"Studies on effect of picking stages, seed treatments and containers on seed quality of okra (*Abelmoschus esculentus* L. Moench)"

BY

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CERTIFICATE - I

This is to certify that this thesis entitled, **"Studies on effect of picking stages, seed treatments and containers on seed quality of okra (*Abelmoschus esculentus* L. Moench)"** submitted for the degree of **Doctor of Philosophy** in the subject of **Seed Science & Technology** to the CCS Haryana Agricultural University, is a bonafide research work carried out by **Mr. Sunil Kumar Malik, Admission No. 2017A36D** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE–II

This is to certify that this thesis entitled, **"Studies on effect of picking stages, seed treatments and containers on seed quality of okra (*Abelmoschus esculentus* L. Moench)"** submitted by **Mr. Sunil Kumar Malik, Admission No. 2017A36D** to the CCS Haryana Agricultural University, Hisar, in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** in the subject of **Seed Science & Technology**, has been approved by the Student's Advisory Committee, after an oral examination on the same.

MAJOR ADVISOR **EXTERNAL EXAMINER**

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Place: Hisar

Date: **(SUNIL KUMAR MALIK)**

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LIST OF ABBREVATION

%	:	Per cent
/	:	Per
^{o}C	:	Degree celcius
C.D	:	Critical difference
cm	:	Centimeter
DHA	:	Dehydrogenase activity
EC	:	Electrical conductivity
cv.	:	Cultivar
et al.	:	*Et allili* (and others)
etc.	:	*Etcetera* (so on)
g	:	Grams
h	:	Hours
ha	:	Hectare
i.e.	:	*id est* (that is)
ISTA	:	International Seed Testing Association
IMSCS	:	Indian Minimum Seed Certification Standards
mg	:	Milligram
MT	:	Metric tonnes
RH	:	Relative humidity
SOD	:	Superoxidase dismustase
viz	:	*Videlicet* (namely)

CHAPTER I

INTRODUCTION

Vegetables play an important role in providing food nutrition and economic security of the country. They are an important component of human diet for the maintenance of good health. They supply proteins, carbohydrates, fats, vitamins, minerals which are an essential requirement of human body. China is the leading producer with a production volume of nearly 554 million MT, followed by India with approximately 127 million MT of fresh vegetables (Shahbandeh, 2020). In India, vegetables are grown largely in commercial scale in an area of 10.4Mha with production of 18.74 Mt (1st Advance Estimate 2018-19).

Okra is one of the most commonly known and utilized species of the family Malvacae, an economically important vegetable crop grown in tropical and sub-tropical parts of the world (Oyelade *et al*., 2003 and Andras *et al.,* 2005). The center of origin of okra is Ethiopia (Satish and Eswar, 2013) thereafter it was propagated in different parts of world and India by the 12th century BC (Nzikou *et al.,* 2006). It is known by many local names *viz.*, lady's finger in England, gumbo in United States of America, guano-gumbo in Spanish, Guibeiro in Portuguese, Baima in Ethopia and bhindi in India (Benchasri, 2012). It is grown commercially in many countries *viz*., India, Turkey, Japan, Africa, Iran and Southern United states (Qhureshi, 2007).

India is the global leader in the production of okra (Saxena *et al*., 2016). In India, okra is commercially cultivated in an area of 5.1 lakh ha and annual production of 61.26 lakh ton (FAOSTAT, 2018) comprising states of Maharastra, Uttar Pardesh, Karnataka, Andhra Pardesh, Tamil Nadu, Haryana and Punjab due to its wider adaptability. However, in Haryana the area under okra cultivation is 24.5 thousand ha with production of 23.39 lakh ton and productivity is 9.54 t/ha (INDIASTAT, 2018).

Okra has a prominent position among vegetables due to its high nutritive and medicinal value, year-round cultivation, high yield, ease of cultivation, wider adaptability to varying weathers, resistance to various diseases and pests and also the export potential (Reddy *et al*., 2012 and Meena *et al*., 2017). The crop is grown over wide range of soils and climatic conditions, both in summer and rainy seasons. It is utilized for its immature, tender and green fruits. The fruits are eaten in various forms, mainly boiled in culinary preparations as sliced, fried pieces and also slice dried in sun for its year around consumption. The chemical composition of okra pod per 100g edible portion is 81 per cent, 86.1g water, carbohydrate 8.2g, fat 0.2g, fiber 1.7g, energy 144kJ, 2.6g protein, Ca 84mg, Fe 1.2mg and B-

carotenoid 185mg. The immature green pods are eaten fresh and cooked as a vegetable. Seeds of okra can be utilized to extract oil and its fiber is used in paper production (Aguair *et al*., 2011). It is also processed in form of canned, dehydrated or frozen produce for preservation and export to a limited extent.

Okra fruits have medicinal values *viz.,* soothes irritated membrane of the intestinal tract, lowers blood sugar, heal burn and any kind of skin rashes (Pustak, 2002), mucilaginous texture soak up unhealthy cholesterol, toxin, mucous waste and clean them from the intestinal tract, acts as laxative that can heal ulcer and may reduce acid reflux, promotes good cardiovascular, gastrointestinal health, antioxidant and an anticancer (Conari, 2010). It is one of the potential natural plant that been used to manage diabetes (IPCBEE, 2011).

Under climatic conditions of Haryana, seed yield of summer crop is significantly lower to the rainy season. It is due to smaller size of seed and early rains (May-June) at the time of pod maturity and drying. Therefore, the rainy season is better for quality seed production. Rainy season crop of okra is having an advantage of better vegetative growth and roughing against yellow vein mosaic virus (YVMV). Yadav and Dhankar (2001) at Hisar reported that rainy season crop (13th June sown crop) produced higher seed yield with better vigour and viability of seeds.

Okra is mainly propagated by the seeds with cropping duration of 90-100 days. The quality of fruits largely depends upon the tenderness and fiber content of the fruits. The yield is directly correlated with the length, thickness of fruit and number of fruits produced per plant. Though these factors are governed by the genetic constitution of the plant, however, the stage at which the fruit is plucked is equally important. The picking stage of fruit is also important from the quality point of view. Aggarwal and Sinha (1980) stated that okra seed pods should be harvested when they are dry (35 days after anthesis). Delayed harvest may lead to low germination and vigour due to adverse weather condition in okra (Agarwal and Sinha, 1980 and TeKrony *et al*., 1980). Hedau *et al.,* (2010) stated that high quality seeds were obtained from the fruits positioned at middle nodes, followed closely by seeds collected from the lower nodes of the plant. However, seeds obtained from the upper fruits showed lowest seed yield and quality.

The importance of seed in agriculture is very well known in developing countries like India, where the majority of the population and GDP significantly depend upon agriculture (Tyagi, 2012). Seed is the core input in crop production on which the efficacy of other inputs and outputs depends. Quality seeds are highly required for optimum plant stand in the field which in turn enhances the yield. The seed quality attributes declines with the passage of time. The hygroscopic nature of seed affects its quality by change in environmental

conditions *viz*., relative humidity, temperature, moisture content, gaseous exchange, packaging material, *etc*. (Doijode, 1988).

Okra seeds are moderate storer under ambient room conditions (Doijode, 1999). The viability of carry over seed lots deteriorates rapidly; hence it is important to sow the viable seeds in the coming sowing season. Deterioration of seed is associated with ageing phenomenon which is stated as an irreversible degradation change in the quality of a seed. The maximum quality of seed is achieved at physiological maturity and it starts declining afterwards on plant itself (Abdul-Baki and Anderson, 1973). The changes associated with seed deterioration are expressed in various seed and seedling characters at different stages of seed testing. Among all deteriorative changes, membrane degradation has been proposed as the primary event in ageing, which effects mainly by leaching of compounds, particularly electrolytes, high level of lipid peroxidation, chromosomal damage, and loss of various enzymes and degradation of respiratory system, loss of ATP production and deterioration of membranes (Dadlani and Agarwal, 1983).

Good storage is an essential requirement in seed programme for the maintenance of high germination and vigour from harvesting to next planting season is of prime importance. During storage, several environmental factors such as temperature, moisture, O_2/CO_2 concentrations, pre and post storage conditions are responsible for loss in germination and vigour of seed. In many cases, there is a long gap between the time of seed production and next planting. So it is important to know the storability of different crop seeds in given storage conditions. A study revealed that proper storage conditions and containers can maintain viability, vigour and seed health status of okra (Islam, 2006).

In storage seeds are to be mainly protected from insects and pathogens. Seed treatment serves as the first line of defense which can improve germination, stand establishment, seedling emergence and plant vigour. Seed dressing is most often used among seed treatments, which is easy to apply and cost effective technology. Seed treatment with chemicals is a common practice performed all over the world, as it mitigates the yield losses caused by the pathogens. For the management of seed transmitted diseases, storage container and seed treatment are an important measure. Seed treatment techniques are designed to improve seed quality *viz.*, higher seed germination, vigour, seedling establishment and thus leading to higher crop yields (Tanweer, 1982). Seeds are treated with chemicals and botanicals which have fungicidal toxicity or antagonistic effect to eliminate most of the seed borne micro-flora. The appropriate package material must protect seeds from moisture exchange, enable to hold low temperature and maintains viability for longer period of time.

There is no doubt that suitable storage container and appropriate seed treatment can considerably improve the quality of seed and seedling which in turn increases the yield. Seed treatment and storage containers are the inexpensive and safest method to control plant diseases. So regular seed health testing, proper storage container and seed treatment before sowing of seeds needs to be mandatory. In many parts of the world the practice of suitable storage container and seed treatment is considered as an assurance against the plant diseases which greatly reduced the yield loss and also improves seed quality in many of the crops. Seed deterioration cannot be reversed but the rate could be slowed down by packing the seeds in controlled conditions. As we know controlled conditions encompasses high costs, so seed treatment remains the best approach to maintain seed quality during ambient storage.

There is very little literature on the repeatability and applicability of studies on effect of picking stages, seed treatments and containers on seed viability of okra. Therefore, the present study entitled "Studies on effect of picking stages, seed treatments and containers on seed viability of okra (*Abelmoschus esculentus* L. Moench)" was carried out in the field and laboratories of Department of Seed Science & Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar with the following objectives:

1. To find out the best picking stage for better seed quality
2. To study the effect of fungicides and botanicals on seed quality
3. To assess the effect of different containers on longevity of treated seeds

CHAPTER II

REVIEW OF LITERATURE

Okra is an important vegetable crop grown throughout the year except in few winter months because of its prolonged period of cultivation. The optimum stage of harvest of okra occupies prime importance for seed purpose. Seed being a biological or living entity, deterioration in its quality is inevitable and it occurs with advancement in ageing, which is universal in all living organisms. Seed deterioration is the reduction in its quality attributes that begins immediately after attaining physiological maturity even on mother plant. Seeds stored in different type of containers for next planting season were generally found with reduced overall seed quality.

It is unquestionable that storage container and seed treatment may probably be the cheapest and safest method of increasing overall seed quality. Very little work has been done on okra crop related to this aspect, hence the literature of okra and other agricultural crops related to picking stages, seed treatment and containers have also been cited below.

2.1 Effect of picking stages on seed quality parameters

There are various factors which generally influences the seed yield in okra among them position of fruit is of great significance. The previously conducted studies on seed quality in relation to nodal position of fruit are discussed here.

Studies revealed that position on which a carrot and celery seed was produced on plant showed significant effect on its size, germination capacity and size of ensuing seedling (Thomas *et al.,* 1979).

Ho and Hewit (1986) stated that during the phase of rapid growth in tomato, the proximal fruits obtained more growth rate and accumulation of starch than those of distal fruits. However, when the assimilate supply is in abundant form, the proximal fruits could gain more weight than the distal ones.

Alpuerto and Philippine (1987) studied the effect of fruit position on mother plant and number of fruits per cluster on the viability of seeds of two tomato varieties. Fruit cluster position on mother plant did not influence fruit size, seed yield and germination percentage but significantly affected the number of seeds per fruit, test weight and rate of germination. The number of seeds increased from the lower fruit zone to the upper fruit zone while germination percentage was decreased.

Clenchik and sung (1998) reported that in grasses the basil seed (caryopsis) in a spikelet is larger and less dormant in lower than the upper one. The annual dune grass *Triplasis purpurea* exhibits a position dependent seed heteromorphism in number of seeds, mass and dormancy characteristics.

Bhatt and Rao (1998) stated a considerable difference in the germination percentage between the seeds collected from different pod positions on plants. The germination varied from 67 to 76 per cent in lower pods, 29 to 87 per cent in middle pods and 28 to 58 per cent in upper pods. When studied at 25 ^{0}C the seed germination varied from 95 to 96 per cent in lower pods, 95 to 98 per cent in middle and 83 to 95 per cent in upper. However, at 35 ^{0}C the lower pod seeds 95 to 97 per cent, middle pod seeds 92 to 98 per cent and upper pods seeds had 87 to 97 per cent germination in various cultivars of okra.

Malik *et al.*, (2000) found that seed quality in terms of test weight, germination and vigour was significantly affected by pod ripening stage. The germination of seeds obtained from ripened pods positioned at lower and middle on the plants remained higher than the minimum seed certification standards. However, seeds obtained from the non-ripened pods positioned at lower, middle and top of the plants maintained the minimum seed certification standard of germination.

Yadav and Dhankhar (2001) reported that higher values of seeds per fruit (48.96), test weight (62.58 g), standard germination (86.57%) and seed yield (14.15 q/ha) were recorded in seed harvested from lower positions of plant, closely followed by middle position (45.81, 60.37 g, 83.79% and 11.23 q/ha, respectively) and significantly lower values were observed in seeds of upper position fruits. Better seed quality in terms of seedling length (28.13 cm), seedling dry weight (1.33 g) and vigour indices I and II (2453 and 115) were recorded in seeds harvested from lower position fruits and their corresponding lowest values (19.64 cm, 1.13 g, 1369.51, 77.97) were recorded in seeds of upper position fruits in okra.

Prabhakar *et al*., (2003) studied seed quality and productivity of okra in relation to nodal position of pod. The fruits produced at third and fourth nodes are bigger with more number of seeds per pod and test weight.

In okra *cv.* VRO-6, the pods from the lower 66 per cent portion of the plant produced best quality seeds. Results of germination and seedling vigour tests indicated that seeds obtained from the middle 33 per cent plant region showed maximum germination and vigour, closely followed by seeds collected from the lower 33 per cent plant region. Seeds collected from the upper 33 per cent portion are lighter seeds tended to decline the seed yield and quality. Although the best quality seeds were produced from lower arid middle nodes, for

practical bulk seed production, seeds can also be collected from upper nodes provided stringent density gravity separation and discarding infected seeds are practiced (Rao *et al*., 2004).

Moravcova *et al.,* (2005) revealed that in vegetables the position of a seed or fruit on a plant can affect its germination, morphology, dormancy and mass characteristics. These reactions are characterized as 'position dependent effects.

Studies conducted on okra fruits developed on positions 1, 3, 5 and 7 harvested on 14, 21, 28, 35, 42, 49 and 56 days after anthesis. The fruits positioned at 7 were shown to increase initial fruit weight between 14 to 21 days after anthesis. However, they were significantly shorter, slimmer and less number of seeds than other ones. The fruits formed at position 1, 3 and 5 have higher seed weight and survival ability (Ibrahim and Oladiran, 2011).

Pod position had significant effect on test weight, rate of germination (time to reach 50% germination, T50) and percentage germination. As regarding test weight of seeds, bottom fruits produced heavier seeds than middle and top fruits. Seeds from bottom and middle fruits germinated faster than those from top fruits. The seeds harvested from bottom and middle fruits showed higher germination than those from top fruits in Spider plant (Francis and Opondo, 2011).

Mohsen *et al.,* (2012) reported that seed weight varied tremendously and the interactions of tiller order x seed position and genotype x seed position on the head was significantly higher. The seeds positioned on the top of tillers had heavier seed than on second tillers, except the basal ones which had similar seed weight on both the tillers in wheat.

kumar *et al.,* (2015) studied the effect of fruit retention and seed position in fruit on the seed yield and seed quality in pumpkin. He proposed to retain one fruit per vine and extract seed from middle and stylar segments of fruit for high quality seed production in pumpkin *cv.* Pusa Hybrid1.

Sharma *et al.,* (2018) showed that for harvesting vigorous and best quality seed, the treatment combination R_1P_1 (Retention of fruits borne on 1-3 nodes for seed purpose and harvesting remaining fruits for vegetable purpose) may be adopted as it exhibited superior performance over other treatment combinations for all the seed quality parameters.

2.2 Effect of fungicides on seed quality parameters

The use of fungicides in seed treatment is not novel to the world. The effectiveness of many fungicides is mainly depends upon its broad-spectrum area of use, systemic control of

diseases and it reduces overall pesticide use, hence lowering the impacts on environment. So considering all these advantages the fungicide seed treatment has been used extensively from last five decades.

Dash and Narain (1996) observed that the pre-treatment of seeds of most crops (okra, cowpea, sorghum, wheat, mung bean and ridge gourd) with bavistin + TMTD (carbendazim + thiram) considerably improved seed germination. For most of the test crops, bavistin + TMTD, thiram, brassicol (quintozene), difolatan (captafol), dithane (flowable mancozeb) and vitavax (carboxin) improved seed germination with decreasing efficacy.

Solunke *et al*., (1998) reported that soybean treated with mancozeb, carbendazim, thiram, captan and thiram + carbendazim maintained its viability up to six months from harvest when stored in cloth bags. However germination percentage and vigour index were significantly superior in thiram, captan and mancozeb with significant reduction in seed mycoflora than other fungicidal seed treatment.

Savithri *et al*., (1998) stated that groundnut seeds treated with fungicides and stored in polythene bags of 600 gauge maintained seed viability and vigour upto 18 months.

Lakshmi *et al*., (1998) observed that seeds of soybean *cv.* Bragg treated with 0.2 per cent thiophanate methyl showed significant improvement in germination and shoot root ratio as compared with untreated seeds.

Sharma *et al*., (1998) stated that the chilli seeds when dried to six per cent moisture content and treated with bavistin and thiram (2 g/kg seed) gave significantly higher germination over control.

Vamadevappa (1998) observed that the total dehydrogenase activity of the stored soybean seeds decreased with advancement of storage. The seeds stored in polythene bag under controlled condition showed higher total dehydrogenase activity.

Padule *et al.,* (1999) studied the effect of fungicidal treatments in field and storage on germination and vigour index of sorghum hybrid CSH14. The storage treatment with thiram (0.2%) + carbendazim (0.2%) were showed significantly higher germination (81.20%) and vigour index (3106). Whereas, untreated control were showed lowest germination (52.10%) and vigour index (2009) at 18 months of storage.

Kamble *et al.,* (1999) studied that among six fungicides *viz.,* captan, thiram, benlate, bavistin, ditane M-45 and dithane Z-78; the bavistin was most effective in inhibiting the growth of the seed borne fungi of cucumber, pumpkin, watermelon and muskmelon.

Studies on onion seeds treated with captan 2 g/kg of seeds recorded significantly highest germination (88%), root length (5.23 cm), shoot length (5.62 cm), seedling dry weight (0.320 g), vigour index (951) and field emergence (59%) when compared to control (Suresh, 1999).

Kumar (2000) noticed drastic reduction in total dehydrogenase activity over the storage period and was highest in polylined cloth bad stored seeds. He also stated that *cv.* KHSb-2 recorded higher total dehydrogenase activity throughout the storage period.

Rahman *et al.*, (2000) observed that seed treatment with vitavax showed higher shoot and root length which was followed by manually cleaned seed.

Ravikumar (2001) recorded the germination percentage above the minimum standards of seed certification (60%) in cucumber seeds treated with thiram (2 g/kg) and when stored.

Patil (2001) stated that green gram seeds treated with captan (2 g/kg) recorded significantly higher germination (82.54%), vigour index (1285) and low EC (1.87 dsm^{-1}) as compared to untreated seeds after 10 months of storage period.

Studies conducted on chilli seeds treated with thiram (2 g/kg) showed significantly better seed quality parameters as compared to the untreated seeds (Sharanamma 2002).

Suman (2002) noticed that seed treatment increases quality parameters such as germination (5.66%), root length (20.91 cm), shoot length (17.11 cm) and vigour index (36.37) in sunflower *cv.* Morden.

Anam *et al*., (2002) revealed the effect of seed treatment on diseases and seed yield in okra. The lowest germination (95%) was recorded in unclean farmer's seeds, while highest germination (99%) was recorded in vitavax–200 treated seeds followed by clean apparently healthy seeds (98.5%).

Kumar (2004) reported that in soybean the seed quality parameters and field emergence was observed higher in seeds when seeds were treated with thiram @ 3 g/ kg, thiram + carbendazim @ 1:1 (3 g/kg) and *T. viride* @ 6 g/ kg. This might be due to suppression of seed borne mycoflora and maintenance of strong membrane integrity.

Wilson and Geneve (2004) noticed that corn seeds treated with fungicide recorded higher germination (98.50%), less number of abnormal seedlings (1.50%) and lower conductivity values (41.60 µ mhos/g) compared to control (89 %, 8.50% and 51.40 µ mhos/g, respectively).

