chemical characters assessed for seed deterioration. Increased seed leachate associated with reduction in germination per cent, vigour and field emergence.

The electrical conductivity of seed leachate increased with advancement in storage period which are in conformity with the results of Aswathi (2015) in cowpea and Shobha (2016) in ash gourd.

The variation in electrical conductivity of seed leachates indicates differences in membrane permeability, seed coat compactness and membrane deterioration. The variation among the treatments for this character was significant. Similar, results were reported by Manjunatha *et al.* (2008) in chilli; Mohammad (2012) in maize; Vinodkumar *et al.* (2013) in pigeonpea; Devi (2014) in soybean; Badiger *et al.*(2014) in cotton and Ghosh *et al.* (2016) in rice.

The untreated control observed the highest values for this parameter among the treatments. It may be due to higher incidence of fungi which can destroy the membrane texture in seeds which stored without any pre storage chemical treatments.

In the present study, a progressive rise in electrical conductivity of seed leachate was observed over the storage period irrespective of the treatments. In both crops, lower seed leachate was recorded in the treatment T_5: Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seeds after sixteen months of storage (Fig. 6 and Fig. 7). Throughout the storage period the polymer coating along with the plant protection chemicals registered lower values for electrical conductivity. Lower value for seed leachate indicates reduction in rate of deterioration and lipid peroxidation. The reason may be that polymer film formed around the seed acts as a physical barrier, which reduce the leaching of electrolytes from the seed and may restrict oxygen diffusion to the embryo.

Seeds treated with polymer, fungicide, insecticide and bioagent have less electrical conductivity of seed leachates as compared to untreated seeds due to maintenance of cell membrane integrity. It might be due to impervious nature of polymers for the internal constituents which also confirmed by Basavaraj and Rai (2016) in chilli.

Fig. 6: Effect of polymer coating on electrical conductivity of seed leachate in okra

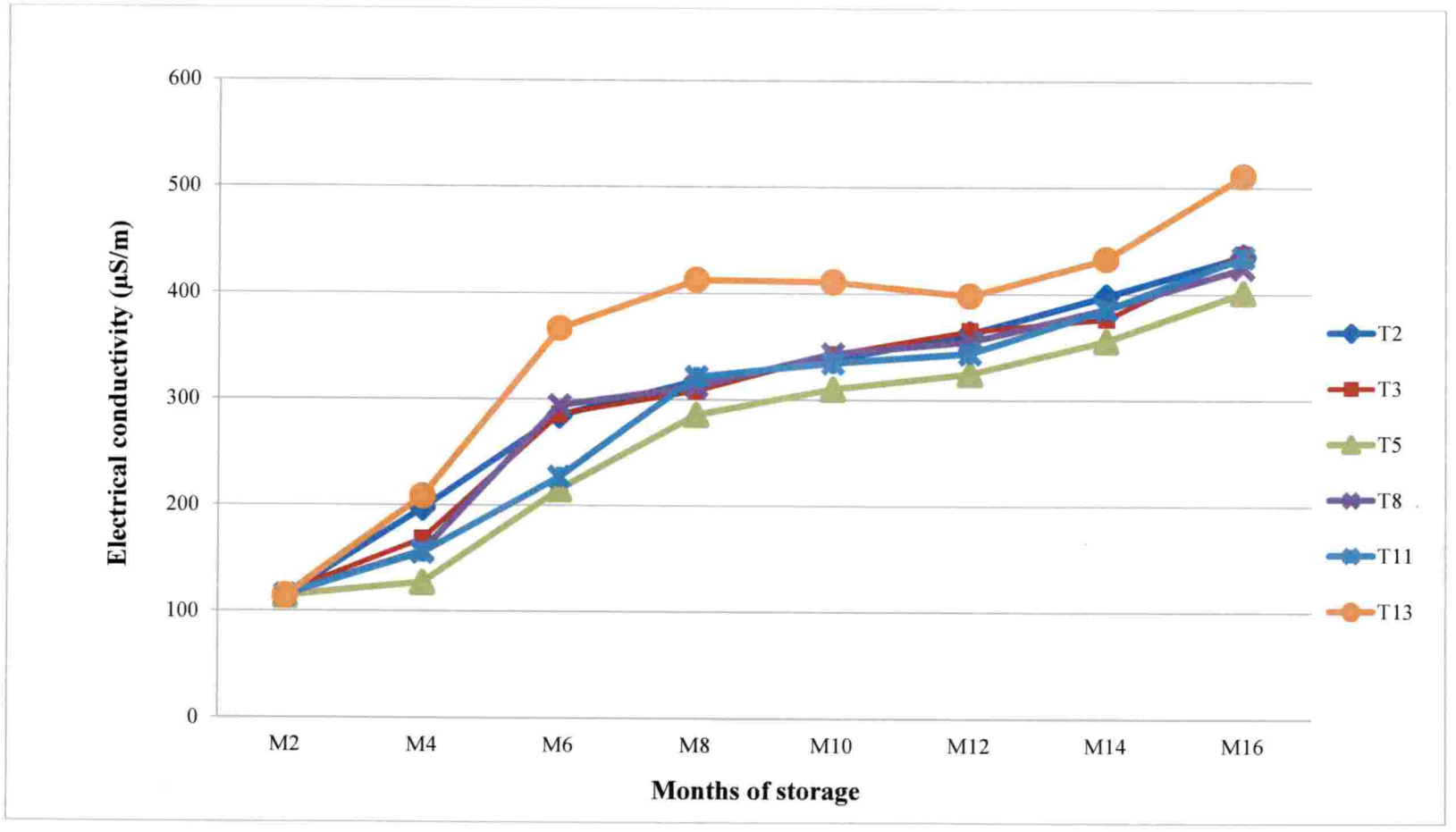
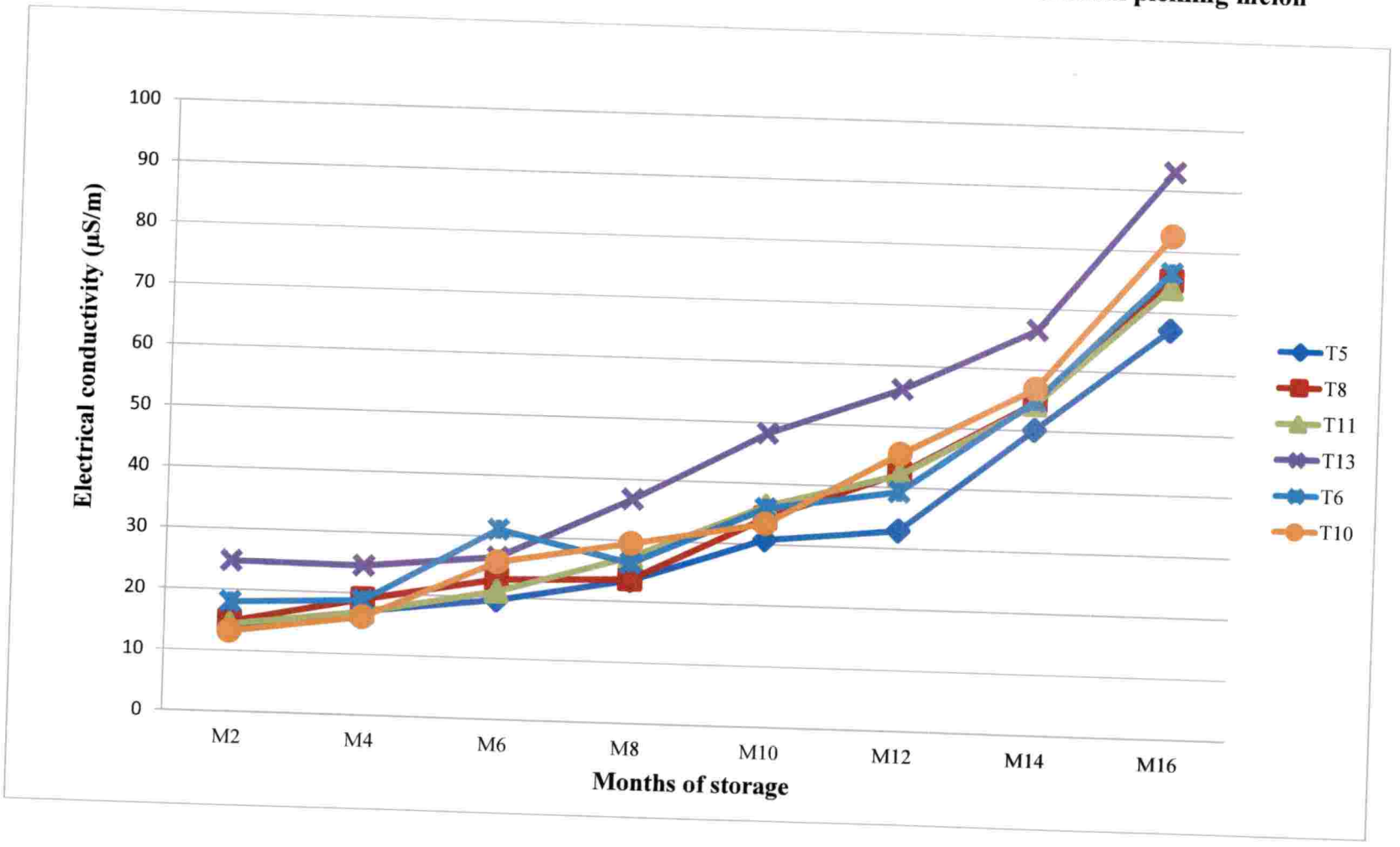