Gopinath *et al*., (2006) observed that the use of difeconazole significantly improved the quality of fruit and increased fruit yield up to 63 per cent on chilli plants.

Singh *et al*., (2007) studied the effect of seed treatments, containers and storage period on longevity of lentil seed. Studied revealed that all the treatments were superior over control viz. germination percentage, seedling vigour index and electrical conductivity during ten months of storage period.

Masooda and Lokesh (2008) observed that bavistin (0.2%), captan (0.3%), dithane (0.3%), vitavax (0.3%) and their mixtures significantly enhanced the seed quality parameters in okra.

Maize seeds when treated with three different fungicides *viz.*, ridomil, mancozeb and metalaxil @ 2.5 g/kg enhanced the germination as compare to control (Taye *et al*., 2012).

Rangwala *et al.,* (2013) took five different concentrations of fungicide (carbendazim) on wheat, all the studied concentrations given increase in germination percentage, root length, shoot length, vigor index, fresh weight and viability percentage.

Chaudhary *et al*., (2013) observed that out of five fungicides when used as seed treatment on chilli seeds found that thiram, captan and bavistin were superior. These three fungicide treatments recorded higher seed germination as compared to others. Bavistin was most effective in germination percentage and increased seedling vigour index as compare to control.

Satishkumar *et al*., (2014) studied the seed treatments among which bavistin (1%) recorded significantly higher germination percentage (85.70) and vigour index (887) than the other treatments *viz.*, $ZnSO_4$, $MnSO_4$, DAP and control at the end of 12 months of storage period.

Santoshreddy *et al*., (2014) found that out of 11 chemical fungicides used as seed treatments, the combination of carboxin 37.5% + thiram 37.5% WS (Vitavax powder) @ 0.2 per cent and metalxyl 4% + mancozeb 64% WP (Ridomil gold) @ 0.2 per cent showed highest seedling vigour index (932.02 and 871.70).

Khatun *et al.,* (2015) observed that among three fungicides tested on chickpea, bavistin had remarkable effect and showed higher seed quality parameters *viz.*, germination, shoot and root length and vigour index as compared to others.

Vujusevic *et al.,* (2017) studied that effect of seed treatment of three commercial pesticide formulations in maize. The experiment was conducted at two temperatures (25 °C

and 15 °C) which showed the differences in maize genotypes response to applied seed treatments, as well as to specific treatment at optimal and sub-optimal temperatures.

Kumar and Jakhar (2019) studied the effect of 15 fungicides and 3 containers on viability of chilli seeds. They found that among seed treatments flusilazole (2 g/kg) proved better when stored in metal box at the end of 12 months of storage period.

Kumar *et al*., (2019) found that among 15 fungicides, flusilazole (2 g/kg) for chilli and carbendazim (2 g/kg) for brinjal was better in case of electrical conductivity and dehydrogenase activity than other seed treatments when stored in metal box for 12 months of study period.

2.3 Effect of botanicals on seed quality parameters

Recently, the use of different plant parts and their derivatives has found to be effective alternative to the use of poisonous chemical insecticides or the cumbersome traditional methods for controlling various insect pests of crops and storage.

Patil (2000) stated that, treated seeds of chickpea with neem product and castor oil @ 5 ml kg $^{-1}$ recorded significantly superior germination, vigour index, seedling dry weight at the end of 10 months of storage period.

Manaddi (2002) reported that, neem extract and castor oil @ 10 ml kg $^{-1}$ was found best for maintaining germination, vigour indices and electrical conductivity as compared to control in cowpea seeds after 10 months of storage in cloth bag.

Saxena (2006) reported that the use of neem can give significant economic advantage to rural areas. Reliable recommendations can be made and given to farmers for the protection of stored commodities like mixing the neem leaves (2-5%) with wheat, rice or other grains. The farmers generally uses neem leaves for protection from major stored grains pests infesting wheat and paddy grains. Paddy can be effectively treated with neem oil (0.5-0.1%) for safe storage up to 8 months.

Khatun *et al.,* (2010) studied three botanicals of whole leaf powders of neem, dholkami and bishkatali. Which were applied on lentil seeds and kept for storage till next planting season. The neem leaf powder treated seeds recorded higher seed quality parameters over other two leaf powders.

Geraldo *et al*., (2011) studied that, Zearalenone, a mycotoxin produced by fungi of the genus Fusarium, triggers reproductive disorders in certain animals and hyperoestrogen syndromes in human. This study investigated the ability of neem oil extract (0.1, 0.25 and

0.5%) to reduce production of zearalenone by *Fusarium graminearum* grown in a rice medium. All 3 neem oil extract concentration decreased zearalenone production, but the highest inhibition (59.05%) was observed at 0.1 per cent.

Lokanadhan *et al.,* (2012) reported that the properties of neem as insecticide, hormonal, antifungal, antiviral and neematicide properties is well known are brought out with neem use in the form of leaves, leaf extracts, seeds, cakes, oil and fruit extracts. The neem and its products are used in seed treatment, manorial application, increasing nutrient efficiency by which the grain yield in rice crop is enhanced and its sustainability is seen in rice based cropping system.

Selvan *et al*., (2014) found that among the seven different tree leaf extracts used, seed treatment with 5 per cent *Dalbergia oliveri* leaf extract can be exploited to get good quality seeds/seedlings of tomato and chilli.

Nishad *et al.,* (2017) found that botanicals, Nimbecidine @ 5 ml kg^{-1} and Karanj oil @ 5 ml kg^{-1} may be utilized as suitable and safe seed protectants to maintain the seed quality above IMSCS level for a period of six months in chickpea.

Gunasekar *et al.,* (2017) concluded that blackgram seeds should be primed with prosopis leaf extract (1%) for 4 h @ 1/3rd volume of solution to enhance the seed and seedling characteristics under adverse environmental conditions. In addition, blackgram seeds may also be primed with moringa leaf extract (1%) to get the similar results.

Saicharan *et al*., (2019) studied the effect of seed hardening with micronutrients and botanicals on seed quality parameters in chickpea. They revealed that seed hardening with KH_2PO_4 @ 2 per cent in micronutrients and Neem leaf extract @ 5 per cent in botanicals showed better performance in maximum seed quality parameters as compared to other treatments and control.

2.4 Effect of containers on seed quality parameters

The prevailing relative humidity and temperature of the storage atmosphere influence greatly on the longevity of seeds since moisture content of the seeds fluctuate more in the moisture pervious containers than the moisture impervious containers. The ideal package material should protect seeds from high moisture, to withstand low temperature and preserve viability for longer periods.

Caneppele *et al*., (1995) harvested the seeds of onion and stored in six types of packing. The highest loss was observed in permeable container than in impermeable

containers. This difference was due to change in moisture content in permeable packing and the degree of hygroscopic equilibrium between seeds and their surroundings.

Doijode (1995) observed that seeds of onion *cv.* Nasik Red at 6.5 per cent moisture content when stored with or without silica gel desiccants in craft paper bag, a glass container, a polythene bag (700 gauges), the percentage of germination was more in seeds stored in polythene bag (700 gauges) than other container.

Ilic (1995) noticed that highest germination (97%) in red pepper seeds after five years of storage in polythene bag as compared to paper bag.

Silva *et al*., (1997) observed that chilli seeds extracted from ripe fruit were dried to 9.7 and 5.9 per cent moisture content and packed in aluminium foil, 500 gauges polythene and woven polypropylene sacks. These packets were kept under ambient conditions and in cold storages. The best packing material for maintaining viability and vigour was triple laminated aluminium foil stored in cold storage than seed stored in other packages.

Doijode (1997a) reported that tomato seeds could maintain viability upto four years. When stored in polythene bag of 700 gauges under ambient temperature as compared to sub-zero temperature of 2 ˚C.

Doijode (1997b) reported that melon seeds could maintain its viability upto two years when stored in polythene bag of 700 gauges under ambient temperature as compared to sub-zero temperature storage.

Doijode (1997c) reported that the okra seeds maintained its viability upto two years when stored in polythene bag of 700 gauges under ambient temperature as compared to storage under sub-zero temperature.

Sharma *et al*., (1998) reported that seeds of chilli *viz.*, Pusa Jwala and Mathania Local were sun dried to six per cent moisture content and stored in polythene bags (700 gauges) and paper bags. The germination decline was higher in seeds stored in paper bags as compared to those in 700 gauges in polythene bags. In paper bags, germination of both the varieties declined below the minimum seed certification standard (60%) after 21 months of storage, whereas, in polythene bags throughout the storage period. It changed in paper bag with concomitant changes in relative humidity and temperature of the surrounding atmosphere.

Padma and Reddy (2000) reported that the onion seed stored in polythene bag and aluminium foil pouch extended the storage life by five and seven months, respectively, as

compared to the seed stored in cloth bag or paper bag which has only 14 months of storage. The germination was highest even after 11 months of storage in laminated bags, whereas, it was less in paper bags.

Hunje (2002) observed that chilli seed stored in aluminium foil recorded significantly higher germination (89.67-82.83%), field emergence (84.0-76.7%), root length (9.77-6.85 cm), shoot length (8.55-6.38 cm), vigour index (1643-1076) and lower electrical conductivity (0.808-1.570 dSm^{-1}) at the end of twenty months of the storage period followed by polythene bag (700 gauges).

Ghimire (2003) studied the effects of different storage periods and packaging materials on storability of onion and okra seeds. The seed stored in different type of packaging materials significantly influenced the normal seedling production (standard germination), seedling emergence (viability) and speed of germination (vigour). It was found that after nine months of storage, the mean germination percentage was the highest in laminated pouches (70.81%) followed by plastic containers (68.50%), polyethylene bags (67.38%), plastic sacks (57.88%) and cloth bags (57.13%) in case of okra. The seed qualities were maintained for longer period in laminated pouches, plastic containers and polyethylene bags.

Fabunmi (2009) studied the effect of packaging materials on moisture contents of okra (*Abelmoschus esculentus*) at room (28±2 ˚C) and refrigeration temperatures (15±2 ˚C) using three different packages (open plastic bowl as control, plastic sieve over–wrapped with low density polyethylene bags and low density polyethylene bags (LDPE 15x15 cm). The results showed that packaging materials had a significant effect on moisture content, where okra stored in polyethylene followed by plastic sieve container controlled moisture content.

Aktaruzzaman *et al*., (2010) studied the effect of initial moisture content and different storage containers *viz.*, sealed container, polythene and gunny bag on the quality of okra seeds, which revealed that the germination percentage of okra seeds of sealed container was the highest (69.48%) and significantly vary from polythene and gunny bag.

Khalequzzaman *et al.,* (2012) found that tin container showed the highest germination, normal seedlings and vigour index which were followed by polythene bag whereas, gunny bag showed the lowest germination, normal seedlings and vigour index upto 60 days after storage in french bean seeds.

Nabila *et al*., (2016) found that tin container showed an increase in germination percentage, shoot and root length, seedlings dry weight with decrease in 1000-seed weight,

moisture percentage, days to germination and electrical conductivity of seeds during storage in wheat seeds. Lowest quality performance was observed from earthen pot.

Meena *et al*., (2017) studied the Influence of different packaging materials and storage conditions on the seed quality parameters of groundnut. Among the different containers the seeds stored in vacuum packed bags maintained the quality with least deterioration compared to seeds stored in gunny bags and high density polythene bags.

Natubhai *et al*., (2018) studied the effect of three containers and duration on seed quality of onion under ambient condition. They found that among the storage containers, the plastic bag exhibited higher seed quality parameters even at the end of 9 month storage duration and it maintained the germination per cent above the Indian Minimum Seed Certification Standard up to six month of storage duration under ambient storage condition.

CHAPTER III

MATERIALS AND METHODS

The present investgation entitled **"Studies on effect of picking stages, seed treatments and containers on seed quality of okra (*Abelmoschus esculentus* L. Moench)"** was conducted during *Kharif* season of 2018 and 2019 at Research farm and during 2018-2020 in the laboratories of Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar, Haryana, India. The experimental details with materials and methods used in present investigation were as follows:

Location:

Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar is situated in semi-arid tropics and located at 29^{o} 10 North Latitude and 75^{o} 46 East Latitudes and at an altitude of about 215.2 m above the mean sea level.

Climate:

The climate of Hisar region is semi-arid with hot and dry desiccating winds accompanied by frequent dust storms of high velocity in summer, severe cold during winter and warm humid conditions during rainy season. The mean monthly maximum and minimum temperatures showed a wide range of fluctuations during both the years. The mean monthly maximum temperature of 43-45 ^{o} C was common during the summer months of May to June while minimum temperature during the winter months of December and January sometimes went as low as 0 ^{o} C.

Seed Procurement:

Okra seed of *cv.* Varsha Uphar harvested in Oct/Nov 2017 was procured from Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The germination of this seed lot was 94 per cent which was above Indian Minimum Seed Certification Standard (IMSCS).

Table 3.1: Average weather data at Hisar during April 2018 to December 2019

Monthly values							
Year	**Month**	**Temperature (°C)**		**Relative Humidity**		**Rainfal l (mm)**	**Rainy Days**
		Maximum	Minimum	Morning	Evenin		
2018	April	36.7	19.5	60	33	14	1
2018	May	40.6	23.7	57	29	0	0
2018	June	39.6	27.8	72	47	58.9	2
2018	July	35.0	26.9	88	69	158.8	7
2018	August	35.2	26.8	88	64	23.5	1

2018	September	33.3	23.6	92	70	115.8	5
2018	October	32.7	16.9	84	38	0	0
2018	November	27.9	11.7	90	46	0	0
2018	December	21.9	4.9	93	50	0	0
2019	January	19.2	5.2	94	60	13.8	2
2019	February	19.7	7.7	89	57	8.8	1
2019	March	26.5	10.5	87	42	6	1
2019	April	36.7	18.4	69	27	15.5	3
2019	May	39.0	21.6	59	26	59.8	5
2019	June	40.5	25.8	68	33	105.1	5
2019	July	35.4	25.7	82	63	120.4	5
2019	August	34.7	26.1	86	63	96.1	4
2019	September	35.3	26.0	86	55	29.9	1
2019	October	32.6	17.9	85	38	2.6	1
2019	November	26.9	12.9	89	46	12.3	2
2019	December	17.1	5.7	94	68	4.5	1

*Source: Agro-Metrology Department, CCS HAU, Hisar

Table 3.2: Physico-chemical properties of soil in the experimental field

Sr.	Parameters	2018	2019
1.	Soil texture	Sandy loam	Sandy loam
2	pH	8.13	8.15
3	EC (µS/cm/g)	0.39	0.38
4	Organic carbon (%)	0.38	0.38
5	Available Nitrogen (kg/ha)	140.00	137.00
6	Available Phosphorus (kg/ha)	21.00	21.00
7	Available Potassium (kg/ha)	220.00	224.00

1: To find out the best picking stage for better seed quality

The field experiment constituted okra *cv.* Varsha Uphar

Experimental details:-

Area: 2 *Kanal* **Seed Rate**: 6kg/acre (1.5kg/2*Kanal*)

Sowing Time: Second fortnight of June 2018 **Seed Soaking:** 12hrs

Sowing Method: Flat Bed **Spacing:** 60x30 cm

The mature fruits of okra were harvested at colour change of pod from grey to brown and formation of hairline cracks. Picking of mature pods were done from the lower, middle and upper portions of the plant. The portions of the plant were divided on the basis of node numbers. The lower portion constitutes 1st to 5th node, middle portion from 6th to 10th and upper portion from 11th to 15th node respectively.

The following parameters were recorded in field during *Kharif* 2018.

No. of days taken to flowering at 1st, 6th and 11th node

Number of days taken from sowing to first flower opening was recorded on first, sixth and eleventh nodes.

Fruit length at maturity (cm)

Fruit length of ten individual selected fruits from each portion of the plant was measured in centimeters and average was calculated.

Seed yield per fruit (g)

Selected ten individual fruits from each portion of the plant were split open to weigh the yield of seeds per fruit in grams and average was calculated.

Test weight (g)

The random seed sample of 1000 seeds was taken from seeds obtained from all the three portions of plant in three replications and average was calculated.

Number of seeds per fruit at harvesting

Selected ten individual fruits from each portion of the plant were split open to count the number of seeds per fruit in grams and average was calculated.

All the field operations were carried out as per recommendations given in package of practices published by CCS HAU, Hisar.

The mature pods from each portion were thrashed and separated. Thus three seed lots formed were evaluated for seed quality against a control *i.e.* seed harvested from whole plant at maturity.

The following seed quality parameters were recorded in laboratories by standard methodology as detailed in experiment 2.

- Standard germination (%) as per ISTA, 2011
- Seedling length (cm)
- Seedling dry weight (mg)
- Vigour indices (I& II) as per Abdul-Baki and Anderson, 1973

The field parameters *viz.*, field emergence index and seedling establishment were evaluated.

Field parameters

One Hundred seeds of *cv.* Varsha Uphar were sown with three replications during June, 2019. The following observations were recorded in field.

Field emergence (%)

The number of seeds germinated was recorded daily until it completed on 21st day.

$$\text{Field emergence (\%)} = \frac{\text{Total number of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

Seedling establishment (%)

The seedling establishment was determined on 21st day by counting the total number of seedlings when the emergence was completed or when there was no further addition in the total emergence.

$$\text{Seedling establishment (\%)} = \frac{\text{Total number of seedlings established}}{\text{Total number of seeds sown}} \times 100$$

Experiment 2: To study the effect of fungicides and containers on longevity of treated seeds

The best seed lot (seeds obtained from middle portion fruits *i.e.* 6th to 11th nodes) was treated with the following fungicides.

Table 3.3: Doses of Fungicides @ 2 gm/kg

Treatments	Fungicides
T_1	Untreated (control)
T_2	Carbendazim 75% WP
T_3	Tebuconazole 2 DS
T_4	Difenoconazole 25% EC
T_5	Flusilazole 40% EC
T_6	Chlorothalonil 78.2% WP
T_7	Azoxystrobin 23% SC
T_8	Vitavax Power (Carboxin 37.5% + Thiram 37.5% DS)

Containers: 1.Polythene bag (30 microns) 2.Hermetic bag (100 microns) 3.Metal box

Coating of seeds with fungicides

The okra seeds and fungicides were weighed 42 g and 0.084 g respectively, wearing gloves using appropriate weighing balance for each treatment. The seeds and fungicides were mixed in beakers and shaked for some time for uniform coating all over the seeds. Then, the treated seeds were kept in different containers (polythene bag, hermetic bag and metal box) in the laboratory under ambient conditions.

Treatments- Total number of treatments: 8 × 3= 24

Replications – Three

Experimental design and layout

The experiment consisted of two factors (three different packing materials as storage container were used as level factor "C" and the eight fungicides treatments were used as level factor "T") and was laid out in completely randomized design (CRD).

General practices

Under the laboratory conditions, distilled water was added whenever the germination paper appeared nearly to dry.

Observations

Seeds are taken from each of the different containers at quarterly interval upto 18 months (October 2018 to March 2020) and observations were recorded by seed technological parameters.

Seed technological parameters (Physiological and Biochemical)

Standard germination test (%) as per ISTA, 2011

Four hundred seeds of each crop for each treatment were placed in three replications in between the germination paper and placed in germinators at 25±1°C. The germination was checked on 10^{th} day and normal seedlings were considered for per cent germination.

$$\text{Seed germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds placed for germination}} \times 100$$

Shoot length (cm)

Ten normal seedlings per replication were selected at random at the time of final count of standard germination. Shoot length was measured using a measuring scale from tip to end of the shoot and average length was recorded.

Root length (cm)

Ten normal seedlings per replication were selected at random at the time of final count of standard germination. Radical length was measured using a measuring scale from tip to end of the root and average length was recorded.

Dry seedling weight (g)

Seedling dry weight was assessed after the standard germination test. The ten seedlings of each treatment replicated thrice were taken. Seedlings were dried in hot air oven

for 24 h at 80±1ºC. The dried seedlings were weighed and average seedling dry weight of each treatment was calculated.

Vigour indices

Seedling vigour indices were calculated according to the method suggested by Abdul-Baki and Anderson, 1973.

(a) Seed Vigour Index I = Seed germination (%) × Average seedling length (cm)

(b) Seed vigour Index II = Seed germination (%) × Average dry seedling weight (mg)

Electrical conductivity test (µS/cm/g)

Electrical conductivity of the seed leachates was measured to know the status of membrane permeability as per ISTA (1999). For this, 50 seeds selected randomly replicated thrice from each seed lot were soaked in separate beakers each containing 75 ml of distilled water. The seeds were immersed completely in water and beakers were covered with the foil. Thereafter, these samples were kept in the germinator at 25°C for 24 h. The electrical conductivity of seed leachates was measured by 60 direct reading conductivity meter. The conductivity was expressed in µS/cm/g.