Fig. 7: Effect of polymer coating on electrical conductivity of seed leachate in oriental pickling melon



5.9 Dehydrogenase enzyme activity (O D)

All the living seeds which respire produce enzymes called dehydrogenase hence, dehydrogenase activity is considered to be a positive indicator for testing the seed viability status. It is a measure of the living cells present in the embryo, a good viable seed possesses higher value for dehydrogenase enzyme activity.

According to Navya (2016) higher enzyme activity is an indication of high vigour in chilliand reported that in the presence of dehydrogenase enzyme the colourless tetrazolium converted to pink coloured formazon.

In the present study, dehydrogenase enzyme activity gradually declined as the seeds lost their vigour and the figure (Fig. 8 and 9) shows the comparison of dehydrogenase enzyme activity at tenth and sixteen months after storage. Similar findings were also reported by Aswathi (2015) in cowpea.

In okra, initially all the treatments observed higher values for dehydrogenase activity which is reflected in the germination per cent. At the end of storage, polymer treatments were found to be superior over untreated seeds for this parameter. Among the treatments, T_5 [Polykote (10ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed], T_8 [Hitron (5ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed], T_{11} [Hitron (10 ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed] recorded best result for dehydrogenase enzyme activity.

In both crops, higher dehydrogenase activity was observed in seeds treated with polymer coupled with plant protection chemicals. Korishettar *et al.* (2017) observed that significant effect was present in dehydrogenase enzyme activity of pigeonpea due to seed polymer coating.

Fig. 8: Impact of polymer film coating on dehydrogenase enzyme activity in okra

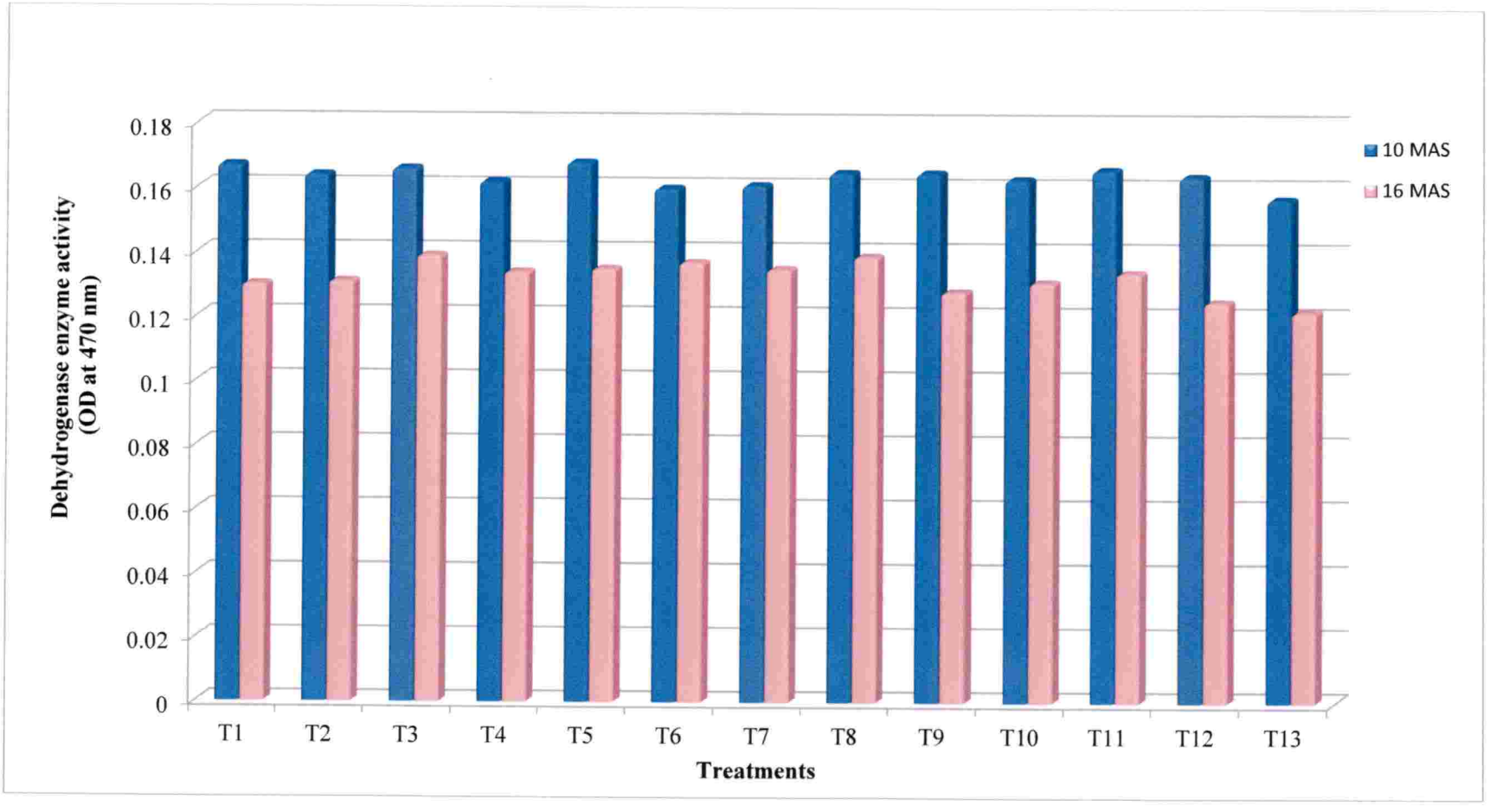
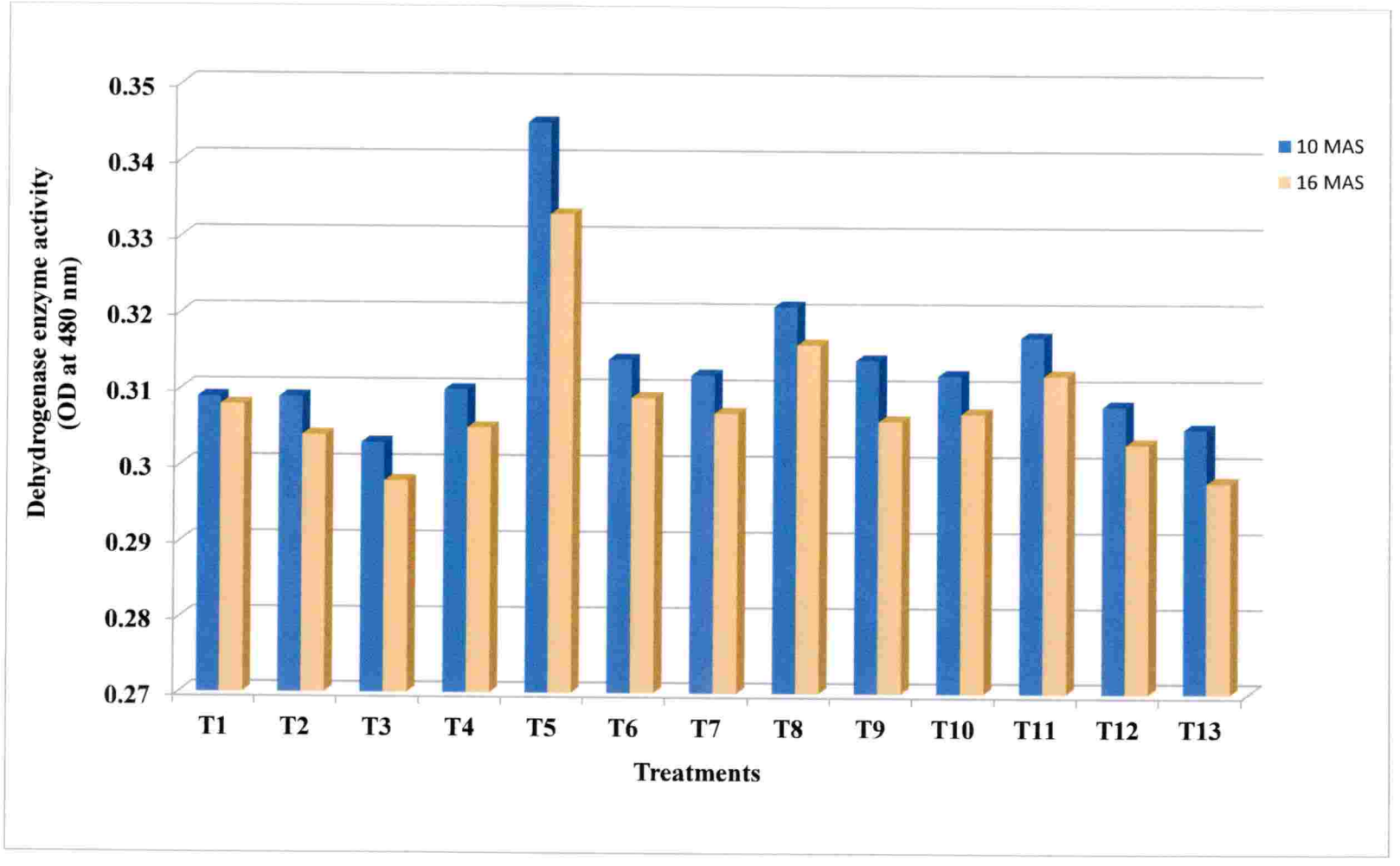