Catalase activity test (mg protein^{-1} min^{-1})

Seeds of each treatment were imbibed in a beaker at 30 º C in the germinator for 24 h to extract the catalase enzyme. Addition of 10 ml phosphate buffer of pH 7.8 and a pinch of Corning sand was done to ground the 200 mg of imbibed seed sample in a chilled Pastle Mortar. Centrifugation of 10 ml was homogenated at 12,000 rpm for 20 min at 4 ºC temp. The supernatant obtained was then re-centrifuged at 15,000 rpm for 10 minutes and clear supernatant was obtained, which was used to estimate the catalase activity. The catalase activity was assessed by using the method described by Aebi (1983), which was based on the reduction of potassium dichromate to chromic acetate by hydrogen peroxide.

Reagents: 0.3M hydrogen peroxide (H_2O_2, 0.1M phosphate buffer (pH 7.0), Dichromate acetic acid reagent (5% potassium dichromate+ glacial acetic acid in the ratio of 1:3)

0.5 ml of H_2O_2 and 1.0 ml of phosphate buffer of pH 7.0 was added in 0.5 ml of enzyme extract in a slide mouthed test tube. This was mixed rapidly and then incubation was done at 37 ºC for 5 min. The test tubes were then taken out and 4.0 ml of dichromate acetic acid reagent was added. Boiling water bath was used to heat the test tube for 10 min. The brown colour, which changed to green due to the formation of chromic acetate after cooling, was measured by Systronic Spectrophotometer 169 at 570 nm wavelength. The activity of

catalase was expressed as the amount of enzyme required to bring about a change in absorbance by 0.01 per min.

Superoxidase dismutase activity (mg protein^{-1} min^{-1})

The enzyme activity was examined by the method of Giannopolitis and Ries (1977) with minor modification.

Reagents:

a. 1.3 µM riboflavin (1ml)

b. 13 mM methionine (1ml)

c. 63 µM nitrobluetetrazolium (NBT)

d. 0.1 M phosphate buffer (pH 7.0)

Procedure

In 3.0 ml of 0.1M phosphate buffer (pH 7.0) containing 1.3 µM riboflavin, 13 mM methionine and 63 µM nitrobluetetrazolium, 0.1 ml of enzyme extract was added. SOD activity was assayed by measuring the ability of the enzyme extract to inhibit the photochemical reduction of NBT. Glass tubes containing the mixture were exposed to light (two 15 W florescent lamps) identical tubes, which were not illuminated, served as blanks. After illumination for 10 min, they were covered with black cloth and absorbance was measured at 560 nm wavelength. Long A560 was plotted as function of volume of enzyme extract used in reaction mixture. From the resultant graph, volume of enzyme extract corresponding to 50 per cent inhibition of the photochemical reaction was obtained and considered as one enzyme unit (Beauchamp and Fridovich, 1971).

Units: one unit of SOD was defined as the enzyme activity, which inhibited the photo-reduction of NBT to blue formazan by 50 per cent and expresse as units SOD mg/protein.

Dehydrogenase activity test (OD g^{-1}ml^{-1})

Dehydrogenase activity test (Kittock and Law, 1968), reduction of 2,3,5-triphenyl tetrazolium chloride to red formazan by dehydrogenase enzyme in seed embryo is the basic principle for topographical tetrazolium test for seed viability. It is a quantitative method, which may be used to determine varying dehydrogenase activity between seeds of similar viability and therefore, it is a measure of seed vigour. Sample of 1 g of each treatment was grounded to pass through a 20-mesh screen to obtain 200 mg flour. The flour was soaked in 5 ml of 0.5% tetrazolium solution at 38 ^{o}C and was centrifuged after 3-4 h at 10,000 rpm for 3 min and supernatant was poured off. Formazan was extracted with 10 ml acetone for 16 h followed by centrifugation and then absorbance of the solution was determined by Systronic spectrophotometer 169 at 520 nm wavelength.

Peroxidase activity test (mg protein^{-1} min^{-1})

The method of enzyme extraction was similar to as described earlier for catalase. POD activity was determined by the method of Shannon *et al.* (1966) following the oxidation of O-dianisidine in the presence of hydrogen peroxide (H_2O_2).

Reagents: 0.1M sodium acetate buffer (pH 4.5); 0.2M hydrogen peroxide (H_2O_2); 10mg O-dianisidine dissolved per 2ml of methanol.

2.0 ml of acetic buffer (pH 4.5) and 0.1 ml of O-dianisidine solution were added to 0.05ml of enzyme extract. To initiate the reaction, 0.1 ml of 0.2M hydrogen peroxide was also added. The reading was recorded at 770 nm wavelength after every 15 second for 1 min and enzyme unit was expressed as the amount of enzyme required to bring about a change in absorbance of 0.01 per min

Experiment 3: To assess the effect of botanicals and containers on longevity of treated seeds

The best seed lot (Seeds obtained from middle portion fruits *i.e.* 6th to 11th nodes) was treated with the following botanicals.

Table 3.4: Doses of Botanicals @100g/kg

T_1 Untreated (Control)	T_2 Pongamia leaf powder
T_3 Neem leaf powder	T_4 Turmeric leaf powder

Containers: 1.Polythene bag (30 microns) 2.Hermetic bag (100microns) 3.Metal box

Prepration of botanicals powder

The fresh leaves of different plants were plucked, cleaned properly and shade dried for 7-10 days at room temperature. After drying, leaves were grinded with electric grinder to make fine powder. These powders were sieved through muslin cloth and stored in air tight containers.

Coating of seeds with botanicals:

The okra seeds, botanicals and gum were weighed 50, 5 and 1 g respectively, wearing gloves using appropriate weighing balance for each treatment. The seeds, botanicals and gum were mixed in beakers and shaked for some time for uniform coating over the seeds. Then, the treated seeds were kept in different containers (polythene bag, hermetic bag and metal box) in the laboratory under ambient conditions.

Treatments- Total number of treatments: 4 × 3= 12

Replications – Three

Experimental design and layout

The experiment consisted of two factors (three different packing materials as storage container were used as level factor “C” and the three botanicals treatment was used as level factor “T”) and was laid out in completely randomized design (CRD).

General practices

Under the laboratory conditions, distilled water was added whenever the germination paper appeared nearly to dry.

Seeds were taken from each container at quarterly intervals upto 18 months (October 2018-March 2020) and same seed technological parameters (physiological and biological) with same methodology were recorded as in Experiment 2.

3.4. Statistical analysis

The statistical analysis of data obtained for character studied was done by T-test and completely randomized design as per standard method (Panse and Sukhatme, 1985).

CHAPTER IV

RESULTS

The okra seed used in experiment was having 94 per cent initial germination which was above Indian Minimum Seed Certification Standards (IMSCS).

Experiment 1: To find out best picking stage for better seed quality

Table 4.1.1. Study of picking stages

Picking stage	Fruit length at maturity (cm)	Number of seeds per fruit	Test weight (1000 seeds/g)	Seed yield per fruit (g)
Lower nodes	12	52.66	63.66	3.27
Middle nodes	14.16	55.33	67.66	3.69
Upper nodes	12.16	49.31	59.61	2.98

T-test was applied on the data presented in table 4.1.1 and it was found significant. The significance between lower nodes characters and middle node characters, middle node characters and upper node characters was $p = 0.026$ and $p = 0.045$ respectively.

4.1.1. No of days taken to flowering at 1st, 6th and 11th nodes

The flowering was recorded on 1st, 6th and 11th nodes after 38th, 54th and 66th day after sowing respectively.

4.1.2. Fruit length at maturity (cm)

Table and figure 4.1.1 showed the fruits collected from different nodes of okra plants showed considerable difference in fruit length at maturity. The maximum fruit length was recorded in fruits collected from middle nodes (14.16 cm) followed by upper nodes (12.16 cm) and minimum was recorded in fruits of lower nodes (12 cm).

4.1.3. Number of seeds per fruit

The maximum number of seeds was counted in fruits from middle nodes (55.33) closely followed by fruits of lower nodes (52.67) and the lowest number of seeds were counted in upper node fruits (49.31) as indicated in table 4.1.1 and figure 4.1.2.

4.1.4. Test weight (1000 seeds/g)

When recorded for test weight, the highest weight was recorded by seeds of middle node fruits (67.67 g) closely followed by seeds of lower node fruits (63.66 g) and lowest

weight was recorded in seeds of upper nodes (59.61 g) as showed in table 4.1.1 and figure 4.1.3.

4.1.5. Seed yield per fruit (g)

Table 4.1.1 and figure 4.1.4 indicated the highest yield of seed per fruit (3.69 g) was from middle node fruits seeds followed by lower node fruit seeds (3.27 g) and the lowest seed yield per fruit was recorded in upper node fruits (2.98 g).

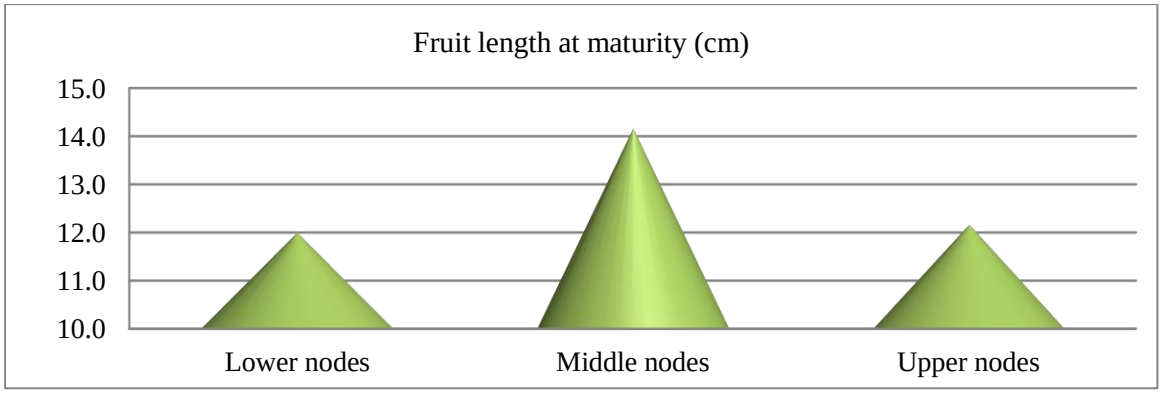

Figure 4.1.1. Study of picking stages on fruit length at maturity

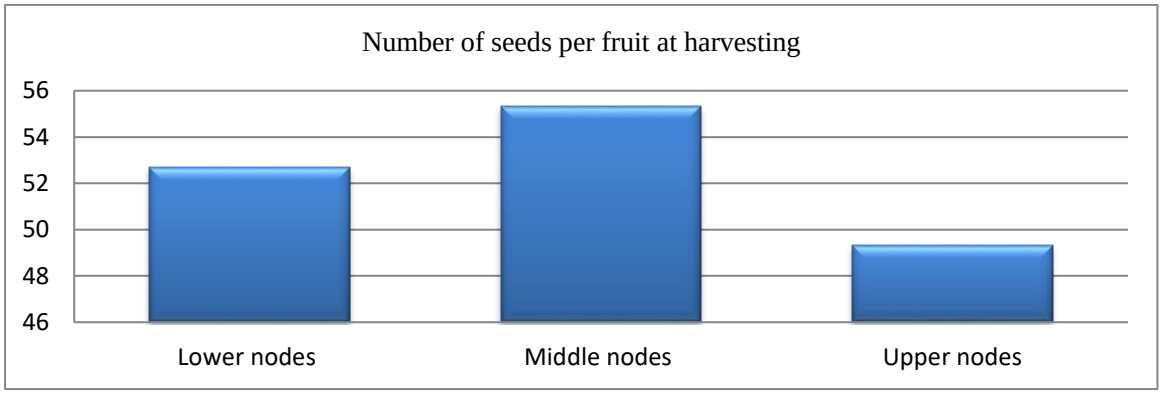

Fig. 4.1.2. Study of picking stages on number of seeds per fruit at harvesting

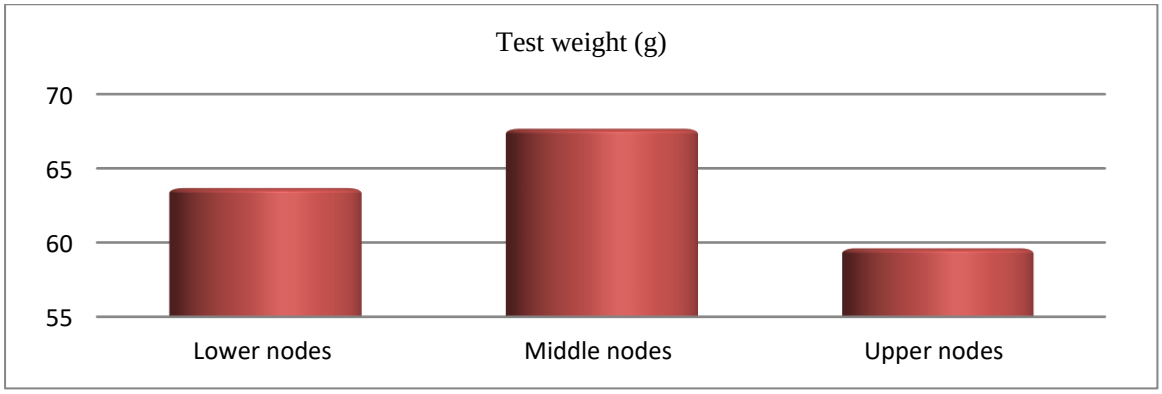

Fig. 4.1.3. Study of picking stages on test weight of seeds

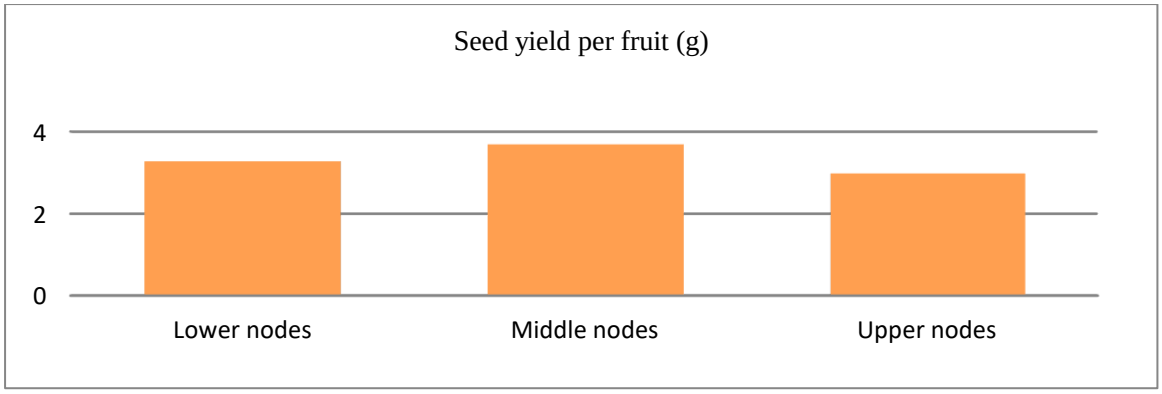

Fig. 4.1.4. Study of picking stages on seed yield per fruit

Table 4.1.2. Effect of different nodes on seed quality parameters

Picking stage	Germination (%)	Seedling length (cm)	Seedling dry weight (g)	Vigour index-I	Vigour index-II
Lower	85	36.40	0.254	3093	21.53
Middle	91	38.11	0.312	3494	28.56
Upper nodes	84	32.33	0.258	2715	21.64
Control	83	25.13	0.234	2086	19.40
C.D (5%)	3.21	2.02	0.05	187.30	3.79
S.E (m)	0.97	0.61	0.015	56.55	1.14

4.1.6. Germination (%)

The perusal of data (Table 4.1.2 and Figure 4.1.5) indicated the germination percentage of seeds of different node fruits was found varied. The significantly higher germination was recorded in seeds of middle nodes (91%) followed by seeds of lower nodes (85%), upper node seeds (84%) and lowest was recorded in seeds of control (83%).

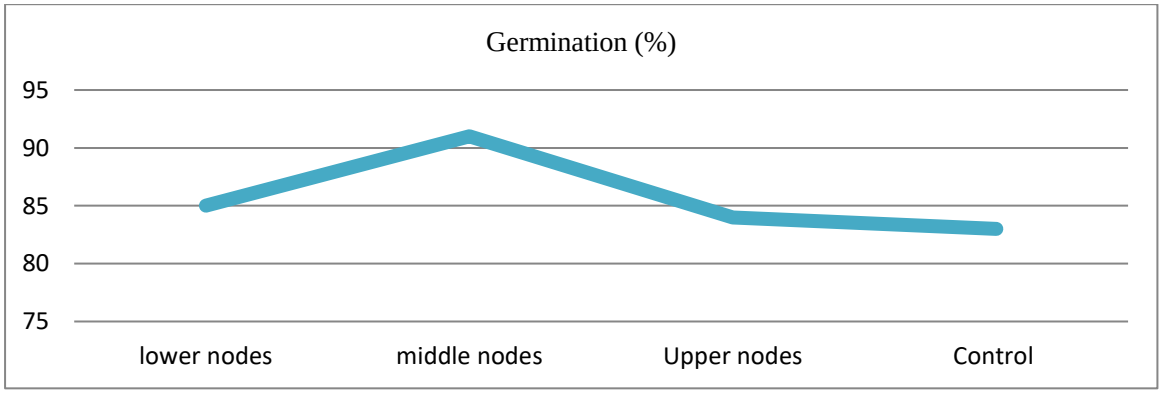

Fig. 4.1.5. Study of picking stages on germination

4.1.7. Seedling length (cm)

The data (Table 4.1.2 and Figure 4.1.6) showed the variation in seedling length. The significantly superior seedling length was measured in seeds obtained from middle node fruits (38.11 cm) followed by lower node fruits (36.07 cm), upper node fruits (32.33 cm) and lowest seedling length was measured in control (25.13 cm).

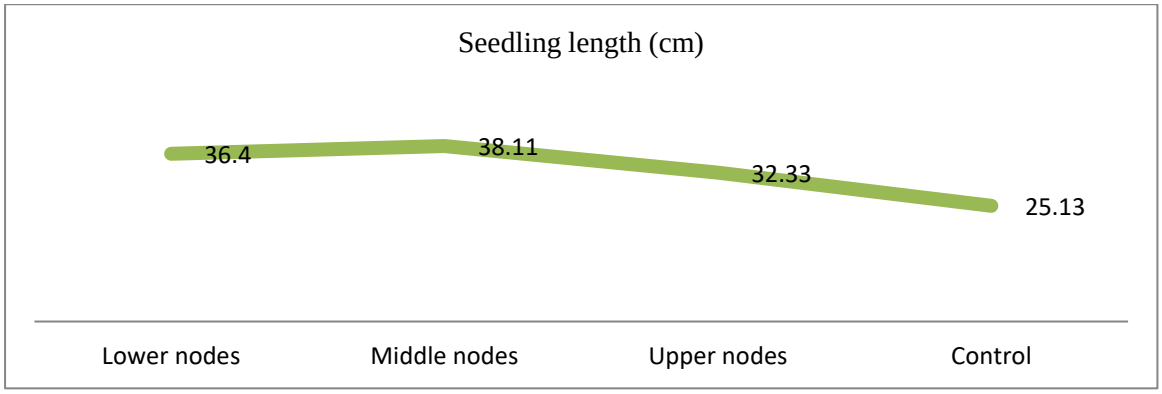

Fig. 4.1.6. Study of picking stages on seedling length

4.1.8. Seedling Dry Weight (g)

Table 4.1.2 and figure 4.1.7 revealed significantly better seedling dry weight in seeds collected from middle node fruits (0.302 g) followed by the seeds of upper node fruits (0.265 g), lower node fruits (0.244 g) and lowest was weighed in seeds of control (0.234 g).

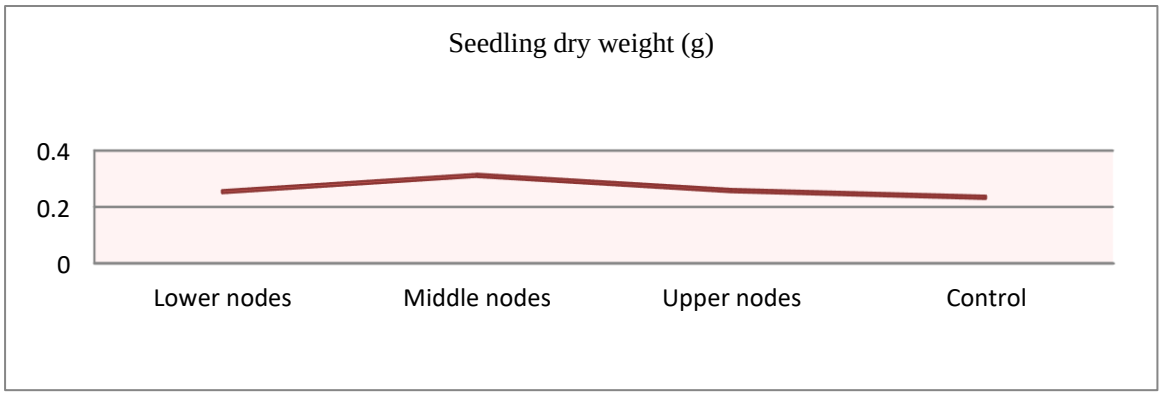

Fig. 4.1.7. Study of picking stages on seedling dry weight

4.1.9. Vigour index- I

The data in table 4.1.2 and figure 4.1.8 showed variation among lower, middle and upper node fruit seeds for vigour index-I. The significantly higher vigour index-I was showed in seeds collected from middle nodes (3494) followed by seeds collected from lower nodes (3093), upper nodes (2715) and lowest was showed in seeds collected from control (2086).