Fig. 9: Impact of polymer coating on dehydrogenase enzyme activity in oriental pickling melon



5. 10 Seed moisture (%)

Throughout the storage period, there was no significant difference in seed moisture content among the treatments. This may be due to the packing material used (700 gauge polyethylene cover) which is moisture impervious.

5.11 Seed microflora (%)

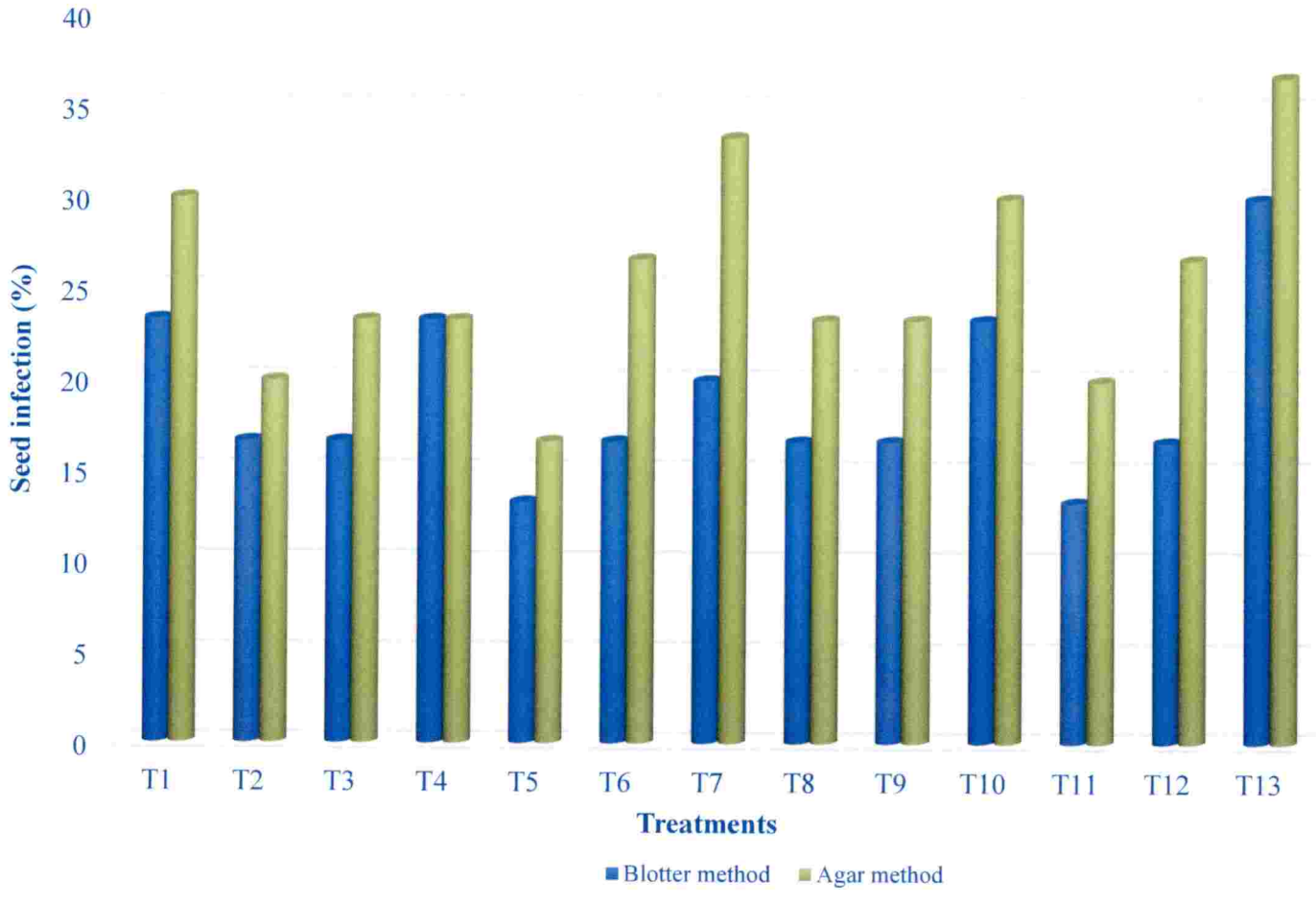
Seed that is neither infested nor infected before sowing may still be a carrier of pathogens. Since healthy seeds are a prerequisite for the success of any crop production it is essential to protect the seeds from the invasion of microorganisms.

Incidence of storage pathogen increases with advancement of storage period. The incidence of storage pathogen is high if the seed is not protected and storage conditions are favourable to them. It is reported that storage fungi can invade and destroy the seeds of several species (Gupta *et al.,* 1993). This causes loss of viability, development of unfavourable odour and discoloration of seed. In the present study, the infection rate differed with seed treatment, chemicals used and storage period.

In okra, higher percentage of infection (30.00%) was observed in untreated seeds followed by T_1: [Polykote (5ml/kg seeds)] (23.33%), T_3: [Polykote (10ml/kg seeds)] (23.33) and T_{10} [Hitron (10ml/kg seeds)] (23.33%). Whereas, lowest infection percentage was noticed in T_5 and T_{11}. It was evident that the pathogen infection less in seeds treated with polymers along with a combination of insecticide and fungicides (Fig 10).

Similar results were observed by Manjunatha *et al.* (2008) in chilli, where they observed significantly lower seed infection in seeds coated with polymer @ 7.0 g per kg of seed along with thiram @ 2 g per kg of seed as compared to control at the end of the storage period.

Fig. 10: Effect of polymer coating on seed infection in okra



Comparatively low per cent of infection was observed in oriental pickling melon. It may be due to the mucilaginous layer around the seed coat which provides an additional protection to the seed. Complete absence of seed infection was noticed in treatments Polykote (5ml) + *T. viride* (4g), Polykote (10ml) +carbendazim- mancozeb (2g) + Bifenthrin (0.1%), Hitron (5ml) +carbendazim-mancozeb (2g) + bifenthrin (0.1%), Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%)in blotter method. The low or less degree of fungal infection might be due to protection by fungicide and bio control agents and their toxic effects against fungal bodies (Fig 11).

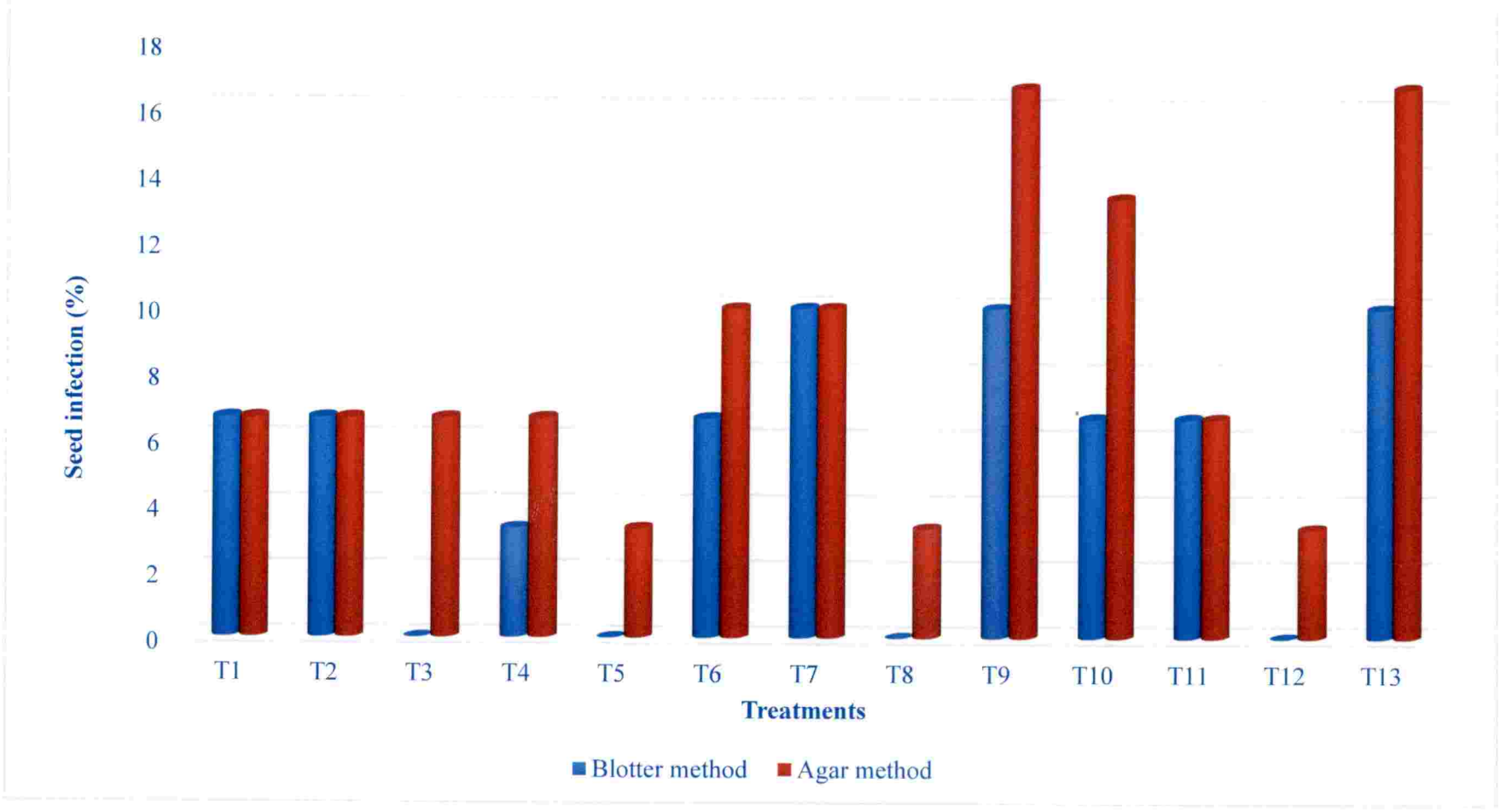
Among the two detection methods, higher infection was observed in agar plate method. The results are in accordance with the results of Shobha (2016) in ash gourd and Nagendra (2017) in oriental pickling melon.

The polymer alone treatments (T_1: Polykote (5ml), T_4: Polykote (10 ml), T_7: Hitron (5ml), T_{10}; Hitron (10ml) had lower fungal invasion compared to control. This result is in line with the findings of Whipps *et al.* (2001), where mycelia growth was less in polymer coated soybean seeds as the polymer itself provided protection from fungal invasion. Similar results were given by West *et al.* (1985) in soybean; Manojkumar and Agarwal (1998) and Ravishankar *et al.* (2002) in maize.

The polymer and fungicide treatment act as barriers to the absorption of moisture from the environment and also prevent the loss of quality of seeds by avoiding fungal infection (Singh 1992; Gupta *et al.* 1993 and Vamadevappa 1998).

Polymer coating is one of the pre storage seed enhancement techniques used either singly or in combination with plant protection chemicals. Polymers play an effective role in retaining the seed quality parameters over a period of time. Apart from extending the shelf life of the seed during storage, polymers have several advantages. Polymers acts as an external covering thus reducing the mechanical damages in seed, this coating provides effective packaging of seed at proper quantities, improving the appearance of seed and it is a good carrier of fungicides, insecticides and bioagents.

Fig. 11: Effect of polymer coating on seed infection in oriental pickling melon



The present study aimed to identify the polymers, appropriate dosage, and combination of additives that could reduce the rapid deterioration of seed and to ensure effective and safe seed storage. From the results it is inferred that polymer coating with a combination of chemicals and bio agents decreases the rate of deterioration of seeds at a slower rate and retains seed quality and vigour longer than the non-coated seeds. It is highly suited to high rainfall, high relative humidity conditions such as Kerala where seed storage is a high problem.

The price for the polymers used is Rs. 450 per kg and Rs.350 for Polykote and Hitron respectively. The cost of one kg seed of okra is Rs.1500 while the cost of one kg OP melon is Rs. 2000. The cost of plant protection chemicals used for this study - Rs.110 (carbendazim-mancozeb), Rs. 300 per ½ kg (Bifenthrin) and Rs.105 per kg (*Trichoderma viride*). The cost of treating one kg of seed with polymer will work to an average of Rs.5 and treating seeds in combination with plant protection chemicals spent less than Rs.8. By spending just Rs.5 the viability is extended to four months than the untreated control. Hence this is highly economic and cost effective.