4.1.10. Vigour index- II

In table 4.1.2 and figure 4.1.9, higher vigour index-II (28.54) was recorded in seeds collected from middle nodes followed by seeds of upper nodes (23.09), lower nodes (21.52) and lowest was recorded in seeds of control (19.40).

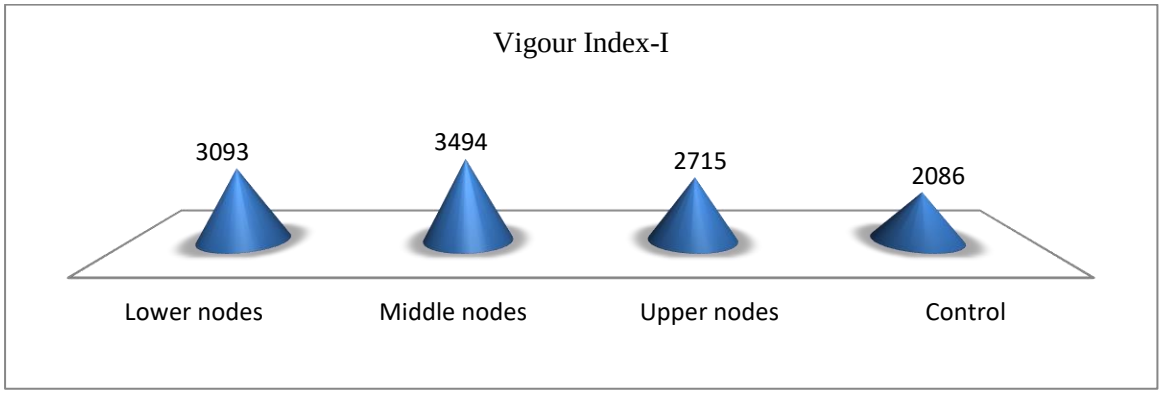

Fig. 4.1.8. Study of picking stages on vigour index-I

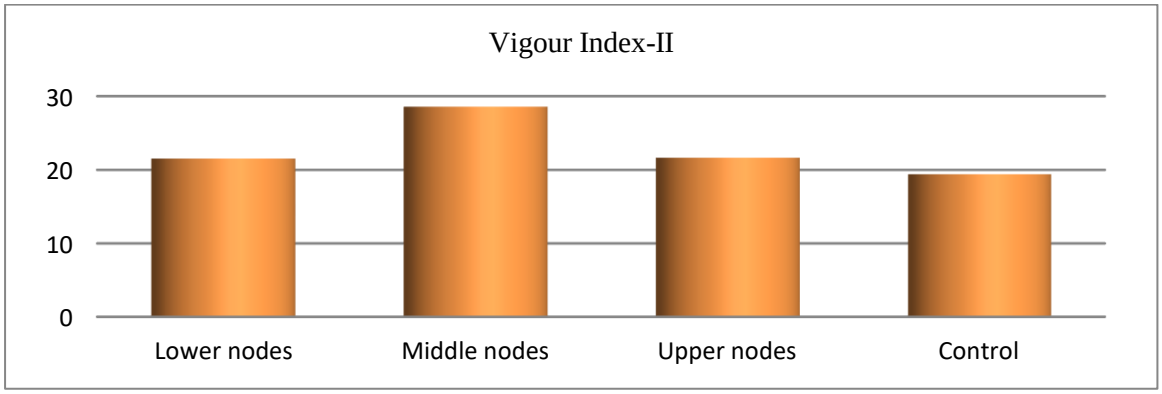

Fig. 4.1.9. Study of picking stages on vigour inex-II

Table 4.1.3. Study of picking stages on field parameters

Picking stage	Field emergence index	Seedling establishment
Lower nodes	82.66	71.83
Middle nodes	84.83	76.83
Upper nodes	76.41	69.50
Control	82.00	72.01

4.1.11. Field emergence index

The data presented in table 4.1.3 and figure 4.1.10 indicated the higher field emergence index (84.83) in seeds of middle nodes followed by seeds of lower nodes (82.66), control (82.00) and lowest was recorded in seeds of upper nodes (76.41).

4.1.12. Seedling establishment

The data presented in table 4.1.3 and figure 4.1.11 showed the case of seedling establishment, highest was observed in seeds of middle nodes (76.83) followed by seeds of

lower nodes (71.833), control (72.01) and minimum (69.50) was recorded in seeds of upper nodes.

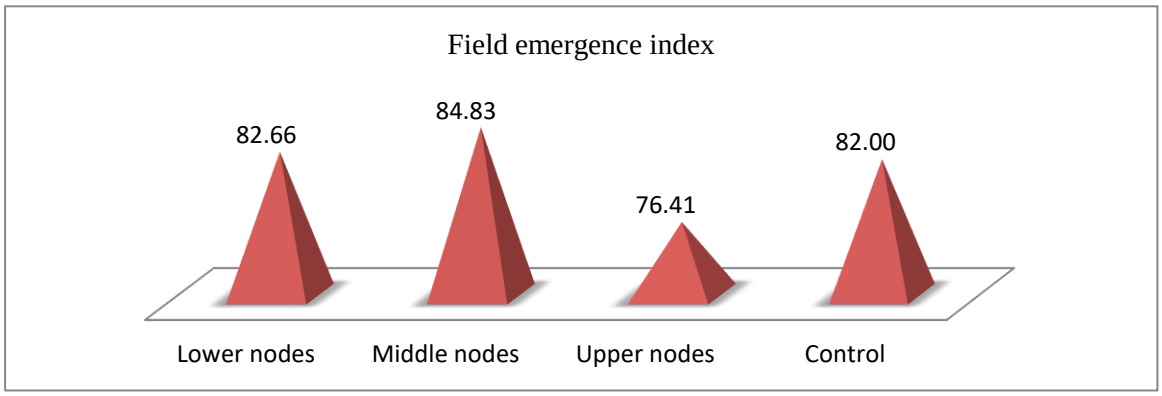

Fig. 4.1.10. Study of picking stages on field emergence index

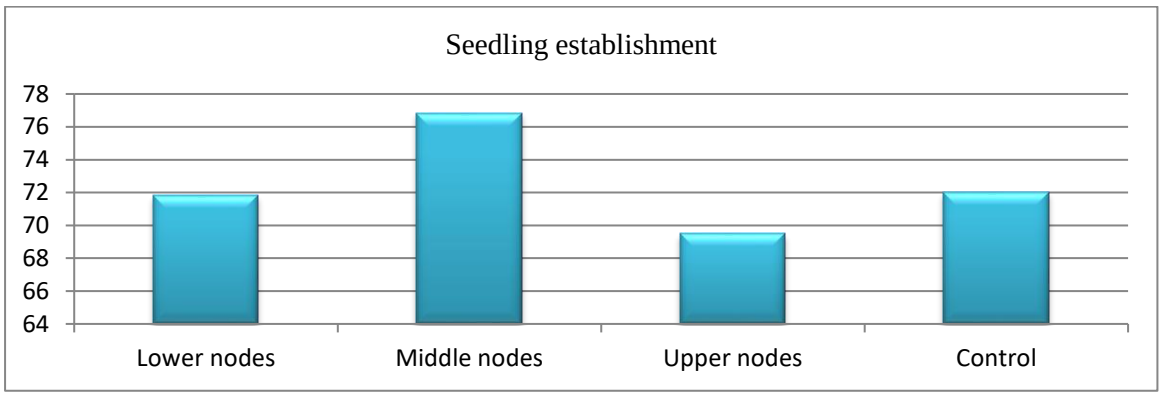

Fig. 4.1.11. Study of picking stages on seedling establishment

Experiment 2: To study the effect of fungicides and containers on longevity of treated seeds

The best seed lot (seeds obtained from middle portion fruits *i.e.* 6^{th} to 11^{th} nodes) was utilized in experiment 2 having initial germination (91%) above the Indian Minimum Seed Certification Standards (IMSCS). At the end of 18 months of storage, all the seed quality parameters *viz.*, germination, shoot and root length, seedling dry weight, vigour index- I & II and enzymatic activities were found gradually decreasing except the electrical conductivity which was gradually increasing with the advancement of storage time. All the fungicide treatments showed higher values than the control. The interaction effect of treatments with containers was found non-significant initially but recorded significant during rest of the storage period in all the parameters recorded. The result mentioned below under each parameter was recorded at an interval of 3, 6, 9, 12, 15 and 18 months of storage (Table 4.2.1

to 4.2.11). However, the results explained below are for last observation recorded at the end of 18 months of storage.

4.2.1. Germination (%)

Table and figure 4.2.1 depicted that all the treatments even control maintained the germination percentage above Indian Minimum Seed Certification Standards (IMSCS) in all the three containers after 18 months of storage. The significantly higher germination was recorded in treatment T_7 (74.9%) which was followed by treatments T_5 (73.4%), T_2 (72.4%), T_3 (71.9%), T_4 (71.1), T_8 (70.9%), T_6 (70%) and lowest was recorded in control (66.9%). Containers effect was found significant during storage and highest value in metal box (C_3) followed by hermetic (C_2) and polythene bag (C_1). The best interaction was observed (75.7%) when seeds were treated with Azoxystrobin (T_7) and stored in metal box (C_3).

Plate 1. Field view of okra

Plate 2. Okra crop in the field

Plate 3. Storage containers: Hermetic bag, Polythene bag, Metal box

Plate 4. Fungicides used for seed treatment

Plate 5. Treated seeds with botanical powders *viz.*, Turmeric, Neem, Pongamia

Plate 6. Preparation for germination test

4.2.2. Shoot length (cm)

The highest shoot length was measured when treatment is done with T_7 (8.8 cm) followed by treatments T_2 (7.8 cm), T_4 (7.4 cm), T_3 (6.7 cm), T_8 (6.7 cm), T_5 (6.6 cm), T_6 (6.4 cm) and lowest was measured in control T_1 (6.2 cm). The containers effect was observed significant with maximum shoot length was showed in metal box (C_3) followed by hermetic (C_2) and polythene bag (C_1). The best interaction (9.5 cm) was found in seeds treated with Azoxystrobin (T_7) and stored in metal box (C_3) as showed in table and figure 4.2.2.

4.2.3. Root length (cm)

The highest root length was recorded in treatment T_7 (6.8 cm) followed by treatments T_4 (6.4 cm), T_6 (6.0 cm), T_5 (5.6 cm), T_8 (5.6 cm), T_2 (5.3 cm), T_3 (4.5 cm) and lowest was in control T_1 (4.2 cm). Containers effect was found significant and maximum root length was observed in metal box (C_3) followed by hermetic bag (C_2) and polythene bag (C_1). The best interaction (7 cm) was observed when the seeds were treated with Azoxystrobin (T_7) and kept in metal box (C_3) as revealed in table and figure 4.2.3.

4.2.4. Seedling dry weight (g)

Table and figure 4.2.4 showed the highest seedling dry weight was recorded in treatment T_7 (0.230 mg) followed by treatments T_4 (0.198 mg), T6 (0.196 mg), T_8 (0.185 mg), T_5 (0.183 mg), T_3 (0.181 mg), T2 (0.176 mg) and lowest was recorded in control T_1 (0.166 mg). The container C_3 (metal box) was found superior over hermetic (C_2) and polythene bag (C_1). The maximum interaction (0.280 mg) was recorded in seeds treated with Azoxystrobin (T_7) and kept in metal box (C_3).

Table 4.2.1 Effect of fungicides and containers on germination (%)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	83.7	84.7	85.7	84.7	81.0	81.7	82.7	81.8	78.3	80.3	81.0	79.9
T_2	87.3	88.0	89.0	88.1	81.3	82.3	84.3	82.7	83.0	84.7	85.0	84.2
T_3	86.3	87.3	88.3	87.3	85.0	84.3	88.0	85.8	83.0	83.7	82.7	83.1
T_4	87.7	88.0	89.7	88.4	84.3	83.3	84.0	83.9	82.0	82.3	84.7	83.0
T_5	84.7	85.0	85.7	85.1	85.0	83.7	86.7	85.1	81.7	83.3	85.3	83.4
T_6	84.0	84.3	85.7	84.7	84.3	84.0	85.0	84.4	83.0	81.0	82.7	82.2
T_7	89.3	89.7	92.0	90.3	89.7	89.7	90.7	90.0	85.3	86.0	87.7	86.3
T_8	86.0	86.7	89.3	87.3	85.0	85.3	85.7	85.3	81.0	84.0	84.7	83.2
MEAN	86.1	86.7	88.2		84.5	84.3	85.9		82.2	83.2	84.2	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.81	0.50	N.S		0.97	0.59	N.S		0.86	0.52	1.49	
S.E (m)	0.28	0.17	0.49		0.34	0.21	0.59		0.30	0.18	0.52	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	77.0	76.7	78.3	77.3	71.3	73.7	74.0	73.0	66.0	67.0	67.7	66.9
T_2	79.0	81.7	84.3	81.7	74.7	74.3	76.3	75.1	72.0	72.3	73.0	72.4
T_3	80.3	83.0	83.0	82.1	74.3	76.3	74.3	75.0	72.3	70.7	72.7	71.9
T_4	81.3	83.3	83.7	82.8	76.3	76.3	76.3	76.3	71.7	70.7	71.0	71.1
T_5	78.7	79.7	81.3	79.9	73.0	74.3	74.7	74.0	73.7	73.7	73.0	73.4
T_6	77.0	79.0	81.7	79.2	74.3	73.0	74.3	73.9	68.3	70.7	71.0	70.0
T_7	86.7	86.0	86.7	86.4	77.3	77.7	78.7	77.9	74.3	74.7	75.7	74.9
T_8	81.0	81.7	83.7	82.1	73.0	73.3	74.7	73.7	70.3	71.3	71.0	70.9
MEAN	80.1	81.4	82.8		74.3	74.9	75.4		71.1	71.4	71.9	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.99	0.61	1.72		0.88	0.49	1.41		0.80	0.49	1.39	
S.E (m)	0.34	0.21	0.60		0.29	0.17	0.49		0.28	0.17	0.49	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

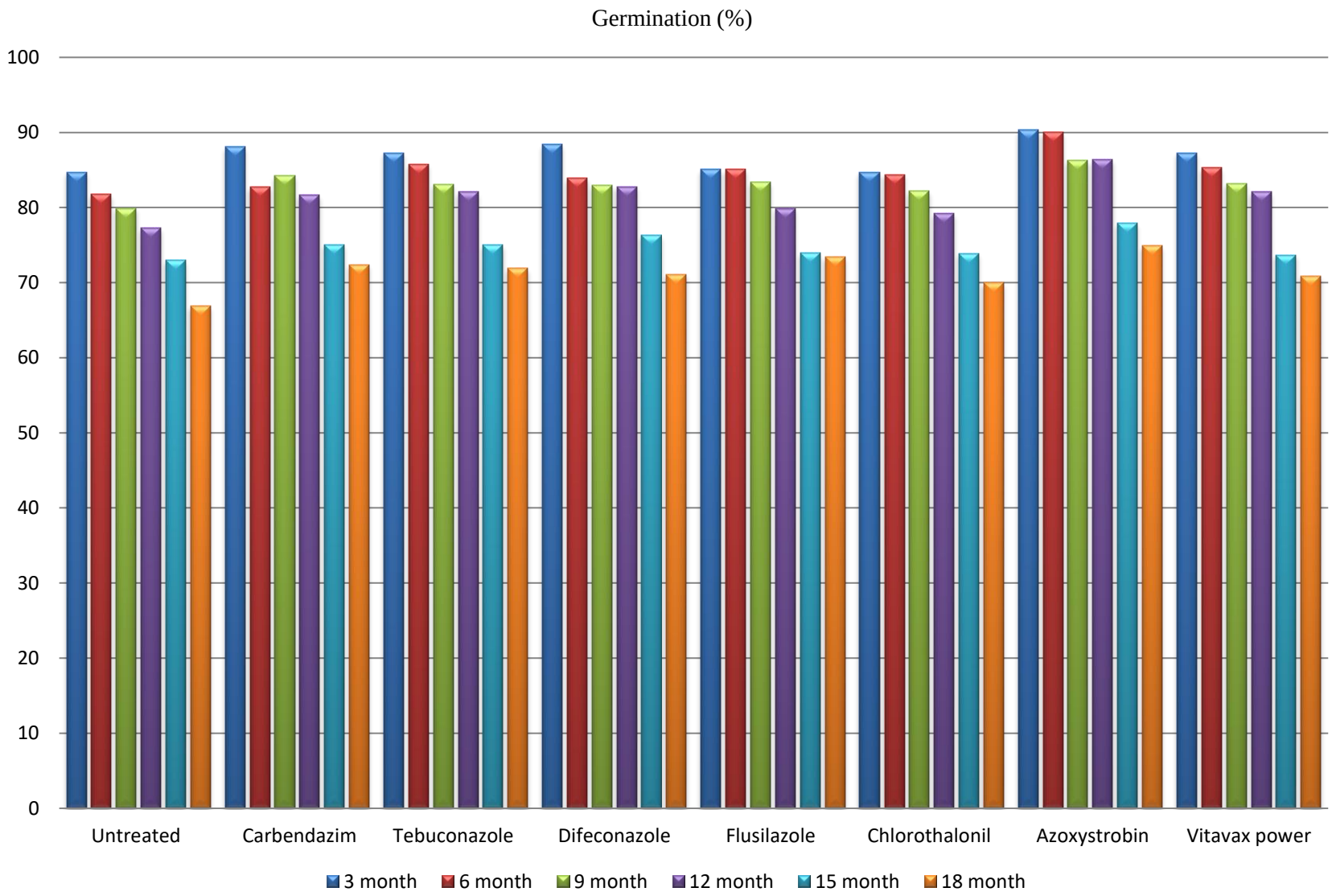

Fig. 4.2.1. Effect of fungicides and containers on germination of seeds stored under ambient conditions

Table 4.2.2. Effect of fungicides and containers on shoot length (cm)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	15.5	15.7	16.5	15.9	13.2	13.4	14.2	13.6	11.3	11.9	12.6	11.9
T_2	17.4	18.1	18.8	18.1	15.1	15.7	16.5	15.8	12.4	12.4	13.0	12.6
T_3	17.4	17.6	18.2	17.7	15.1	15.3	15.9	15.4	12.6	13.4	13.4	13.1
T_4	18.4	18.7	18.7	18.6	16.1	16.4	16.5	16.3	14.5	15.0	15.4	14.9
T_5	16.0	16.6	16.9	16.5	13.7	14.3	14.6	14.2	13.2	14.3	14.4	14.0
T_6	17.0	17.2	17.8	17.4	14.8	15.2	15.5	15.2	12.4	12.6	13.8	12.9
T_7	19.7	20.3	20.6	20.2	17.5	18.0	18.3	17.9	15.4	16.3	17.4	16.4
T_8	16.5	16.9	17.7	17.1	14.2	14.6	15.3	14.7	12.4	13.2	13.3	13.0
MEAN	17.3	17.7	18.2		15.0	15.4	15.9		13.0	13.6	14.2	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.26	0.16	N.S		0.26	0.15	N.S		0.24	0.14	0.41	
S.E	0.09	0.05	0.16		0.08	0.05	0.15		0.08	0.05	0.14	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	9.6	10.3	10.4	10.1	7.8	8.5	8.7	8.3	5.5	6.3	6.7	6.2
T_2	12.5	12.4	13.2	12.7	10.7	10.7	11.5	11.0	7.5	7.6	8.4	7.8
T_3	12.9	12.9	13.5	13.1	11.1	11.2	11.8	11.4	6.3	6.6	7.2	6.7
T_4	13.3	13.4	14.0	13.6	11.5	11.6	12.3	11.8	7.2	7.6	7.5	7.4
T_5	12.3	12.7	13.5	12.8	10.5	11.0	11.8	11.1	6.6	6.6	6.7	6.6
T_6	11.3	12.1	12.5	11.9	9.5	10.4	10.8	10.2	6.2	6.5	6.6	6.4
T_7	14.3	14.4	14.7	14.5	12.5	12.7	13.0	12.7	8.3	8.6	9.5	8.8
T_8	12.3	12.4	12.6	12.4	10.5	10.7	10.9	10.7	6.5	6.7	6.8	6.7
MEAN	12.3	12.6	13.1		10.5	10.8	11.4		6.8	7.1	7.4	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.24	0.15	0.41		0.25	0.15	0.44		0.31	0.19	0.53	
S.E (m)	0.08	0.05	0.15		0.09	0.05	0.15		0.10	0.06	0.18	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