FUTURE LINE OF WORK

In present work, storage studies were restricted to ambient conditions only. Storing the seeds under controlled conditions enhance the shelf life of seed. Hence the effect of polymer coating under controlled atmospheric condition, and the interaction of both polymer treatment and the storage conditions can be studied.

Since the present study involved assessing the seed quality under laboratory conditions there is no scope to predict the effect of these seed treatments in field condition. The role of polymer treatment in storage along with the performance of treated seeds under field conditions will ensure better results.

The study may be extended to the use of other bio and natural polymers along with other additives for more effective recommendations.

The quality of seed is also influenced by the storage containers. As the present work did not involve the use of different storage containers, such studies and their interaction with seed treatment may be initiated to get better results.

The effect of polymer film coating may be extrapolated to other varieties in okra and oriental pickling melon to assess the effectiveness of the doses selected in the present study. The experiment may be replicated in different locations to draw valid conclusions and to bring out a uniform recommendation in the package of practices.

The study was restricted to two vegetables and hence it may be extended to other crops to ascertain whether film coating is advantageous for all crops under Kerala conditions.

Summary

6. SUMMARY

An experiment was conducted at the Department of Seed Science and Technology, College of Horticulture, Kerala Agricultural University,Vellanikkara, Thrissur, to standardize the optimum dose of polymer to be used in film coating and to evaluate the efficacy of different polymer treatments on the storability of okra and OP melon seeds under ambient storage conditions.

- Throughout the storage period there was a decline in the seed quality parameters like germination, seedling shoot length, seedling root length, seedling dry weight and dehydrogenase activity in both treated and untreated seeds.
- The electrical conductivity increased irrespective of the treatments throughout the storage period.
- Polymer treatments were found to be superior over control. Treatments in which polymer was applied in combination with plant protection chemicals performed better than the treatments which had polymers alone.
- In okra and OP melon Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) were found to be superior among the treatments with respect to germination (%), seedling shoot and root length, vigour indices and dehydrogenase activity. While the electrical conductivity values were the lowest for these treatments. These treatments could retain the MSCS up to fourteen months while the untreated seeds retained viability only for ten months in storage.
- In okra, the treatment T_5 : Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) recorded 14 per cent increase in germination, 37.26 per cent in vigour index I, 48.45 per cent in vigour index II , 7.00 percent per cent increase in dehydrogenase enzyme activity over control at tenth month of storage.

- In OP melon , the treatment T_5 : Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) recorded 13.51 per cent increase in germination, 28.41 per cent in vigour index I , 13.97 per cent in vigour index II, 16.23 per cent increase in dehydrogenase enzyme activity over control at tenth month of storage.
- Increase in seed moisture content was negligible and there was no significant difference among the treatments.
- Seed infection in treated seeds was very low compared to untreated seeds of both crops used in the study. Control recorded a high infection per cent in both okra and oriental pickling melon. While comparing the treated and untreated seeds it was evident that polymers play an important role in maintaining the seed health, which is a critical quality of seed.
- Thus, it is concluded that using polymers along with plant protecting chemicals, the seed viability could be extended (compared to untreated seeds) up to fourteen months of storage.

References

REFERENCES

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

Ahmed, B., Khan, B., Ghazanfar, M. U., Rajput, N. A., Jabbar, A., Ahmad, W. and Walait, M. 2017. Occurrence and distribution of vegetables seed-borne mycoflora in Punjab, Pakistan. *Pakist. J. Phytopathol.* 29(2): 265-271.

Ali, M. S. and Deka, B. 1996. Role of fungi causing grain discolouration of rice and management under storage. *Indian J. Mycol. Plant pathol.* 26(1): 79-85.

Antony, A. L. 2016. Effect of seed protectants against pulse beetles on viability, vigour and health of cowpea seeds. M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 99p.

*AOSA, I., 1983. Seed vigour testing handbook. *Association of Official Seed Analysts. Contribution,* (32).

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

Badiger, B., Patil, S. and Ranganath, G. K. 2014. Impact of synthetic polymer coating and seed treatment chemicals on seed longevity of cotton seed (*Gossypium hirsutum* L.). *Adv. Res. J. crop. Improv.* 5(2): 74-78.

Basavaraj and Rai, P. K. 2016. Effect of polymer seed coating chemicals and biological agent on storability of chickpea (*Cicer arietinum* L.) seeds. *New York. Sci. J.* 9(10):1-6.

133

Basavaraj, B. O. 2007. Effect of fungicide, polymer and polymer dyes treatment on storability of onion seeds. M.Sc. (Ag) thesis, University of Agricultural Sciences, Bangalore, 74p.

Basavaraj. B. O., Patil, N. K. B., Vyakarnahal, B. S., Basavaraj, N., Channappagoudar, B. B., Hunjie, R. 2008. Effect of fungicides and polymer film coating on storability of onion seeds. *Karnataka J. Agric. Sci.* 21(2): 212-218.

Baxter, L., and Waters, C. J. 1987. Field and laboratory response of sweet corn and cowpea to a hydrophilic polymer seed coating. *Acta Hortic.* 198: 31 - 34.

Bharathi, V., Naidu, N. V, Rani, M. S. and Durga, K. K. 2015. Studies on effect of the seed coating substances against paddy seedborne and their shelf life during storage. *Life Sci. Int. Res. J.* 2(2): 27-36.

Bhatnagar, G.S. and Porwal, M.K. 1990. Effect of organic polymeric compounds on the seed yield of chickpea. *Int. J. Trop. Agric.* 8(3): 217-219.

Bhattacharyya, S., Hazra, A. K. and Sen, M. S. 1985. Accelerated ageing of seeds in hot water: germination characteristics of aged wheat seeds. *Seed Sci. Technol.* 13: 683-690.

Chachalis, D. and Smith, M. L. 2001. Hydrophobic polymer application reduces imbibition rate and partially improves germination or emergence of soybean seedlings. *Seed Sci. Technol.* 29**:** 91-98.

Chandravathi, B. 2008. Effect of hydropriming and polymer coating on field performance and storability of pearlmillet [*Pennistum glaucum* (L.)]. M.Sc. (Ag) thesis, University of Agricultural Sciences, Bangalore, 125p.

Chaubey, T., Upadhyay, D. K. and Singh, B. 2014. Polymer coating of vegetable seeds. *Adv. Res. J. crop Improv.* 5 (2): 204-207.

Chavan, A. M. 2011. Nutritional changes in oilseeds due to *Aspergillus spp. J. Exp. Sci.* 12(1):11-17.

Coolbear, P., Francis, A. and Grierson, D. 1984. The effect of low temperature pre-sowing treatment on the germination performance and membrane integrity of artificially aged tomato seeds. *J. Exp. Bot.* 35:1609-1617.

Dadlani, M., Shenoy, V. V. and Seshu, V.1992. Seed coating to improve stand establishment in rice. *Seed Sci. Technol.* 20: 307-321.

Delouche, J. C. and Baskin, C. C. 1973. Accelerated ageing techniques for predicting the storability of seed lots. *Seed Sci. Technol.* 1: 427-452.

Devi, R. B. 2014. Effect of seed coating on storability and yield in soybean (*Glycine max.* L). M.Sc. (Ag) thesis, Acharya NG Ranga Agricultural University, Hyderabad, 115p.

Devi, S. J. 2004. Studies on film coating technique to improve field performance of sorghum cv. APK 1. M.Sc. (Ag) Thesis, Tamilnadu Agricultural University, Coimbatore.113p.