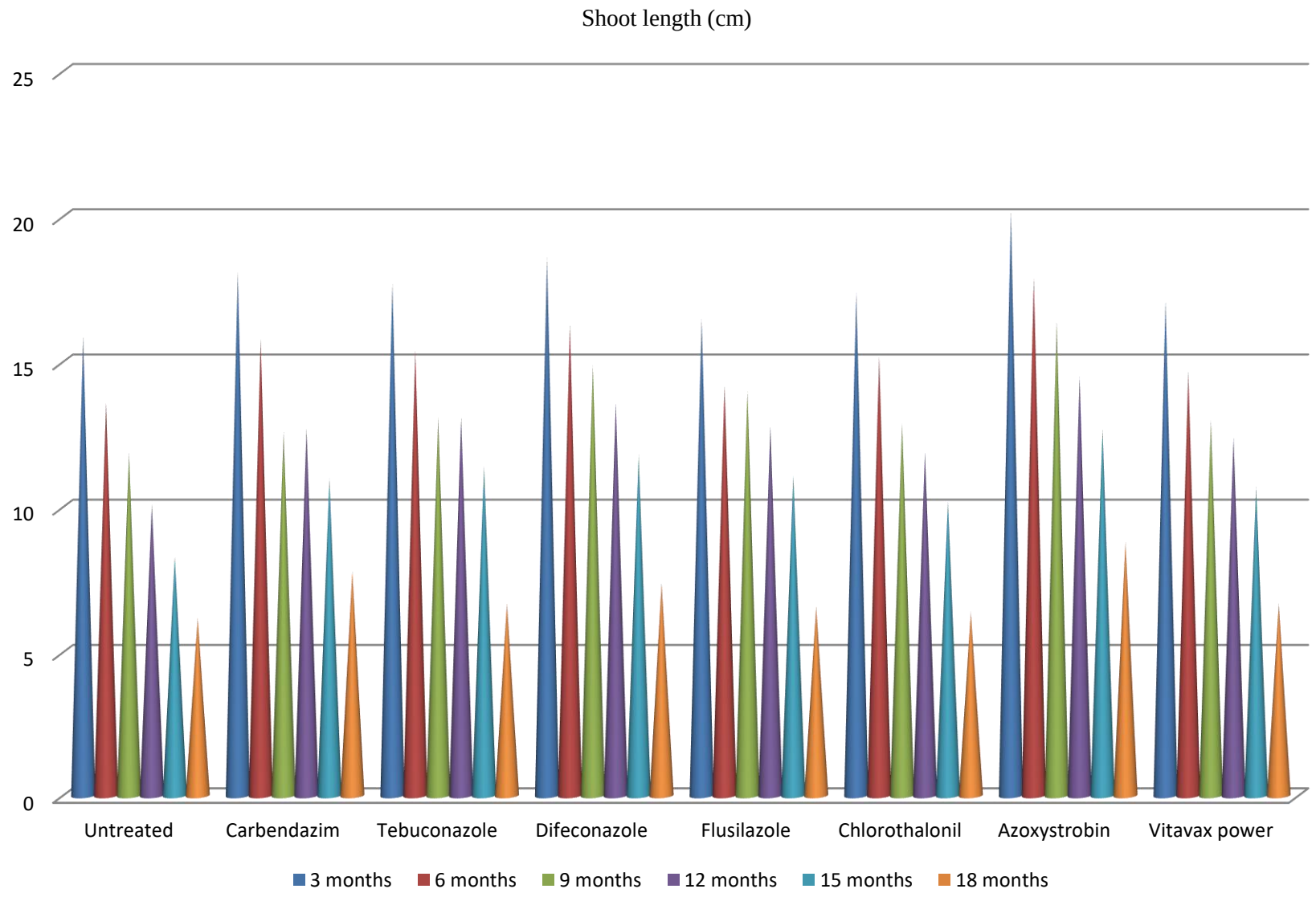

Fig. 4.2.2. Effect of fungicides and containers on shoot length of seeds stored under ambient conditions

Table 4.2.3. Effect of fungicides and containers on root length (cm)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	12.0	12.2	12.4	12.2	10.2	10.4	10.7	10.4	7.3	7.4	8.2	7.6
T_2	13.1	13.3	13.5	13.3	11.3	11.5	11.8	11.6	9.5	9.5	9.3	9.4
T_3	12.3	12.4	12.9	12.5	10.5	10.7	11.2	10.8	8.3	8.5	9.2	8.7
T_4	14.2	14.5	14.6	14.4	12.4	12.8	12.9	12.7	9.6	9.7	10.3	9.9
T_5	13.5	13.4	14.0	13.6	11.7	11.6	12.3	11.9	7.5	7.6	8.4	7.9
T_6	13.8	13.6	14.2	13.9	12.0	11.9	12.5	12.1	8.4	8.7	9.2	8.7
T_7	14.6	14.6	14.8	14.7	12.8	12.9	13.1	12.9	10.6	11.0	11.2	10.9
T_8	13.1	13.4	13.8	13.4	11.3	11.6	12.1	11.7	7.4	7.3	8.4	7.7
MEAN	13.3	13.4	13.8		11.5	11.7	12.1		8.6	8.7	9.3	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.200	0.123	N.S		0.211	0.129	N.S		0.260	0.159	0.449	
S.E (m)	0.070	0.043	0.122		0.074	0.045	0.128		0.091	0.056	0.158	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	6.7	6.8	7.6	7.0	6.0	6.1	7.0	6.3	4.2	4.1	4.2	4.2
T_2	8.8	8.9	8.7	8.8	8.1	8.2	8.1	8.2	5.4	5.2	5.3	5.3
T_3	7.7	7.8	8.6	8.0	7.0	7.1	8.0	7.4	4.5	4.4	4.7	4.5
T_4	8.9	9.0	9.7	9.2	8.2	8.3	9.1	8.6	6.5	6.5	6.4	6.4
T_5	6.9	7.0	7.8	7.2	6.2	6.3	7.2	6.6	5.6	5.3	5.8	5.6
T_6	7.7	8.1	8.6	8.1	6.0	6.4	7.0	6.5	5.9	5.8	6.4	6.0
T_7	10.0	10.4	10.6	10.3	8.3	8.7	9.0	8.7	6.7	6.8	7.0	6.8
T_8	6.7	6.7	7.8	7.1	5.0	5.0	6.3	5.4	5.2	5.6	6.0	5.6
MEAN	7.9	8.1	8.7		6.9	7.0	7.7		5.5	5.5	5.7	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.264	0.162	0.457		0.272	0.167	0.471		0.202	0.124	0.350	
S.E (m)	0.093	0.057	0.160		0.095	0.058	0.165		0.071	0.043	0.123	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

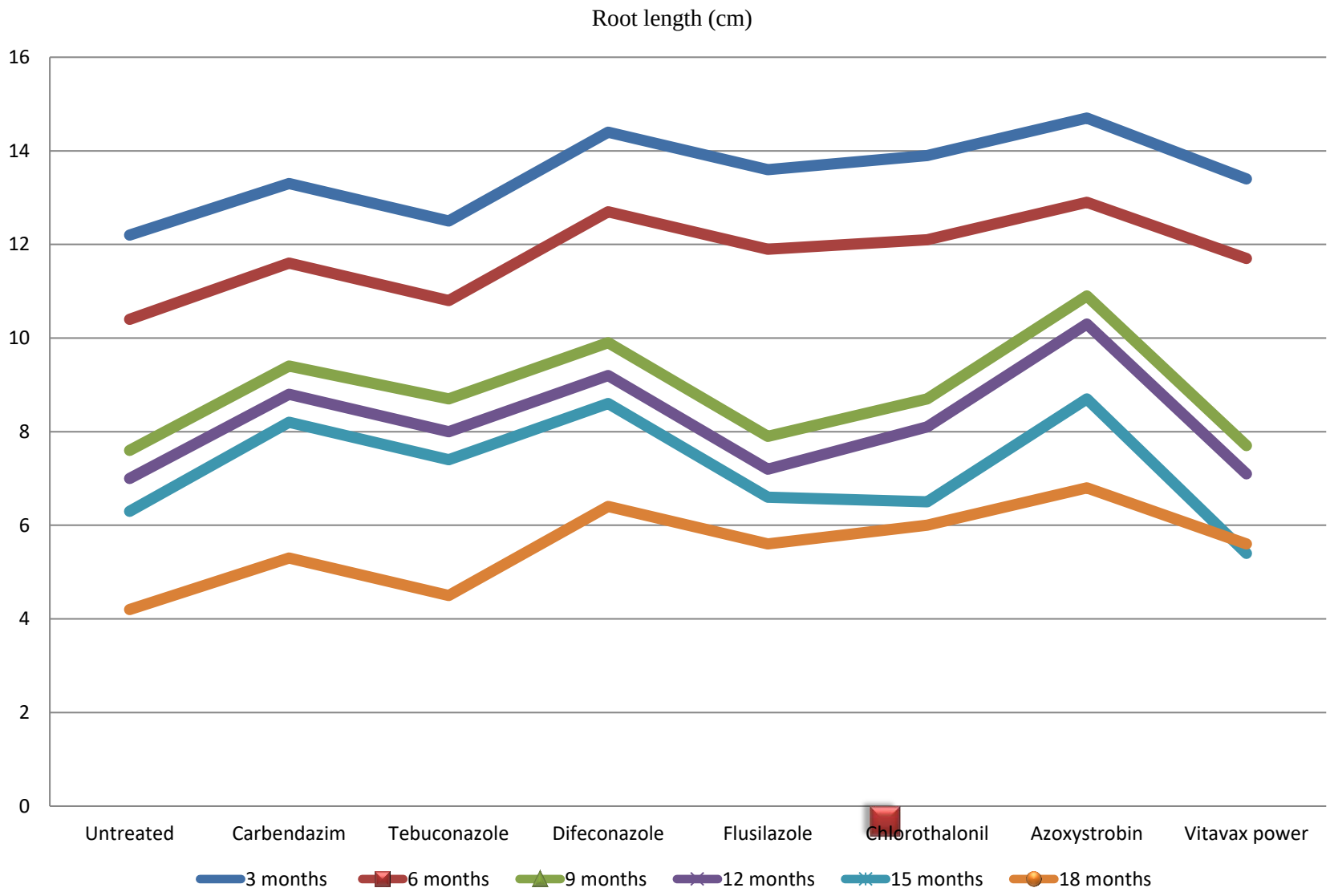

Fig. 4.2.3. Effect of fungicides and containers on root length of seeds stored under ambient conditions

Table 4.2.4. Effect of fungicides and containers on seedling dry weight (g)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.252	0.248	0.257	0.252	0.225	0.229	0.228	0.227	0.214	0.218	0.226	0.219
T_2	0.265	0.267	0.268	0.267	0.233	0.232	0.239	0.235	0.226	0.227	0.233	0.229
T_3	0.253	0.258	0.258	0.257	0.225	0.225	0.225	0.225	0.230	0.236	0.238	0.234
T_4	0.276	0.279	0.286	0.280	0.256	0.256	0.264	0.258	0.253	0.257	0.242	0.250
T_5	0.266	0.267	0.270	0.268	0.235	0.237	0.242	0.238	0.230	0.236	0.235	0.234
T_6	0.270	0.279	0.271	0.273	0.243	0.245	0.247	0.245	0.240	0.249	0.245	0.245
T_7	0.297	0.299	0.304	0.300	0.277	0.280	0.285	0.281	0.274	0.278	0.280	0.277
T_8	0.277	0.276	0.279	0.277	0.242	0.244	0.245	0.244	0.229	0.230	0.237	0.232
MEAN	0.269	0.272	0.274		0.242	0.244	0.247		0.237	0.241	0.242	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.005	0.003	N.S		0.003	0.002	N.S		0.002	0.001	0.004	
S.E	0.002	0.001	0.003		0.001	0.001	0.002		0.001	0.001	0.001	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.203	0.208	0.216	0.209	0.174	0.181	0.191	0.182	0.159	0.163	0.176	0.166
T_2	0.214	0.220	0.223	0.219	0.186	0.193	0.199	0.193	0.171	0.175	0.184	0.176
T_3	0.218	0.227	0.228	0.224	0.189	0.199	0.202	0.197	0.174	0.181	0.186	0.181
T_4	0.241	0.248	0.233	0.240	0.214	0.220	0.209	0.214	0.199	0.202	0.193	0.198
T_5	0.219	0.228	0.226	0.224	0.194	0.201	0.203	0.199	0.179	0.183	0.187	0.183
T_6	0.229	0.240	0.236	0.235	0.204	0.213	0.214	0.210	0.191	0.199	0.198	0.196
T_7	0.262	0.272	0.271	0.268	0.237	0.249	0.246	0.244	0.224	0.236	0.230	0.230
T_8	0.217	0.224	0.228	0.223	0.192	0.200	0.204	0.199	0.179	0.187	0.188	0.185
MEAN	0.225	0.233	0.232		0.199	0.207	0.209		0.185	0.191	0.193	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.003	0.002	0.005		0.003	0.002	0.006		0.004	0.002	0.007	
S.E (m)	0.002	0.001	0.002		0.001	0.001	0.002		0.001	0.001	0.002	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

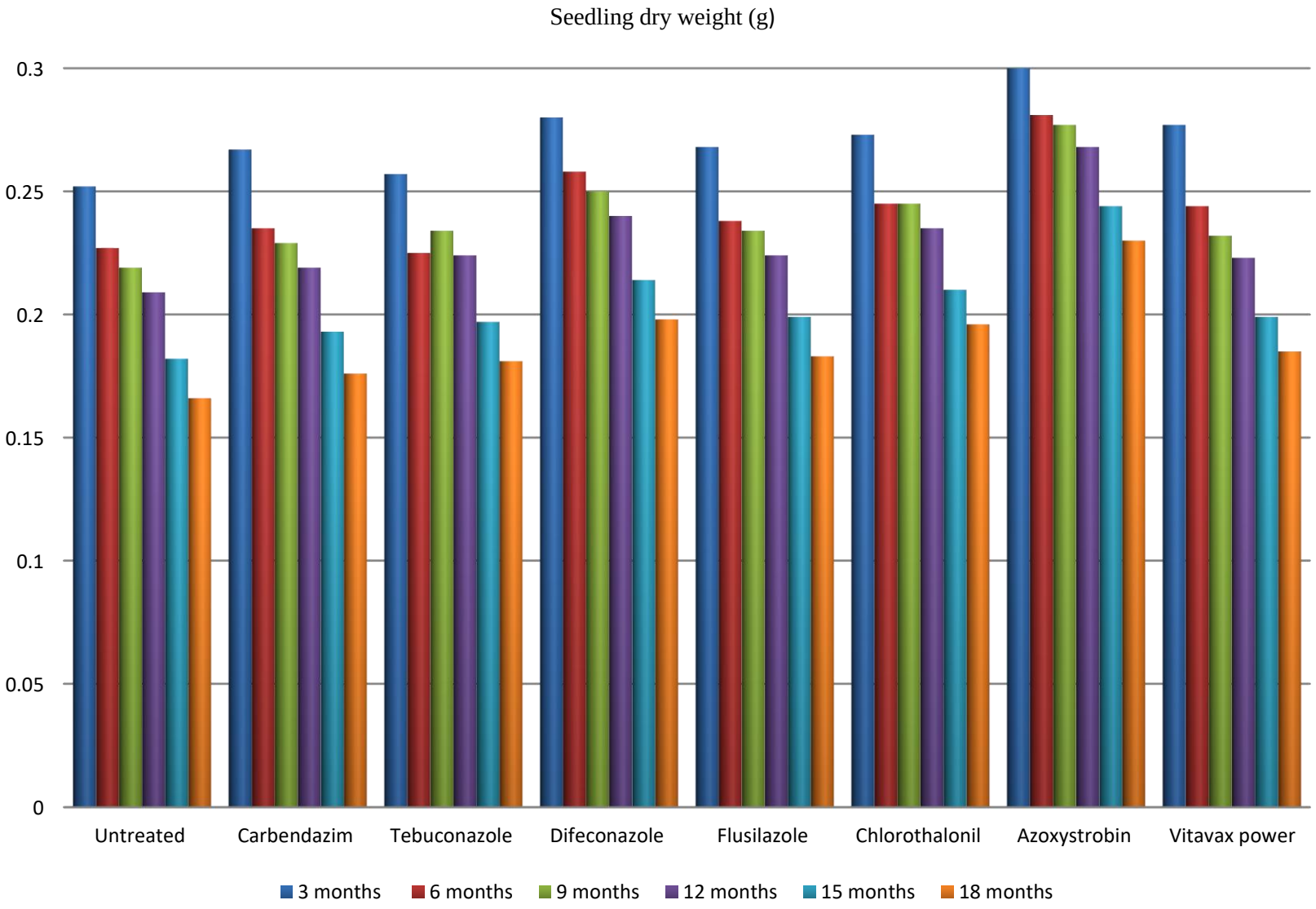

Fig. 4.2.4. Effect of fungicides and containers on seedling dry weight of seeds stored under ambient conditions

4.2.5. Vigour index-I

The highest vigour index-1 was observed with T_7 treatment (1171) followed by treatments T_4 (985), T_2 (952), T_5 (894), T_6 (874), T_8 (868), T_3 (809) and the lowest was observed in control T_1 (694). The containers effect was found significant in all the storage months. The preeminent results was found in seeds stored in metal box (C_3) followed by hermetic (C_2) and polythene bag (C_1). The superior interaction (1253) was recorded when seeds were treated with azoxystrobin (T_7) and stored in metal box (C_3) as indicated in table and figure 4.2.5.

4.2.6. Vigour index-II

Table and figure 4.2.6 revealed the highest vigour index-II was recorded in treatment T_7 (17.22) followed by treatments T_4 (14.09), T_6 (13.74), T_5 (13.43), T_8 (13.09), T_3 (12.99), T_2 (12.78) and lowest was in control T_1 (11.09). Containers effect was significant throughout the storage period. The metal box (C_3) recorded better than the others *viz.*, hermetic bag (C_2) and polythene bag (C_1). The best interaction (17.38) was recorded in seeds treated with azoxystrobin (T_7) and stored in metal box (C_3).

4.2.7. Electrical conductivity (µS/cm/g)

Table and figure 4.2.7 indicated the values of electrical conductivity were recorded highest after 18 months of storage. The lowest value was observed in treatment T_7 (1.036 µS/cm/g) followed by treatments T_4 (1.043 µS/cm/g), T_5 (1.051 µS/cm/g), T_3 (1.053 µS/cm/g), T_6 (1.055 µS/cm/g), T_8 (1.066 µS/cm/g), T_2 (1.068 µS/cm/g) and highest was in control T_1 (1.100 µS/cm/g). Containers effect was found significant in all months of storage. The lowest electrical conductivity mean value was found when the seeds were stored in metal box (C_3) followed by hermetic bag (C_2) and polythene bag (C_1). The highest interaction (1.029 µS/cm/g) was found in seeds treated with azoxystrobin (T_7) stored in metal box (C_3).

Table 4.2.5. Effect of fungicides and containers on vigour index-I

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	2,298	2,362	2,476	2,379	1,892	1,949	2,058	1,967	1,457	1,553	1,682	1,564
T_2	2,667	2,761	2,878	2,768	2,150	2,245	2,392	2,262	1,812	1,857	1,898	1,856
T_3	2,561	2,623	2,747	2,644	2,173	2,193	2,385	2,250	1,735	1,832	1,868	1,812
T_4	2,858	2,928	2,986	2,924	2,404	2,436	2,464	2,435	1,970	2,028	2,179	2,059
T_5	2,495	2,550	2,647	2,564	2,159	2,173	2,334	2,222	1,696	1,828	1,943	1,822
T_6	2,587	2,603	2,747	2,646	2,257	2,274	2,383	2,305	1,721	1,726	1,899	1,782
T_7	3,067	3,135	3,257	3,153	2,711	2,774	2,853	2,779	2,224	2,351	2,507	2,361
T_8	2,548	2,626	2,814	2,663	2,165	2,241	2,351	2,252	1,604	1,722	1,835	1,720
MEAN	2,635	2,698	2,819		2,239	2,286	2,403		1,777	1,862	1,976	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	39	24	N.S		41	25	N.S		33	20	57	
S.E (m)	13	8	23		14	8	25		11	7	20	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	1,252	1,309	1,405	1,322	982	1078	1157	1072	643	699	740	694
T_2	1,683	1,739	1,852	1,758	1404	1402	1501	1436	929	926	1000	952
T_3	1,655	1,723	1,837	1,738	1345	1399	1474	1406	783	777	865	809
T_4	1,811	1,867	1,989	1,889	1509	1524	1639	1557	979	992	985	985
T_5	1,513	1,570	1,729	1,604	1222	1284	1416	1307	896	875	913	894
T_6	1,463	1,594	1,718	1,591	1152	1222	1323	1232	827	869	925	874
T_7	2,103	2,130	2,193	2,142	1606	1657	1736	1666	1110	1150	1253	1171
T_8	1,542	1,560	1,704	1,602	1134	1149	1280	1187	821	873	912	868
MEAN	1,628	1,686	1,803		1294	1339	1441		873	895	949	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	35	21	61		27	16	46		28	17	48	
S.E (m)	12	7	21		9	5	16		9	6	17	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

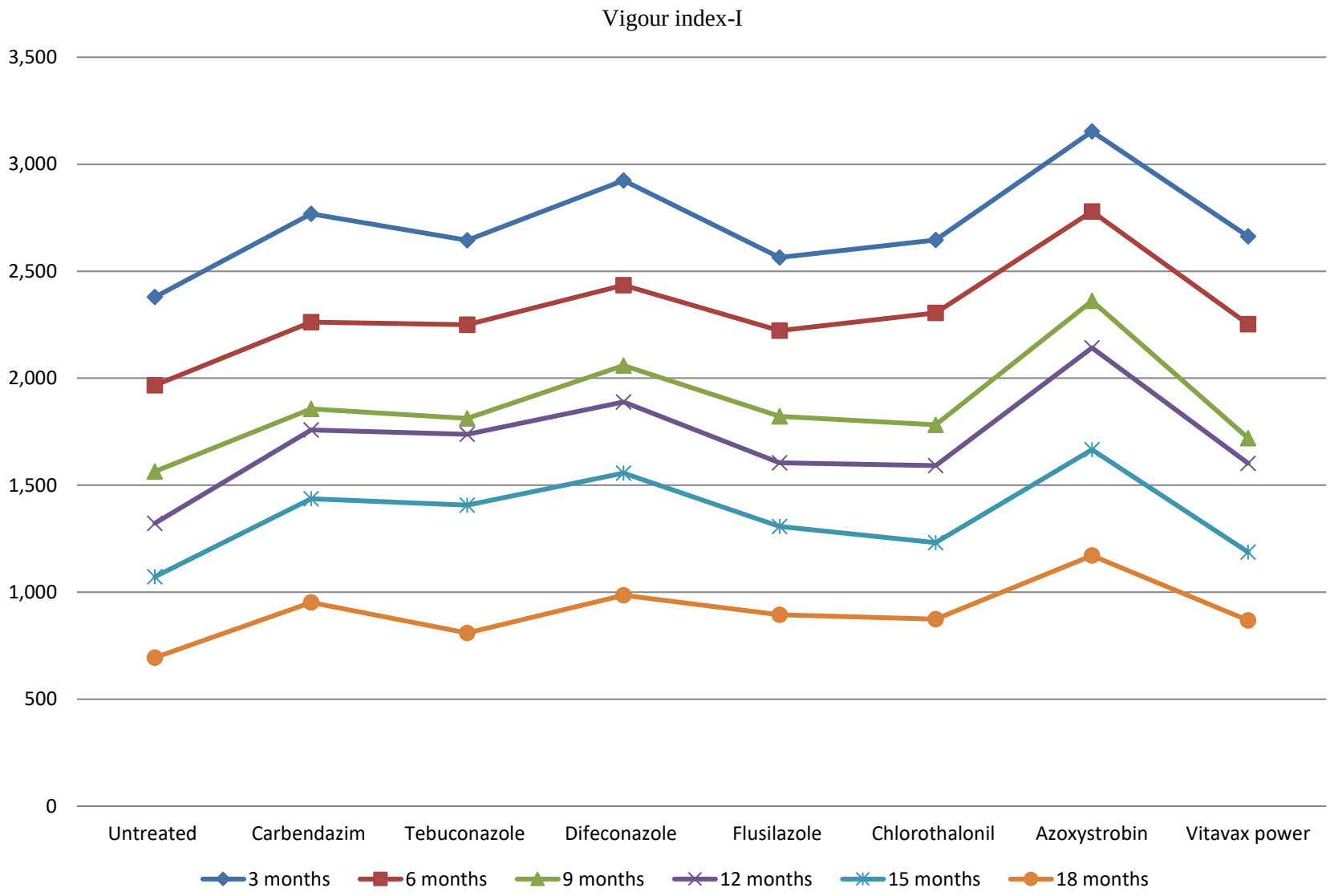

Fig. 4.2.5. Effect of fungicides and containers on vigour index-I of seeds stored under ambient conditions

Table 4.2.6. Effect of fungicides and containers on vigour index-II

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	21.06	21.00	22.04	21.37	18.20	18.67	18.85	18.57	16.79	17.49	18.33	17.54
T_2	23.17	23.47	23.83	23.49	18.95	19.13	20.16	19.41	18.76	19.25	19.80	19.27
T_3	21.87	22.53	22.82	22.41	19.09	18.95	19.77	19.27	19.06	19.72	19.65	19.48
T_4	24.16	24.52	25.65	24.78	21.56	21.33	22.15	21.68	20.72	21.16	20.46	20.78
T_5	22.49	22.72	23.10	22.77	19.98	19.86	21.00	20.28	18.81	19.67	20.05	19.51
T_6	22.65	23.56	23.19	23.13	20.47	20.58	20.97	20.67	19.95	20.17	20.23	20.11
T_7	26.53	26.84	28.00	27.12	24.87	25.11	25.81	25.26	23.35	23.94	24.52	23.94
T_8	23.79	23.92	24.90	24.20	20.57	20.85	20.96	20.79	18.52	19.29	20.04	19.28
MEAN	23.22	23.57	24.19		20.46	20.56	21.21		19.50	20.08	20.39	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.47	0.28	N.S		0.35	0.21	N.S		0.25	0.15	0.44	
S.E (m)	0.16	0.10	0.28		0.124	0.076	0.21		0.09	0.05	0.15	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	15.61	15.97	16.95	16.18	12.41	13.31	14.16	13.29	10.50	10.90	11.89	11.09
T_2	16.94	17.99	18.81	17.91	13.86	14.32	15.21	14.47	12.28	12.63	13.41	12.78
T_3	17.51	18.84	18.90	18.42	14.07	15.22	15.02	14.77	12.61	12.82	13.54	12.99
T_4	19.60	20.64	19.47	19.90	16.34	16.79	15.96	16.36	14.26	14.28	13.73	14.09
T_5	17.20	18.17	18.38	17.92	14.14	14.94	15.16	14.75	13.16	13.48	13.65	13.43
T_6	17.61	18.99	19.25	18.61	15.14	15.57	15.93	15.55	13.05	14.09	14.08	13.74
T_7	22.71	23.42	23.46	23.20	18.33	19.31	19.33	18.99	16.68	17.60	17.38	17.22
T_8	17.58	18.27	19.05	18.30	14.01	14.67	15.21	14.63	12.61	13.34	13.32	13.09
MEAN	18.09	19.04	19.28		14.79	15.52	15.75		13.14	13.64	13.87	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.36	0.22	0.62		0.31	0.19	0.54		0.28	0.17	0.49	
S.E (m)	0.12	0.07	0.21		0.09	0.05	0.18		0.10	0.06	0.17	

*T_1:Untreated T_2:Carbendazim T_3:Tebuconazole T_4:Difenoconazole T_5:Flusilazole T_6: Chlorothalonil T_7:Azoxystrobin T_8: Vitavax Power
*C_1:Polythene bag C_2:Hermetic bag C_3:Metal box

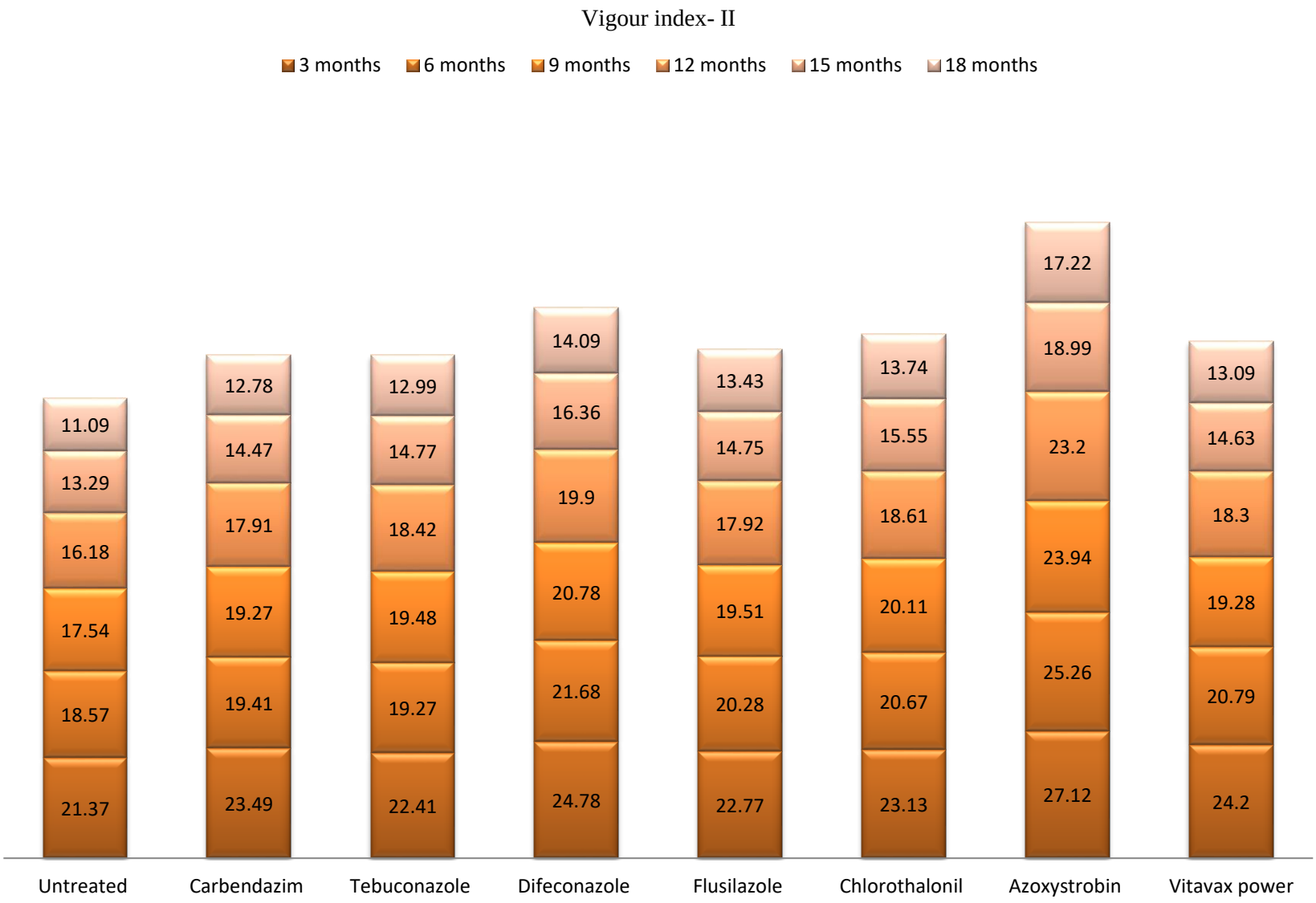

Fig. 4.2.6. Effect of fungicides and containers on vigour index-II of seeds stored under ambient conditions

Table 4.2.7. Effect of fungicides and containers on electrical conductivity (µS/cm/g)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.673	0.674	0.668	0.672	0.709	0.695	0.691	0.698	0.734	0.724	0.732	0.730
T_2	0.623	0.622	0.616	0.620	0.667	0.658	0.655	0.660	0.712	0.703	0.694	0.703
T_3	0.667	0.658	0.657	0.661	0.683	0.673	0.667	0.674	0.691	0.68	0.687	0.686
T_4	0.608	0.609	0.603	0.607	0.629	0.622	0.619	0.623	0.683	0.676	0.678	0.679
T_5	0.644	0.645	0.642	0.644	0.662	0.652	0.649	0.654	0.693	0.685	0.683	0.687
T_6	0.638	0.642	0.640	0.640	0.649	0.643	0.635	0.642	0.687	0.684	0.682	0.684
T_7	0.580	0.571	0.571	0.574	0.616	0.604	0.602	0.608	0.675	0.669	0.671	0.672
T_8	0.627	0.637	0.626	0.630	0.641	0.627	0.626	0.631	0.706	0.695	0.69	0.697
MEAN	0.632	0.632	0.628		0.657	0.647	0.643		0.698	0.689	0.69	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.006	0.004	N.S		0.005	0.003	N.S		0.004	0.003	0.007	
S.E (m)	0.002	0.001	0.003		0.002	0.001	0.002		0.001	0.001	0.002	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.866	0.862	0.852	0.860	0.926	0.929	0.917	0.924	1.100	1.106	1.094	1.100
T_2	0.828	0.838	0.831	0.832	0.889	0.9	0.894	0.894	1.063	1.072	1.069	1.068
T_3	0.821	0.818	0.809	0.816	0.883	0.881	0.874	0.879	1.057	1.053	1.049	1.053
T_4	0.818	0.81	0.804	0.811	0.879	0.873	0.866	0.873	1.054	1.045	1.041	1.046
T_5	0.823	0.817	0.808	0.816	0.882	0.879	0.869	0.877	1.056	1.051	1.044	1.051
T_6	0.823	0.814	0.807	0.814	0.884	0.88	0.872	0.879	1.058	1.057	1.049	1.055
T_7	0.811	0.798	0.793	0.801	0.871	0.861	0.854	0.862	1.046	1.033	1.029	1.036
T_8	0.831	0.83	0.819	0.827	0.894	0.893	0.884	0.89	1.068	1.069	1.061	1.066
MEAN	0.827	0.823	0.815		0.889	0.887	0.879		1.063	1.061	1.055	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.003	0.002	0.005		0.003	0.002	0.006		0.004	0.002	0.007	
S.E (m)	0.001	0.001	0.002		0.002	0.001	0.002		0.001	0.001	0.002	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

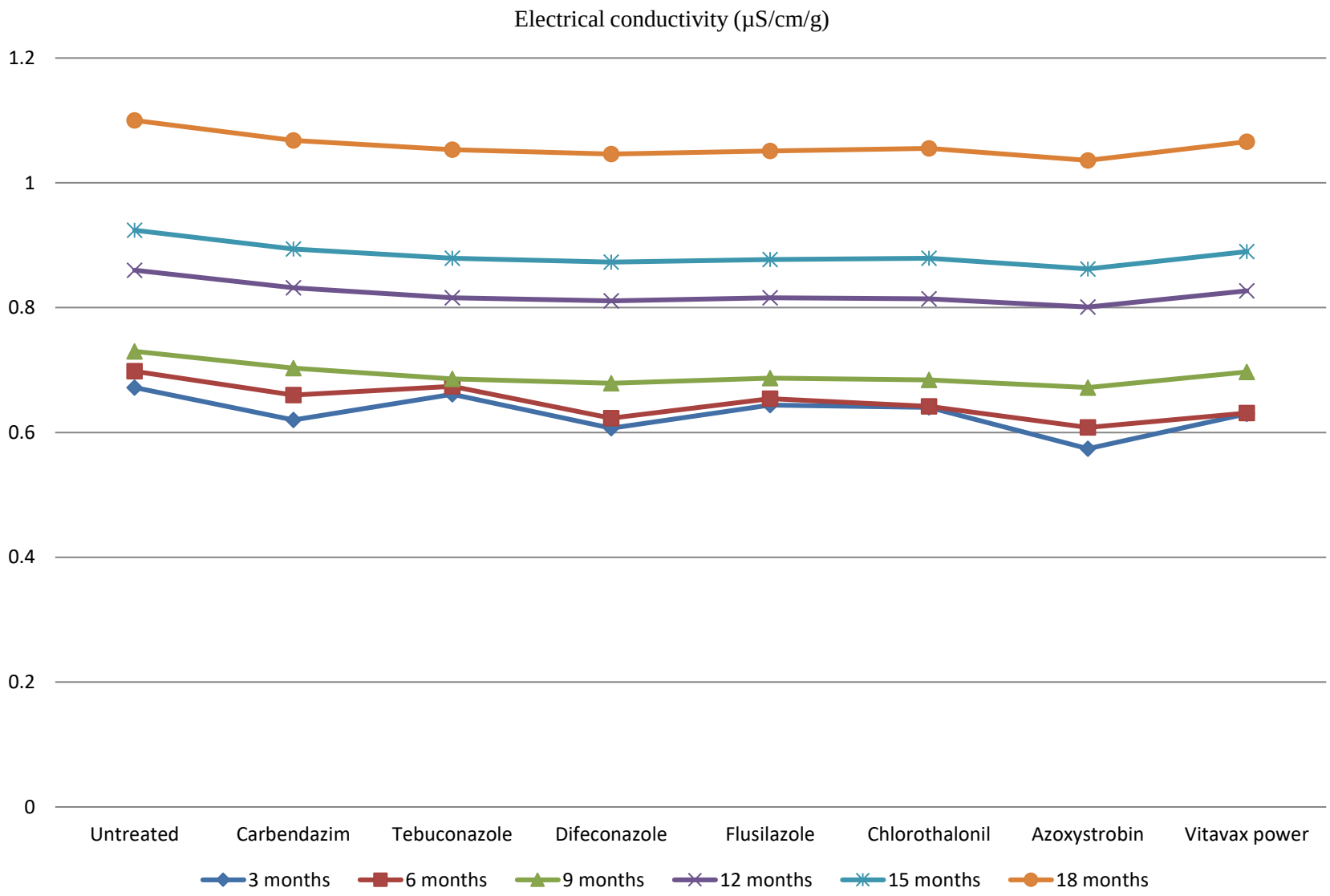

Fig. 4.2.7. Effect of fungicides and containers on electrical conductivity of seeds stored under ambient conditions

4.2.8. Catalase activity (mg protein^{-1} min^{-1})

The highest catalase activity was observed in treatment T_7 (198.9 mg protein^{-1} min^{-1}) followed by treatments T_4 (167.1 mg protein^{-1} min^{-1}), T_6 (165.2 mg protein^{-1} min^{-1}), T_8 (153.7 mg protein^{-1} min^{-1}), T_5 (151.9 mg protein^{-1} min^{-1}), T_3 (149.7 mg protein^{-1} min^{-1}), T_2 (145.3 mg protein^{-1} min^{-1}) and the lowest was in control T_1 (134.8 mg protein^{-1} min^{-1}). Among containers metal box (C_3) was found at par with hermatic bag (C_2). The maximum interaction was recorded in seeds treated with azoxystrobin (T_7) and stored in hermetic bag (C_2) container as revealed in table and figure 4.2.8.

4.2.9. Superoxidase dismustase activity (mg protein^{-1} min^{-1})

The highest S.O.D activity was recorded in treatment T_7 (132.2 mg protein^{-1} min^{-1}) followed by treatments T_4 (100.9 mg protein^{-1} min^{-1}), T_6 (97.6 mg protein^{-1} min^{-1}), T_5 (94.4 mg protein^{-1} min^{-1}), T_8 (90.8 mg protein^{-1} min^{-1}), T_3 (89.9 mg protein^{-1} min^{-1}), T_2 (87.8 mg protein^{-1} min^{-1}) and lowest was in control T_1 (71 mg protein^{-1} min^{-1}). Containers effect was recorded significant during the entire storage. Hermetic bag (C_2) proved better over other two containers. The highest interaction (136 mg protein^{-1} min-^{1}) was recorded in seeds treated with azoxystrobin (T_7) stored in hermetic bag (C_2) as showed in table and figure 4.2.9..

4.2.10. Dehydrogenase activity (OD g^{-1} ml^{-1})

Table and figure 4.2.10 showed that the highest D.H.A value was showed by treatment T_7 (0.46 OD g^{-1} ml^{-1}) followed by treatments T_4 (0.42 OD g^{-1} ml^{-1}), T_5 (0.34 OD g^{-1} ml^{-1}), T_6 (0.33 OD g^{-1} ml^{-1}), T_2 (0.31 OD g^{-1} ml^{-1}), T_8 (0.27 OD g^{-1} ml^{-1}), T_3 (0.23 OD g^{-1} ml^{-1}) and lowest was recorded in control T_1 (0.20 OD g^{-1} ml^{-1}). Containers effect was found significant in all the months of storage. Metal box (C_3) container showed superiority over hermetic and polythene bag. The maximum interaction (0.48 OD g^{-1} ml^{-1}) was observed when seeds were treated with azoxystrobin (T_7) stored in metal box (C_3).