Dheeraj, M., Dayal, A., Thomas, N., and Ramteke, P. W. 2018. Effects of seed pelleting, polymer coating and packaging materials on seed quality characters of tomato (*Lycopersicon esculentum* L.) seeds after three months of ambient storage. *Int. J. pure Appli. Bio Sci.* 6(2): 1511-1518.

Dhiman, N. 2015. Effect of hydropriming and polymer coating of seeds on storability and field performance in okra [*Abelmoschus esculentus* (L) Moench]. M.Sc. (Ag) thesis, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, 93p.

135

Duan, X. and Burris, J. S. 1997. Film coating impairs leaching of germination inhibitors in sugar beet seeds. *Crop Sci.*37: 515- 520.

Duan, X. and Joseph, S. B. 1997. Seed physiology, production and technology – Film coating impairs leaching of germination inhibitors in sugarbeet seed. *Crop Sci.* 37:515-520.

Ellis, R. A. and Robert, E. H. 1981. The quantification of ageing and survival in orthodox seeds. *Seed Sci. Technol.* 9: 373-409.

Ellis, R. H., Hong, T. D. and Roberts, E. H. (2008). Seed moisture content, storage, viability and vigor. *Seed Sci. Res*. 1: 275–279.

Ester, A. and Vogel, R. D. 1994. Film-coating of leek seeds with insecticides: Effects on germination and on the control of onion fly [*Delia antiqua* (Meigen)]. Agris.1:195– 199.

Evanari, J. A. (1980). The history of germination research and the lesson it contains for today. *Israel J. Bot.* 229: 4-21.

Farooq, M., Basra, S. M. A., Hafeez, K. and Ahmad, N. 2005. Thermal hardening: a new seed vigour enhancement tool in rice. *J. Integ. Plant Biol.* 47:187-193.

Geetharani, R.A.S., Ponnuswamy, S. and Srimathi, P. 2006. Influence of polymer coating on nursery management in chillies. *Seed Res.* 34(2): 212-214.

Ghosh, A., Singh, V. J., Gampala, S. and Chakraborti, S. K. 2016. Role of polymer seed coating in controlling seed deterioration and maintaining pod and alpha amylase activity in rice (*Oryza sativa*). *Environ. Ecol.* 34(4): 2088-2092.

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

Gupta, A. and Singh, D. 1993. Effect of fungicidal treatment on seed viability and mycoflora of stored vegetable seeds. *Seed Res.* 20: 270-275.

Henckel P. A. (1964). Physiology of plants under drought. *Ann. Rev. Plant Physiol.* 15: 363-386.

Hussain. S., Khan. F., Hussain H., and Nie. L. 2016. Physiological and biochemical mechanisms of seed priming-induced chilling tolerance in rice cultivars. *Front. Plant Sci.* 7:116.

Indiastat. 2017. Home page [online]. Available: www.indiastat.com/agriculture/2/stats.aspx [5 june 2018].

Issac, S. and Vijayakumar, A. 2014. Effect of comprehensive seed treatments on storability of coriander (*Coriandrum sativum* L.) cv.CO4. *IOSR J. Agric. Vet. Sci.* 7(7): 61-63.

ISTA [International Seed Testing Association]. 1985. International rules for seed testing. *Seed Sci. Technol.* 13: 299-355.

ISTA [International Seed Testing Association]. 1993. International rules for seed testing. *Seed Sci. Technol.* 21: 25-30.

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

ISTA [International Seed Testing Association]. 2003. International Rules for Seed Testing. *Seed Sci. Technol.* 24: 167-177.

ISTA [International Seed Testing Association]. 2007. International rules for seed testing. *Seed Sci. Technol.*29: 1-348.

ISTA [International Seed Testing Association]. 2009. International rules for seed testing. *Seed Sci. Technol.* 29: 1-348.

137

ISTA [International Seed Testing Association]. 2010. International Rules for Seed Testing. *Seed Sci. Technol. 33: 188-194.*

Jacob, S. R., Kumar, M.B.A., Varghese, E. and Sinha, S.N. 2015. Hydrophilic polymer film coat as a micro container of individual seed facilitates safe storage of tomato seeds. *Pharm. Res.* 2(3): 375-385.

Jacob, S.R., Kumar, M.A.B., and Sinha, S.N. 2015. An eco-friendly seed coating technology for high value vegetable seeds. *Conceptual Framework and Innovations in Agroecol. Food Sci.* 4(1): 39-41.

John, S. S., Bharathi. A., Natesan, P., and Raja, K. 2005. Seed film coating technology for maximizing the growth and productivity of maize. *Karnataka J. Agric. Sci.* 18(2): 349-356.

John. S. S., Bharathi. A. and Raja, P. N. K. 2005. Effect of polymer coating on germination and seedling vigour in maize CV.Co.1. *Karnataka. J. Agric. Sci.* 2: 343-348.

Joshi, V.R., Panchal, Y.C. and Mutanal, S.M. 1998. Effect of hydrophilic polymer on the germination and seedling growth of rabi sorghum. *Karnataka J. Agric. Sci.* 11(1): 216-219.

Justin, B. O. L. and Bass, L. N. 1978. Principles and Practices of Seed Storage. US Department of Agriculture, Washington, 296p.

Jyoti, K. and Malik, C. P. 2013. Seed deterioration: a review. *Int. J. Life Sci.*12: 122-135.

Kapoor, N., Arya, A., Siddiqui, M. A., Amir, A., and Kumar, H. 2010. Seed deterioration in Chickpea (*Cicer arietinum* L.) under accelerated ageing. *Asian J. Plant Sci.* 9: (3) 158-162.

Kaushik, S.K. and Gautam, R.C. 1994. Response of rainfed pearlmillet (*Pennisetum glaucum)* to water harvesting, moisture conservation and plant population in light soils. *Indian J. Agric. Sci.* 64(12): 858-860.

Kaushik, S.K. and Kumar, R. 2014. Effects of polymer film coating, fungicide and storage treatment on vigour and viability of maize seeds. *Trend in Bio Sci.* 7 (17): 2361-2364.

Keawkham, T., Siri, B. and Hynes, R.K. 2014. Effect of polymer seed coating and seed dressing with pesticides on seed quality and storability of hybrid cucumber. *Aust. J.crop. Sci.* 8(10): 1415-1420.

*Kim., Hyeon. S., Alan, G. and Taylor. 2004. Germinability of Film-Coated Snap Bean Seed as Affected by Oxygen Diffusion Rate under Different Soil Moisture Contents. *Korean J. crop. Sci.* 49(1): 46-51.

Kittock, D. L. and Law, A. G. 1968. Relationship of seedling vigour to respiration and tetrazolium chloride reaction of germinating wheat seeds. *Agron. J.* 60:286-288.

Knowles, A. (2008): Recent Developments of Safer Formulations of Agrochemicals. The Environmentalist. 28(1): 35-44.

Korishettar, P., Vasudevan, S. N., Shakuntala, N. M., Doddagoudar, S. R., Hiregoudar, S. and Kisan, B. 2017. Influence of seed polymer coating with Zn and Fe nanoparticles on storage potential of pigeonpea seeds under ambient conditions. *J. Appl. Nat. Sci.* 9 (1): 186-191.

Kumari, S.S., Umajyothi, K., Giridhar, K., Vijayalakshmi, T., Rajani, A., Ramana, C. K., and Naidu, L.N. 2014. Influence of temperature and relative humidity on viability of coated seeds of chilli under stored conditions. *IOSR-J. Agric. Vet. Sci.* 7 (1): 40-44.

139

Ma, O., Yadav, B. and Rai, P. K. 2017. Effects of polymer seed coating and seed treatment on plant growth, seed yield and quality of cowpea (*Vigna unguiculata*). *J. Pharmacognosy and phytochemistry*. 6(4): 106-109.

Mahantesh, V. B. N., Rai, P. K., Srivastava, D. K., Bara, B. M. and Kumar, R. 2017. Effects of polymer seed coating, fungicide seed treatment and storage duration on seedling characteristics of cotton (*Gossypium hirsutum*) seeds. *J. Pharmacognosy and phytochemistry*. 6(4): 534- 536.

Malarkodi, K and Ananthi, M. 2017. Effect of seed treatments and storage containers on seed quality parameters of stored blackgram var. ADT 3. *Int. J. Chem. Stud*.5 (4): 1263-1267.

Manjunatha, S. N., Hunje, R., Vyakaranahal,B.S., and Kalappanavar, I. K. 2008. Effect of seed coating with polymer,fungicide and containers on seed quality of chilli during storage. *Karnataka J. Agric. Sci.* 21(2): 270-273.

Manoharapaladagu, P.V., Rai, P. K., Srivastava, D. K., and Kumar, R. 2017. Effects of polymer seed coating, fungicide seed treatment and packaging materials on seed quality of chilli (*Capsicum annuum* L.) during storage. *J.* pharmacognosy phyto *Chem*. 694: 324-327.

Manojkumar, and Agarwal, V. K. 1998. Effect of fungicidal seed treatment on seed germination percentages in different soybean cultivars. *Seed Tech News*. 22 (2): 35.

*Mathre, D. E., Johnston, R. H. and Grey, W. E. 2001. Small grain cereal seed treatment. Am. Phytopathological Society, The Plant Health Instructor, (2001). DOI: 10.1094/PHI-I-2001-1008-01. Retrieved: 31 September, 2014 from http://www.apsnet.org/education/ AdvancedPlantPath/Topics/SeedTreatment/.

40

Mohammad, M.2012. Influence of seed coating with synthetic polymer and seed treatment chemicals on seed quality and longevity of maize hybrid Hema. M.Sc. (Ag) thesis, University of Agricultural Sciences, Bangalore, 125p.

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.

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

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

NHB [National Horticulture Board]. 2017. Indian Horticulture Database 2017 [on-line]. Available: http://nhb.gov.in/area-pro/Indian%20Horticulture%202017.pdf [11 June 2018].

Patekar, M. A., Kadam, R. M. and Biradar, R. P. 2017. Assessment of seed borne fungi of tomato and brinjal seeds. *Trends Biotechnol. Res.* 6(1): 1-7.

Patil, A.C. 2017. Studies on seed mycoflora of sunflower (*Helianthus annuus* L.). M.Sc. (Ag) thesis, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. 115p.

Perl, M., Luria, I., and Gelmond H. 1978. Biochemical changes in sorghum seeds affected by accelerated ageing. *J. Exp. Bot.* 29(109): 479-509.

Perry, D.A. Report of the vigour test committee. 1978. Seed science and technology. 6:159-181.

141

*Poonia, T. C. 2013. History of seed production and its key issues. *Int. J.* Food *Agric. vet. Sci.*3(1): 148-154.

Qualls, M. and Cooper, C.S. 1968. Germination, growth and respiration rates of birds foot trefoil at three temperatures during the early non-photosynthetic stage of development. *Crop Sci.*9: 758-760.

Rajasekaran, R. 2004. Investigations on seed production, enhancement and storage techniques in brinjal hybrid COBH 1 (*Solanum melongena* L.) and its parental lines. M.Sc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, 112p.

Rajeshwari, S.A., Shankutala, N. M., Doddagoudar, S. R., Kurnallikar, V., and Bai, R.S. R. 2016. Standarization of seed coating polymer on seed quality of rice (*Oryza sativa* L.). Environ. Ecol. 35(2): 1327-1330.

Rakesh, P., Prasad, R.D., Devi, G.U. and Bhat, B. N. 2017. Effect of biopolymer and synthetic seed coating polymers on castor and groundnut seed. *Int. J. Pure. Appli. Bio Sci*. 5(4): 2043-2048.

Ramya, H. 2003. Studies on seed colouring, coating, fruit maturity and fruit size variation on seed quality in tomato. M.Sc. (Ag.) thesis, Tamilnadu Agricultural University, Coimbatore.115p.

Rathinavel, K. 2015. Extension of shelf life of cotton (*Gossypium hirsutum* L.) seeds through polymer coating under ambient storage condition. Indian *J. Agric. Res.* 49(5): 447-451.

Ravishankar, R. V., Lokesh, S and Khan, A. 2002. Occurrence and management of fungi, germiatnion and seedling vigour in maize. *Seed Res.* 26(2): 147- 149.

Renugadevi, J., Natarajan, N. and Srimathi, P. 2008. Influence of film coating with Polykote on seed quality characteristics of cluster bean (*Cyamopsis tetragonoloba*) (L.) Taub.). Madras *Agric. J.* 95(12): 475-479.

Rettinassababady, C., Ramanadane, T. and Renuka, R. 2012. Role of polymer coating on seed quality status of hybrid rice (*Orza sativa* L.) during storage under coastal ecosystem. *J. Biol. Chem. Res.* 29(2): 142-150.

Sadhale, N., 1996. Surpalas Vrikshayurveda (The Science of Plant Life by Surpalas). Asian Agri-History Foundation, Secunderabad. *Agri-Hist. Bullet. NI*, 99 p.

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

Sathya, S., Lakshmi, S. and Nakkeeran, S. 2016. Combined effect of biopriming and polymer coating against chilli damping off. *Int. J. Agric. Sci. Res.* 6(3): 45-54.

Shakuntala, N. M., Vyakaranahal, B. S., Shankergouda, I., Deshpande, V. K., Pujari, B. T., and Nadaf, H. L. (2009). Effect of seed polymer coating on growth and yield of sunflower hybrid RSFH-130. *Karnataka J. Agric. Sci.* 23:708-711.

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

Sharma, K. K.., Singh, U. S., Sharma, P., Kumar, A. and Sharma, L., 2015. Seed treatments for sustainable agriculture- A review. *J. Appl. Nat. Sci.* 7 (1): 521-539.

Sherin and John. S, 2003. Seed film coating technology using polykote for maximizing the planting value, growth and productivity of maize, Cv. Col. M.Sc. (Ag) Thesis, Tamilnadu Agricultural. University, Coimbatore, 112p.

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.

Siddaraju, R., Narayanaswamy, S. and Ramanappa, T. M. 2015. A study on the effect of seed coating with synthetic polymer and seed treatment chemicals on physiological changes and seed infestation of maize hybrid Hema (*Zea mays* L.) during seed storage. *Mysore J. Agric. Sci.* 49(3): 467-477.

Silva, R., Runge, F. and Auweter, H. 2013. Evaluation of the quality of seed coating formulations by application-oriented methods. *Proc. ISAA.* 5(2): 315-321.

Singh, D. P. 1992, Fungicidal treatment for control of seed borne fungi and improving some seedborne fungi pathogens of maize and sorghum *in vitro*. *Seed Res.* 30(1):112-117.

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

Sujatha. K, and Ambika, S. 2016. Designer seed for enhancement of yield in black gram (*Vigna mungo* L.). *Indian J. Agric. Res.* 50(5): 479-482.

Suma, A., Sreenivasan, K., Singh, A.K., and Radhamani, J. 2013. Role of relative humidity in processing and storage of seeds and assessment of variability in storage behaviour in *Brassica spp.* and *Eruca sativa. Sci. world J.*1-9.

Sushma, P. P. 2013. Effect of polymer coat and seed treatment chemicals on seed storability and field performance of chickpea. M .Sc. (Ag) thesis, University of Agricultural Sciences, Bangalore, 128p.

Taylor, A. G., Allen, P. S., Bennett, M. A., Bradford, K. J., Burris, J. S., and Misra, M. K.

1998, Seed enhancements. *Seed Sci. Res.* 8:245-256.