4.2.8. Effect of fungicides and containers on catalase activity (mg protein^{-1} min^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	295.5	298.0	300.0	297.8	261.5	267.0	266.5	265.0	205.3	208.7	217.3	210.4
T_2	312.0	315.0	319.0	315.3	299.5	310.5	314.0	308.0	217.0	218.3	224.0	219.8
T_3	305.0	306.0	308.5	306.5	276.5	280.0	284.5	280.3	220.7	226.7	228.7	225.3
T_4	323.5	326.0	328.0	325.8	305.5	309.5	315.0	310.0	243.7	248.0	232.7	241.4
T_5	298.0	300.0	302.0	300.0	283.0	286.5	292.5	287.3	221.3	227.0	226.0	224.8
T_6	311.0	312.0	314.5	312.5	274.0	276.5	279.0	276.5	231.3	240.0	235.7	235.7
T_7	332.0	335.0	336.5	334.5	313.0	316.5	325.5	318.3	264.7	269.3	270.7	268.2
T_8	303.0	305.0	305.5	304.5	276.5	284.5	287.0	282.7	219.7	220.7	227.7	222.7
MEAN	310.0	312.1	314.3		286.2	291.4	295.5		228.0	232.3	232.8	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	4.28	2.62	N.S		4.00	2.45	N.S		2.43	1.49	4.22	
S.E (m)	1.46	0.89	2.52		1.36	0.83	2.36		0.85	0.52	1.48	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	195.7	201.3	209.3	202.1	153.0	159.7	170.3	161.0	128.0	131.7	144.7	134.8
T_2	207.3	213.3	216.0	212.2	164.7	171.7	178.3	171.6	139.7	143.7	152.7	145.3
T_3	211.0	220.0	220.7	217.2	168.3	178.3	181.0	175.9	143.3	150.3	155.3	149.7
T_4	234.0	240.7	225.7	233.4	193.0	199.0	188.0	193.3	168.0	171.0	162.3	167.1
T_5	211.7	221.0	219.0	217.2	172.7	180.0	182.0	178.2	147.7	152.0	156.0	151.9
T_6	221.7	233.3	228.7	227.9	182.7	192.3	193.3	189.4	160.0	168.3	167.3	165.2
T_7	255.0	265.3	263.7	261.3	216.0	227.7	224.7	222.8	193.3	204.7	198.7	198.9
T_8	210.0	216.7	220.7	215.8	171.0	179.0	182.7	177.6	148.3	156.0	156.7	153.7
MEAN	218.3	226.5	225.5		177.7	186.0	187.5		153.5	159.7	161.7	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	3.12	1.91	5.41		3.54	2.11	5.99		3.90	2.39	6.77	
S.E (m)	1.09	0.67	1.89		1.21	0.74	2.10		1.37	0.83	2.37	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

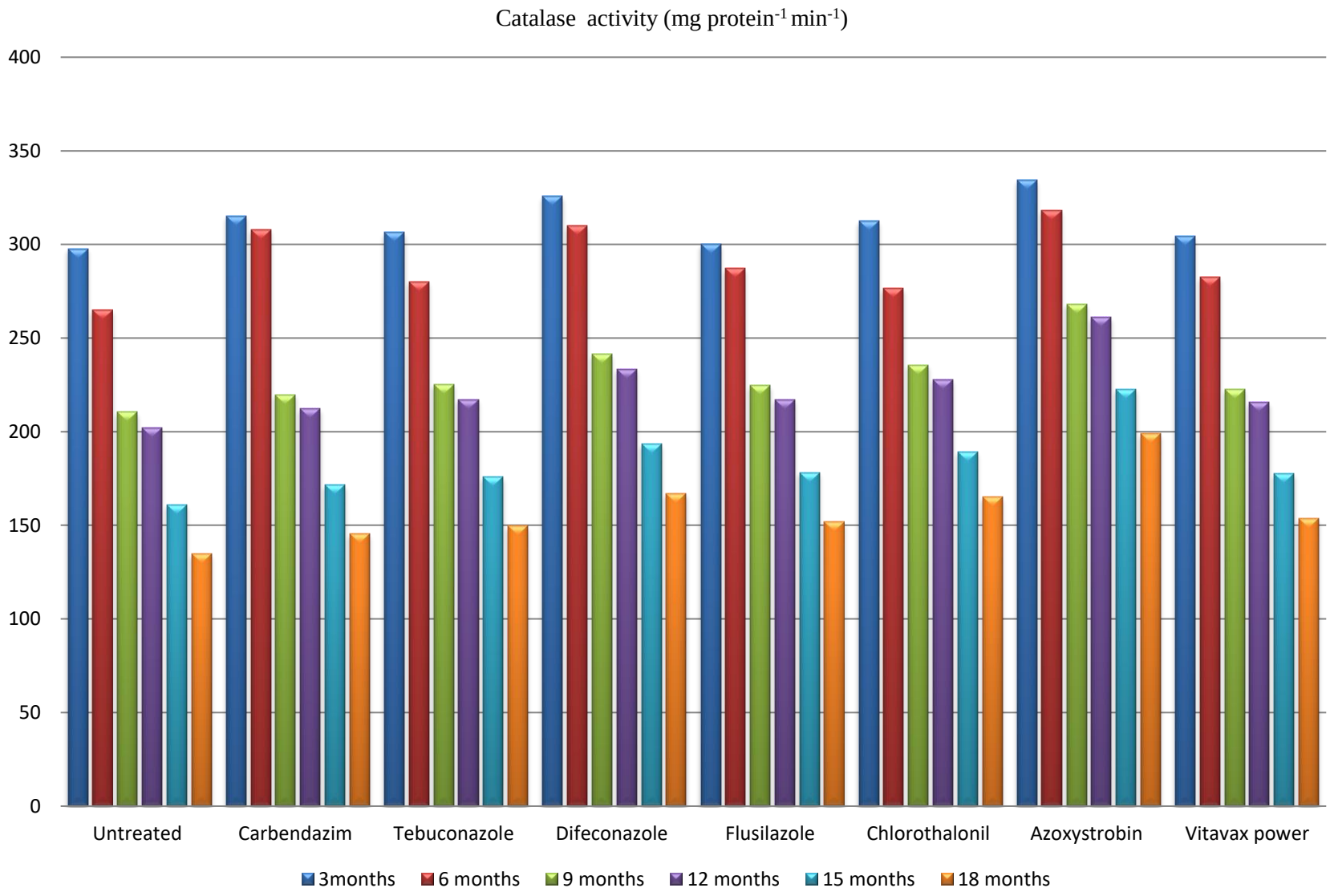

Fig. 4.2.8. Effect of fungicides and containers on catalase activity in okra seeds stored under ambient conditions

4.2.9. Effect of fungicides and containers on superoxidase dismustase activity (mg protein^{-1} min^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	279.0	287.5	289.5	285.3	256.5	266.0	270.5	264.3	171.7	178.7	187.3	179.2
T_2	289.0	296.0	297.0	294.0	272.5	277.0	276.0	275.2	191.7	196.3	202.3	196.8
T_3	281.5	287.5	288.0	285.7	261.5	270.0	275.0	268.8	195.0	201.3	200.7	199.0
T_4	305.0	313.0	315.0	311.0	282.5	290.5	295.0	289.3	211.0	215.7	208.3	211.7
T_5	284.5	289.5	292.5	288.8	270.5	276.5	279.5	275.5	192.3	200.7	204.3	199.1
T_6	287.0	293.0	295.0	291.7	275.5	277.0	284.0	278.8	203.3	205.7	206.3	205.1
T_7	310.5	318.5	322.0	317.0	292.5	299.0	306.5	299.3	237.3	243.0	249.0	243.1
T_8	299.5	307.5	310.5	305.8	280.0	285.5	291.0	285.5	189.3	197.0	204.7	197.0
MEAN	292.0	299.1	301.2		273.938	280.188	284.688		199.0	204.8	207.9	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	5.96	3.65	N.S		3.61	2.21	N.S		2.54	1.55	4.40	
S.E (m)	2.03	1.24	3.51		1.23	0.75	2.13		0.89	0.54	1.54	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	129.3	132.7	142.3	134.8	79.0	87.7	96.7	87.8	65.0	69.0	79.0	71.0
T_2	142.3	152.7	161.0	152.0	93.7	98.0	107.3	99.7	82.7	86.7	94.0	87.8
T_3	148.3	161.3	161.7	157.1	96.0	107.0	105.0	102.7	86.0	88.3	95.3	89.9
T_4	168.7	179.3	167.7	171.9	118.3	123.0	114.7	118.7	102.7	103.0	97.0	100.9
T_5	145.0	154.7	157.0	152.2	96.7	104.7	106.7	102.7	91.7	95.0	96.7	94.4
T_6	149.0	163.0	165.3	159.1	106.7	110.7	114.3	110.6	90.7	101.0	101.0	97.6
T_7	200.0	207.7	208.0	205.2	138.3	148.3	148.3	145.0	126.7	136.0	134.0	132.2
T_8	148.7	155.7	163.3	155.9	95.3	101.7	107.3	101.4	86.0	93.3	93.0	90.8
MEAN	153.9	163.4	165.8		103.0	110.1	112.5		91.4	96.5	98.8	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	3.58	2.19	6.21		3.15	1.93	5.47		2.81	1.72	4.87	
S.E (m)	1.25	0.77	2.17		1.10	0.67	1.91		0.98	0.60	1.70	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

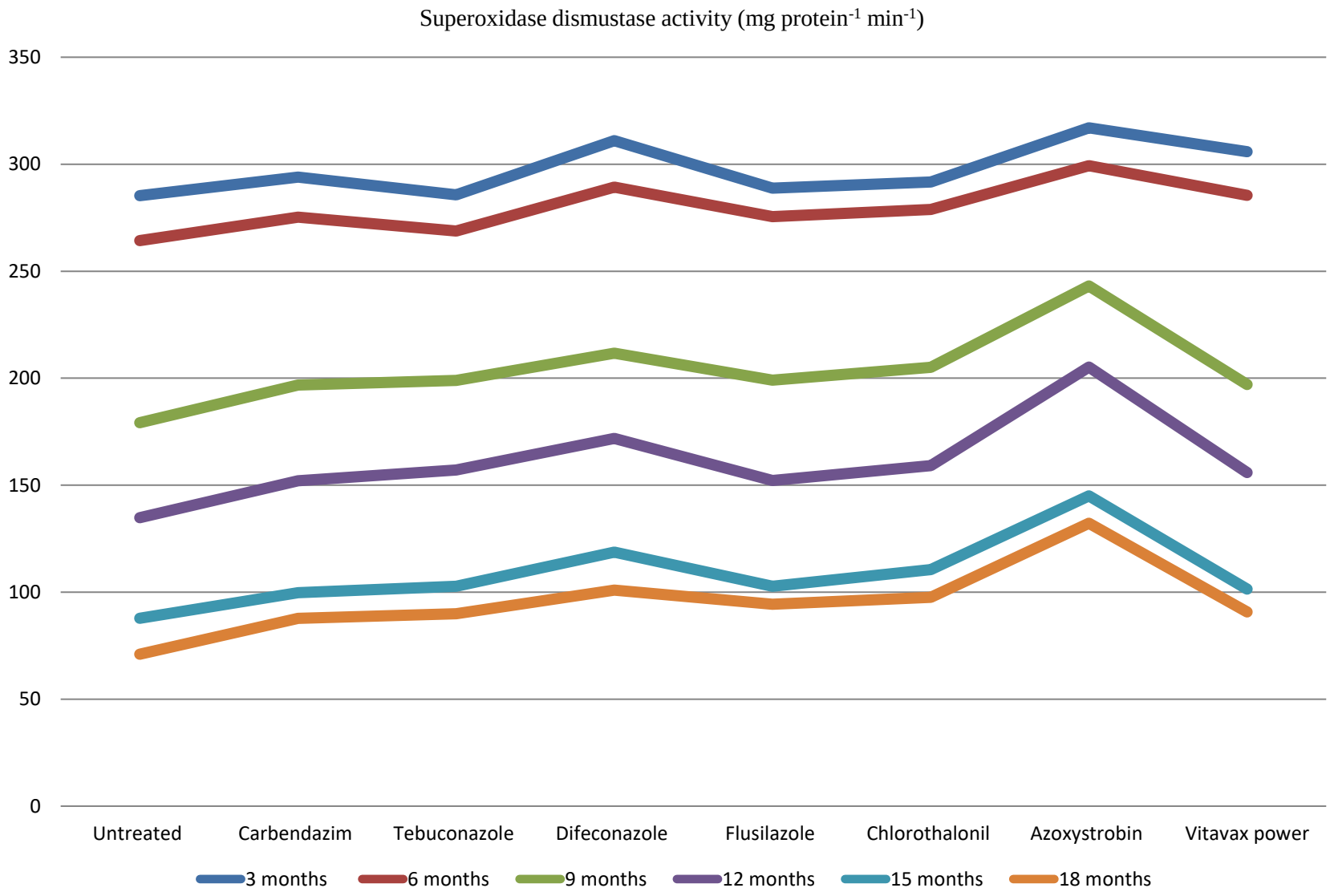

Fig. 4.2.9. Effect of fungicides and containers on superoxidase dismustase activity of seeds stored under ambient conditions

4.2.10. Effect of fungicides and containers on dehydrogenase activity (OD g^{-1} ml^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	1.26	1.32	1.34	1.31	1.20	1.22	1.24	1.22	0.85	0.86	0.94	0.88
T_2	1.44	1.46	1.48	1.46	1.31	1.33	1.35	1.33	1.07	1.07	1.05	1.06
T_3	1.30	1.35	1.37	1.34	1.23	1.24	1.29	1.25	0.95	0.97	1.04	0.99
T_4	1.50	1.53	1.55	1.53	1.42	1.45	1.46	1.44	1.08	1.09	1.15	1.11
T_5	1.36	1.37	1.41	1.38	1.35	1.34	1.40	1.36	0.87	0.88	0.96	0.91
T_6	1.35	1.40	1.42	1.39	1.38	1.36	1.42	1.39	0.96	0.99	1.04	0.99
T_7	1.59	1.62	1.64	1.61	1.46	1.46	1.48	1.47	1.18	1.22	1.24	1.21
T_8	1.34	1.41	1.44	1.40	1.31	1.34	1.38	1.34	0.86	0.85	0.96	0.89
MEAN	1.39	1.43	1.45		1.33	1.34	1.38		0.98	0.99	1.05	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.046	0.028	N.S		0.020	0.012	N.S		0.031	0.016	0.049	
S.E (m)	0.016	0.010	0.027		0.007	0.004	0.012		0.009	0.006	0.016	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.31	0.32	0.40	0.34	0.28	0.29	0.38	0.31	0.20	0.19	0.20	0.20
T_2	0.56	0.57	0.55	0.56	0.51	0.52	0.51	0.52	0.32	0.30	0.31	0.31
T_3	0.45	0.46	0.54	0.48	0.40	0.41	0.50	0.44	0.23	0.22	0.25	0.23
T_4	0.57	0.58	0.65	0.60	0.52	0.53	0.61	0.56	0.43	0.43	0.42	0.42
T_5	0.37	0.38	0.46	0.40	0.32	0.33	0.42	0.36	0.34	0.31	0.36	0.34
T_6	0.45	0.49	0.54	0.49	0.30	0.34	0.40	0.35	0.32	0.31	0.37	0.33
T_7	0.68	0.72	0.74	0.71	0.53	0.57	0.60	0.57	0.45	0.46	0.48	0.46
T_8	0.35	0.35	0.46	0.39	0.26	0.26	0.39	0.30	0.23	0.27	0.31	0.27
MEAN	0.47	0.48	0.54		0.39	0.41	0.48		0.31	0.31	0.34	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.026	0.016	0.046		0.028	0.017	0.042		0.020	0.012	0.035	
S.E (m)	0.009	0.006	0.016		0.010	0.006	0.017		0.007	0.004	0.012	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

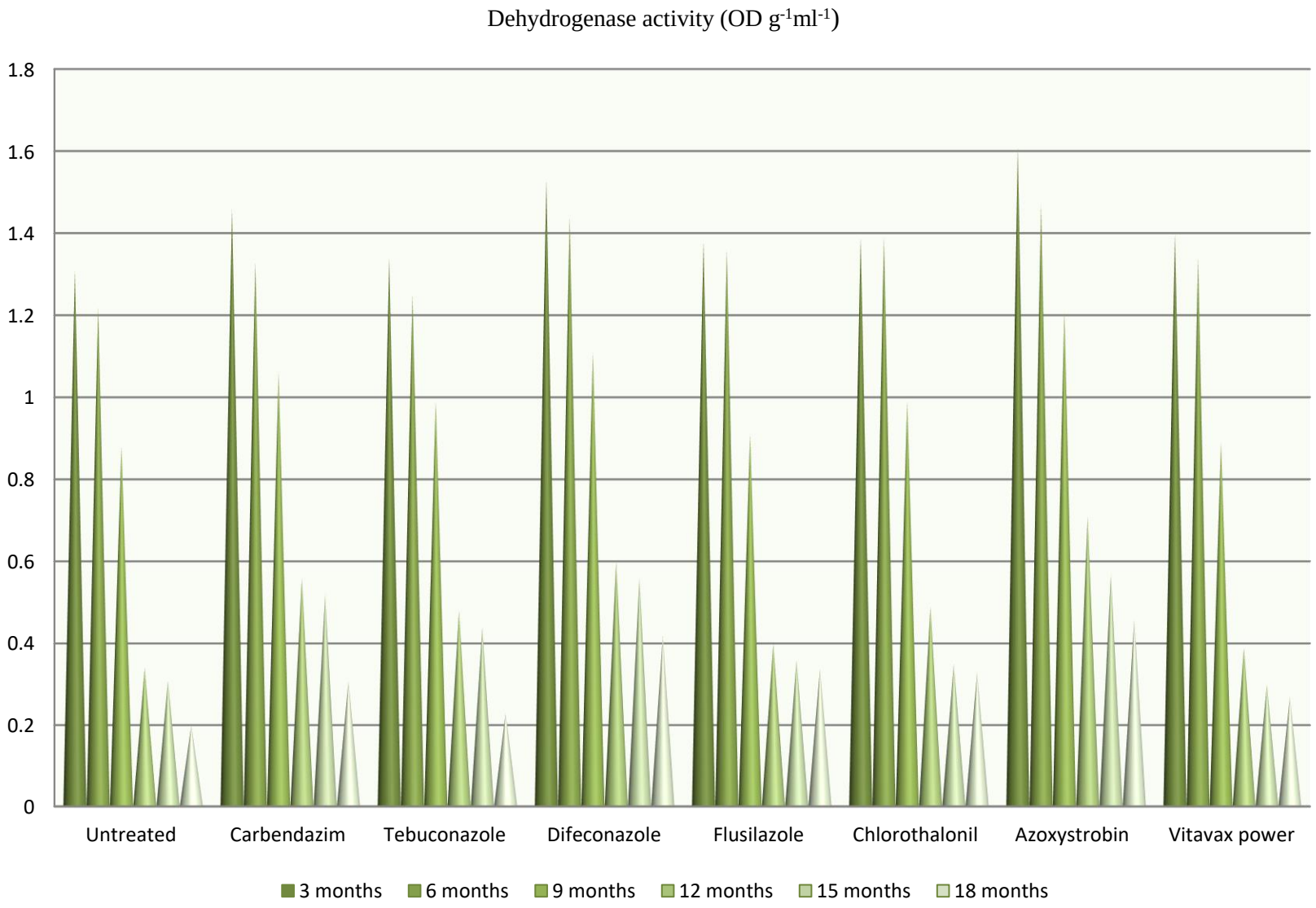

Fig. 4.2.10. Effect of fungicides and containers on dehydrogenase activity of seeds stored under ambient conditions

4.2.11. Peroxidase activity (mg protein^{-1} min^{-1})

Table and figure 4.2.11 indicated that the highest peroxidase activity was recorded in treatment T_7 (676 mg protein^{-1} min^{-1}) followed by treatments T_2 (622 mg protein^{-1} min^{-1}), T_4 (612 mg protein^{-1} min^{-1}), T_8 (579 mg protein^{-1} min^{-1}), T_3 (550 mg protein^{-1} min^{-1}), T_5 (508 mg protein^{-1} min^{-1}), T_6 (470 mg protein^{-1} min^{-1}) and lowest was in control T_1 (446 mg protein^{-1} min^{-1}). Containers effect was significant during complete storage period. Metal box (C_3) showed better performance over the other two containers *viz.*, hermatic and polythene bag. The maximum interaction (680 mg protein^{-1} min^{-1}) was recorded in seeds treated with azoxystrobin (T_7) kept in metal box (C_3).