Thakur, S. and Dhiman, K. C. 2016. Effect of seed coating with synthetic polymer and additives on storability of soybean seeds under mid hill condition of Himachal Pradesh. *Himachal J. Agric. Res.* 42(1): 22-28.

Thontadarya, R.N., Praveenkumar, D.A., Chougala, V., and Krishnakumary, K. 2010. Standardisation of the dose of film coating in vegetable cowpea. *Environ. Ecol.* 33 (3): 1066-1069.

Tiwari,T. N., Kamal, D. and Singh, R.K. 2015. Enhancement in seed quality, growth and yield of wheat (*Triticum aestivum* L.) through polymer seed coating. *Int. J. Agric. Sci.* 11(1):99-103.

Vamadevappa, H. 1998, Studies on seed viability and vigour in relation to storage in soybean [*Glycine max* (L.) Merrill]. M. Sc. (Agri.) thesis, Universityof Agric. Sci., Bangalore, 112p.

Vanagamudi, K., Kalaivani, S., Vanagamudi, M., Sasthri, G., Selvakumari, A., and Srimathi, P. 2010. Seed Quality Enhancement Principles and Practices, Scientific publishers, Jodhpur, 485p.

Verma, O. and Verma, R. S. 2014. Effect of seed coating material and storage containers on germination and seedling vigour of soybean (*Glycie max* L.). SAARC *J. Agri.* 12
(2):16-24.

Vijayalakshmi, V., Ponnuswamy, A. S. and Ramamoorthy, K. 2013. Effect of fortified seed coating on seed germination and seedling vigour of tomato (*Lycopersicon esculentum*), Brinjal (*Solanum melongena*) and Chilli (*Capsicum annuum*). Madras *Agric. J.* 100 (4-6): 342-344.

145

Vinitha, G. (2006). Flim coating and pelleting technology to augment the seed quality in tomato (*Lycopersicon esculentum* Mill.) cv. PKM1. M.Sc. (Ag.) thesis, Tamilnadu Agricultural University, Coimbatore, 111p.

Vinodkumar, S. B., Vyakaranahal, B. S., Dhananjaya, P., Hipparagi, Y., and Asha, A. M. 2013. Effect of seed polymer coating on field performance and quality of pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Environ. Ecol.* 31(1): 43-46.

West, S.H., Loftin, S.K., Wahl, M., Batich, C.D. and Beatty, C.L. 1985. Polymers as moisture barriers to maintain seed quality. *Crop Sci.* 25(6): 941-944.

Whipps, J.M., Budge, S.P. and Quilken, M. P. (2001). Biocontrol activity of *Pythium oligandrum* and *Coniothyrium minitans* in pelleted and film-coated seed. *British Crop*

Protection). Vegetable seed quality, a local and international perspective: http://www.co.wha.wsu.edu/proceedings/whiteakar.doc.

*Yap, L. R. and Kulshreshta, D. D. 1975. A preliminary survey of seed borne fungi of maize farm Visayas Philippines. *Res. Res.* 3: 86-89.

**originals not seen*

146

Appendices

Monthly meteorological data from November 2016 to February 2018

Months	Temperature		Relative humidity (%)	Rainfall (mm)	Rainy Mean days
	Mean Maximum	Mean minimum			
Nov-16	31.72	21.16	78.11	0.00	0.00
Dec-16	32.15	21.18	78.21	0.00	0.00
Jan-17	33.99	22.89	68.42	0.00	0.00
Feb-17	35.61	23.19	70.14	0.00	0.00
Mar-17	36.03	24.68	84.81	0.00	0.00
Apr-17	35.34	25.88	83.04	19.10	1.00
May-17	34.26	24.89	85.68	167.50	8.00
Jun-17	30.48	23.55	94.63	640.20	22.00
Jul-17	30.47	22.78	93.81	384.40	16.00
Aug-17	29.92	23.39	95.90	478.00	25.00
Sep-17	31.20	22.98	94.47	413.90	20.00
Oct-17	31.46	22.40	92.77	183.20	7.00
Nov-17	32.74	21.79	86.93	58.30	4.00
Dec-17	32.55	21.11	78.06	00.00	0.00
Jan-18	32.87	23.76	69.52	0.00	0.00
Feb-18	34.65	23.65	71.18	0.00	0.00

SEED QUALITY ENHANCEMENT IN OKRA AND ORIENTAL PICKLING MELON WITH FILM COAT

By

RESHMA P. K.
(2016-11-083)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

(Seed Science and Technology)

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA
2018

148

Seed quality enhancement in okra and oriental pickling melon with film coat

Abstract

An experiment on 'Seed quality enhancement in okra and oriental pickling melon with film coat'' was conducted at the Department of Seed Science and Technology, College of Horticulture, Vellanikkara during 2016-18 to standardise the optimum dose and effect of polymer coating on okra and oriental pickling melon seeds and to evaluate the storage potential of polymer coated seeds under ambient storage condition

Seeds of okra variety, Arka Anamika and oriental pickling melon variety Mudicode local were used in this study. Polykote and Hitron were the polymers used. Seeds were treated with polymers either alone or in combination with plant protection chemicals. Performance of treated seeds was compared with untreated control. The polymer treatments comprised of both polymers at two doses *Viz.* Polykote @ 5 ml per kg of seed, Polykote @ 10 ml per kg of seed, Hitron @ 5 ml per kg of seed and Hitron @ 10 ml per kg of seed. A combination of plant protection chemicals such as fungicides, carbendazim-mancozeb (2g per kg of seed), insecticide- bifenthrin (0.1%) and biocontrol agent – *Trichoderma viride* (4g) were used. Polymer coated seeds were packed in 700 G polyethylene bag and stored under ambient conditions. Seed quality parameters were recorded at bimonthly intervals for a period of sixteen months.

With the advancement of storage period, germination declined irrespective of the treatments in both the seeds. Throughout the storage period, performance of treated seeds was found to be superior over control. In okra, at the end of the storage period of sixteen month , higher germination per cent (60.67 %) was recorded in seeds treated with Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) followed by Hitron (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) (54.00%), while lower values were recorded in untreated control (28.67%).

All the treatments except untreated control maintained MSCS (Minimum Seed Certification Standards) of 65 per cent germination up to ten months of storage. The seeds treated with Polykote (5ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed, Polykote (10ml/kg seed), Polykote (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed, Hitron (5ml/kg seed), Hitron (10ml) + carbendazim-mancozeb (2g) + bifenthrin (0.1%) per kg seed retained germination per cent above MSCS up to twelve months of storage whereas, the best treatment Polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) maintained MSCS up to fourteen months of storage. Similarly in the case of quality parameters like vigour indices and dehydrogenase activity, seed treatment with polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) found to be superior. In case of electrical conductivity of seed leachate a higher value was observed in untreated control while the least was recorded in seed treatment with polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) per kg of seed.

In OP melon, the effect of polymer film coating on seed quality parameters followed the same trend as that of okra. Higher per cent of germination noticed in seed treated with polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%). These treatments retained germination per cent above MSCS till fourteenth month. Electrical conductivity of seed leachate was least in seeds treated with polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) per kg of seed compared to untreated control.

Microflora infection was found to be lower in polymer treated seeds when compared to control in both the crops. The major microorganisms observed were *Aspergillus niger, Aspergillus flavus.*

The results indicated that seed treatment with polymers was highly effective for enhancing the storage life of okra and OP melon. The polymers along with plant protection chemicals help to retain viability and storability of seeds. Among the treatments, polykote (10ml) +carbendazim- mancozeb (2g) + bifenthrin (0.1%) showed best results which may be recommended for pre storage seed treatment. Seed treatment with polymers therefore provides a cheaper and safe method to enhance seed viability and seedling performance under ambient storage condition.