4.2.11. Effect of fungicides and containers on peroxidase activity (mg protein^{-1} min^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	1,406	1,411	1,421	1,412	1,262	1,268	1,270	1,267	1,023	1,032	1,048	1,034
T_2	1,545	1,550	1,551	1,548	1,375	1,385	1,389	1,383	1,195	1,208	1,227	1,210
T_3	1,495	1,499	1,502	1,498	1,340	1,343	1,344	1,342	1,131	1,137	1,146	1,138
T_4	1,585	1,591	1,595	1,590	1,405	1,410	1,416	1,410	1,220	1,230	1,237	1,229
T_5	1,456	1,459	1,462	1,459	1,344	1,348	1,358	1,350	1,104	1,111	1,111	1,109
T_6	1,435	1,437	1,440	1,437	1,350	1,359	1,362	1,357	1,055	1,073	1,082	1,070
T_7	1,627	1,632	1,640	1,633	1,447	1,455	1,459	1,453	1,237	1,243	1,254	1,245
T_8	1,520	1,523	1,525	1,523	1,356	1,365	1,371	1,364	1,163	1,167	1,172	1,167
MEAN	1,509	1,512	1,517		1,360	1,367	1,371		1,141	1,150	1,160	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	7.78	4.76	N.S		5.81	3.56	N.S		5.46	3.34	9.46	
S.E (m)	2.65	1.62	4.59		1.98	1.21	3.43		1.90	1.17	3.21	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	741	749	758	749	579	603	626	602	430	446	463	446
T_2	913	926	937	925	751	779	805	778	602	622	642	622
T_3	849	854	856	853	686	708	724	706	537	551	561	550
T_4	938	947	947	944	776	801	815	797	598	615	623	612
T_5	842	848	841	844	660	682	689	677	504	512	510	508
T_6	793	810	812	805	610	644	660	638	454	474	481	470
T_7	965	970	974	970	793	814	832	813	672	677	680	676
T_8	891	894	892	892	718	738	750	735	569	581	587	579
MEAN	866	875	877		697	721	738		546	560	568	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	7.13	4.37	10.13		5.03	3.08	8.71		5.63	3.44	9.75	
S.E (m)	2.50	1.53	4.33		1.76	1.08	3.05		1.97	1.20	3.52	

*T_1: Untreated T_2: Carbendazim T_3: Tebuconazole T_4: Difenoconazole T_5: Flusilazole T_6: Chlorothalonil T_7: Azoxystrobin T_8: Vitavax Power
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

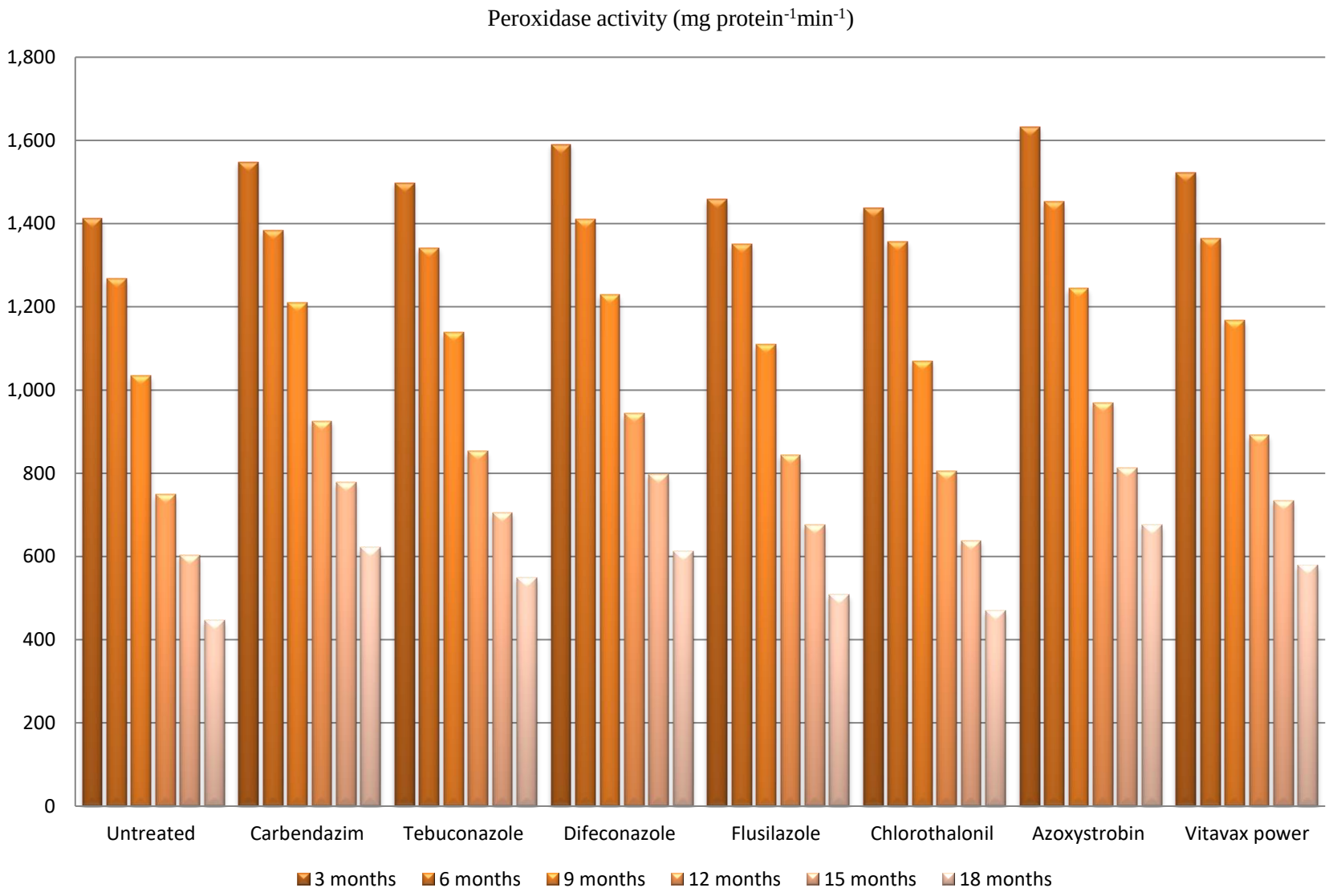

Fig 4.2.11. Effect of fungicides and containers on peroxidase activity of seeds stored under ambient conditions

Experiment 3: To assess the effect of botanicals and containers on longevity of treated seeds

The best seed lot (seeds obtained from middle portion fruits *i.e.* 6^{th} to 11^{th} nodes) was utilized in experiment 3 having initial germination (91%) above the Indian Minimum Seed Certification Standards (IMSCS). All the seed quality parameters *viz.,* germination, shoot and root length, seedling dry weight, vigour index- I & II and enzymatic activities were declined gradually except electrical conductivity with the passage of storage till the end of 18 months of storage. The botanical treatments showed better values than the control. The interaction effect of botanicals with containers was non-significant initially but recorded significant during rest of the storage period in all the parameters studied. The result mentioned below under each parameter was recorded at an interval of 3, 6, 9, 12, 15 and 18 months of storage (Table 4.3.1 to 4.3.11). However, the results explained below are for last observation recorded at the end of 18 months of storage.

4.3.1. Germination (%)

Table and figure 4.3.1 showed the germination observed for treated okra seeds with *viz.*, pongamia, neem and turmeric leaf powders with control (untreated seeds) over 18 months of storage. The highest germination was showed by neem leaf powder treated seeds T_3 (71.9%) followed by turmeric T_4 (71.1%), pongamia T_2 (68.0%) and the lowest was in control T_1 (66.9%). Among containers the maximum values were showed by the seeds kept in metal box (C_3) as compared to hermetic and polythene bags. The best interaction (71.7%) was recorded in seeds treated with neem leaf powder (T_3) stored in metal box (C_3).

4.3.2. Shoot length (cm)

Table and figure 4.3.2 showed that the neem powder treated seeds (T_3) gained maximum shoot length (8.2 cm) as compared to turmeric powder treated (7.4 cm), pongamia powder treated (6.5 cm) and the lowest was observed in control T_1 (6.2 cm). Containers effect was significant and higher values were obtained in metal box (C_3). The maximum interaction (8.0 cm) was recorded in neem leaf powder treated seeds (T_3) kept in metal box (C_3).

Table 4.3.1 Effect of botanicals and containers on germination (%)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	83.7	84.7	85.7	84.7	81.0	81.3	82.7	81.7	78.3	80.3	81.0	79.9
T_2	85.3	86.0	87.0	86.1	82.7	82.7	83.3	82.9	81.0	81.7	80.7	81.1
T_3	89.7	89.7	90.7	90.0	87.3	87.0	88.7	87.7	83.0	84.7	85.0	84.2
T_4	88.3	88.7	88.0	88.3	85.0	85.3	85.3	85.2	83.0	81.0	82.7	82.2
MEAN	86.8	87.3	87.8		84.0	84.1	85.0		81.3	81.9	82.3	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.93	0.81	N.S		0.97	0.84	N.S		0.84	0.73	1.46	
S.E (m)	0.31	0.27	0.55		0.33	0.28	0.57		0.28	0.25	0.50	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	77.0	76.7	78.3	77.3	71.3	73.7	74.0	73.0	66.0	67.0	67.7	66.9
T_2	77.0	79.0	81.7	79.2	75.0	75.7	75.7	75.4	66.3	68.7	69.0	68.0
T_3	81.3	83.3	83.7	82.8	77.0	78.7	80.0	78.6	72.3	70.7	72.7	71.9
T_4	79.3	82.0	82.0	81.1	77.0	75.0	77.7	76.6	71.7	70.7	71.0	71.1
MEAN	78.7	80.3	81.4		75.1	75.8	76.8		69.1	69.3	70.1	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.99	0.85	1.71		0.94	0.80	1.62		0.83	0.72	1.44	
S.E (m)	0.33	0.29	0.58		0.30	0.28	0.55		0.28	0.24	0.49	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

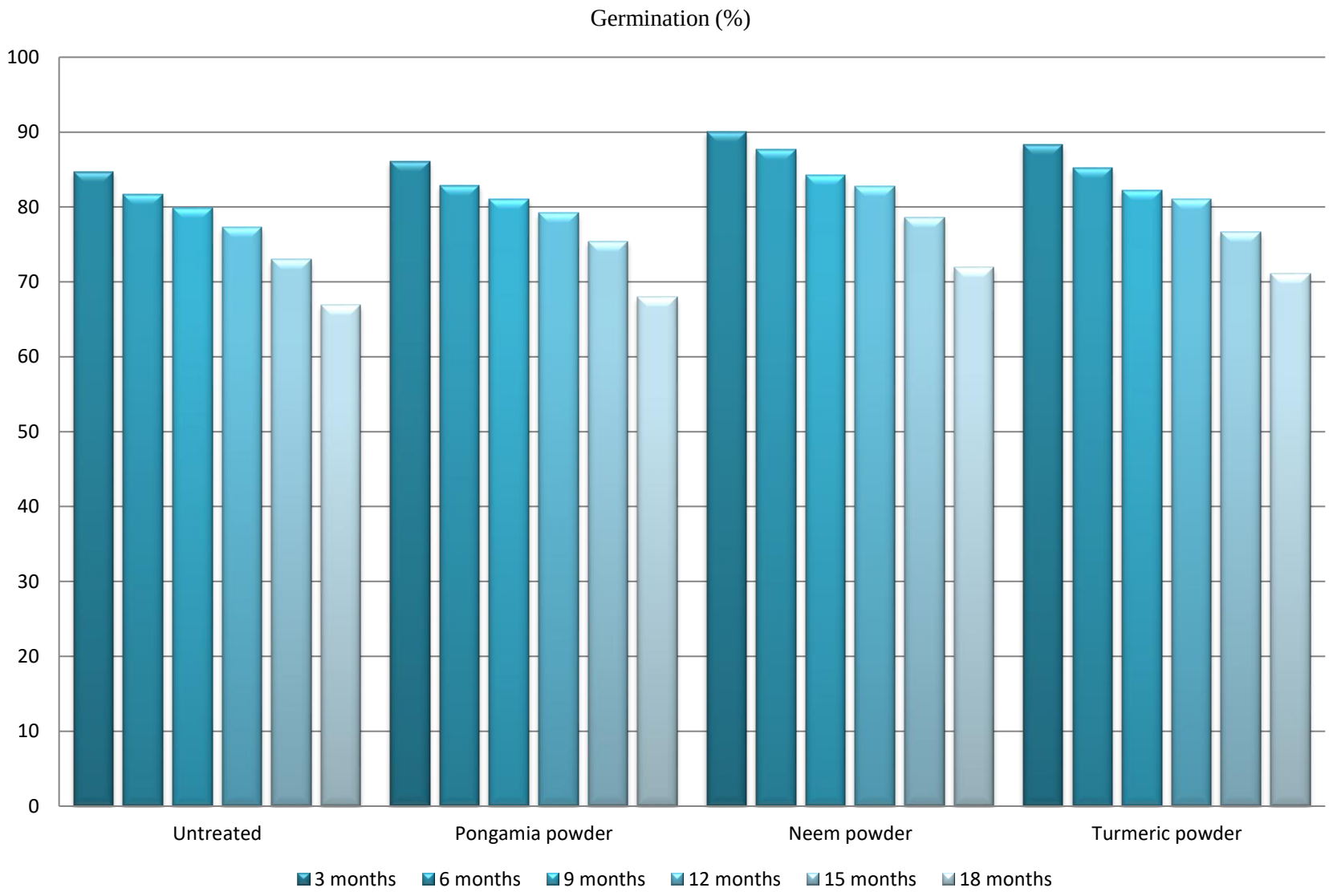

Fig 4.3.1. Effect of botanicals and containers on germination of seeds stored under ambient conditions

Table 4.3.2. Effect of botanicals and containers on shoot length (cm)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	15.5	15.7	16.5	15.9	13.2	13.4	14.2	13.6	11.3	11.9	12.6	11.9
T_2	16.8	17.0	17.1	17.0	14.5	14.9	15.0	14.8	12.5	12.5	13.1	12.7
T_3	18.8	18.9	19.0	18.9	17.2	17.3	17.4	17.3	13.9	14.8	15.9	14.9
T_4	17.7	18.0	18.1	17.9	15.3	15.7	15.9	15.6	12.6	13.4	13.4	13.1
MEAN	17.2	17.4	17.7		15.0	15.3	15.6		12.6	13.2	13.8	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.32	0.27	N.S		0.30	0.26	N.S		0.25	0.22	0.44	
S.E (m)	0.11	0.09	0.19		0.10	0.09	0.18		0.08	0.07	0.15	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	9.6	10.4	10.4	10.1	7.8	8.5	8.7	8.3	5.5	6.3	6.7	6.2
T_2	11.3	12.1	12.5	11.9	9.5	9.7	9.9	9.7	6.0	6.4	7.0	6.5
T_3	13.3	13.4	14.0	13.6	10.5	11.0	11.8	11.1	8.1	8.2	8.1	8.2
T_4	12.3	12.7	13.5	12.8	9.5	10.4	10.8	10.2	7.0	7.1	8.0	7.4
MEAN	11.6	12.1	12.6		9.3	9.9	10.3		6.7	7.0	7.5	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.22	0.19	0.39		0.25	0.21	0.43		0.26	0.22	0.45	
S.E (m)	0.07	0.06	0.13		0.08	0.07	0.14		0.08	0.07	0.15	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

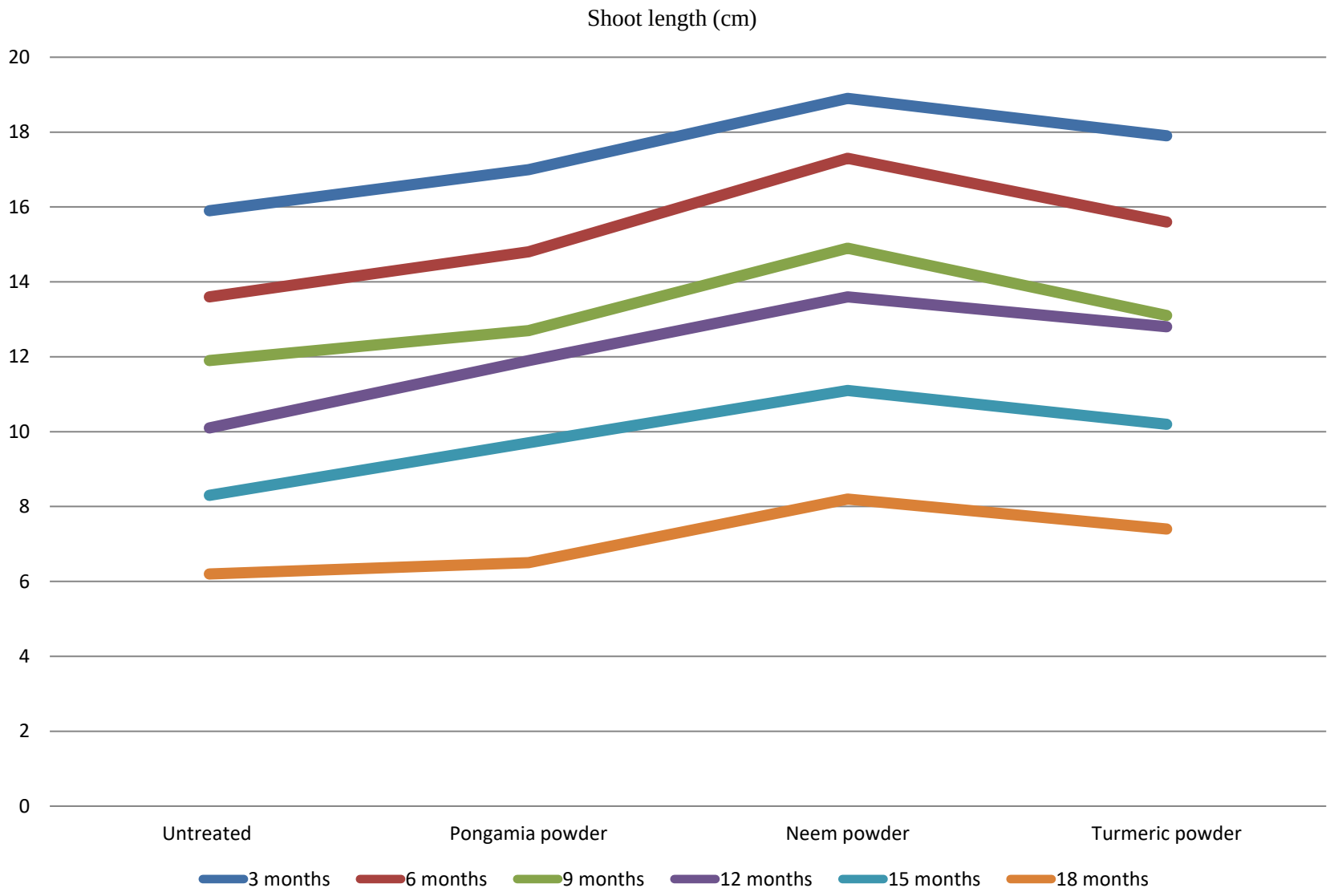

Fig. 4.3.2. Effect of botanicals and containers on shoot length of seeds stored under ambient conditions

4.3.3. Root length (cm)

The maximum root length was observed with neem leaf powder seed treatment T_3 (6.0 cm) followed by turmeric leaf powder seed treatment T_4 (5.6 cm), pongamia leaf powder seed treatment T_2 (4.5 cm) and mimimun was in contol T_1 (4.2 cm). Containers effect was significant throughout the storage period and maximum was found in metal box (C_3) followed by hermetic (C_2) and polythene bag (C_1). The highest interaction (6.0 cm) was observed in treatment with neem leaf powder (T_3) kept in metal box (C_3) as showed in table and figure 4.3.3.

4.3.4. Seedling dry weight (g)

Table and figure 4.3.4 indicated the maximum dry weight was recorded for neem leaf powder treated seeds T_3 (0.195 g) followed by turmeric leaf powder treatment (0.180 g), pongamia leaf powder treatment (0.178 g) and the minimum was under control T_1 (0.166 g). Containers effect was significant and metal box proved superior to other two containers. The maximum interaction for dry weight of seedlings (0.199 g) was recorded with neem leaf powder treated seeds (T_3) kept in hermetic bag (C_2).

4.3.5. Vigour index-I

The maximum vigour index-1 was recorded with treatment T_3 (1021) followed by T_4 (921), T_2 (748) and the minimum was recorded in T_1 control (694). Containers effect was significant throughout the storage and superiority was shown by metal box (C_3) followed by polythene bag (C_1) and hermetic bag (C_2). The maximum interaction (1059) was observed with neem leaf powder treated seeds (T_3) kept in metal box (C_3) as revealed in table and figure 4.3.5.

Table 4.3.3 Effect of seed botanicals and containers on root length (cm)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	12.0	12.2	12.4	12.2	10.2	10.4	10.7	10.4	7.3	7.4	8.2	7.6
T_2	11.6	12.8	12.9	12.4	11.5	11.8	12.0	11.8	8.3	8.5	9.2	8.7
T_3	14.2	15.4	15.5	15.0	13.4	13.7	13.9	13.7	10.1	10.5	10.7	10.4
T_4	13.4	14.8	14.6	14.3	12.5	13.0	13.1	12.9	9.5	9.5	9.3	9.4
MEAN	12.8	13.8	13.8		11.9	12.2	12.4		8.8	9.0	9.3	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.32	0.27	N.S		0.29	0.25	N.S		0.26	0.23	0.46	
S.E (m)	0.10	0.09	0.18		0.09	0.07	0.18		0.09	0.07	0.15	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C1	C2	C3	MEAN	C1	C2	C3	MEAN	C1	C2	C3	MEAN
T_1	6.7	6.8	7.6	7.0	6.0	6.1	7.0	6.3	4.2	4.1	4.2	4.2
T_2	7.7	7.8	8.6	8.0	7.1	7.2	8.0	7.4	4.5	4.4	4.7	4.5
T_3	9.6	9.7	10.3	9.9	8.7	8.8	8.6	8.7	5.9	5.8	6.4	6.0
T_4	8.8	8.9	8.7	8.8	7.7	8.1	8.6	8.1	5.2	5.6	6.0	5.6
MEAN	8.2	8.3	8.8		7.4	7.5	8.0		5.0	5.0	5.3	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.28	0.24	0.48		0.29	0.25	0.50		0.21	0.18	0.37	
S.E (m)	0.09	0.08	0.16		0.09	0.08	0.17		0.07	0.06	0.12	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

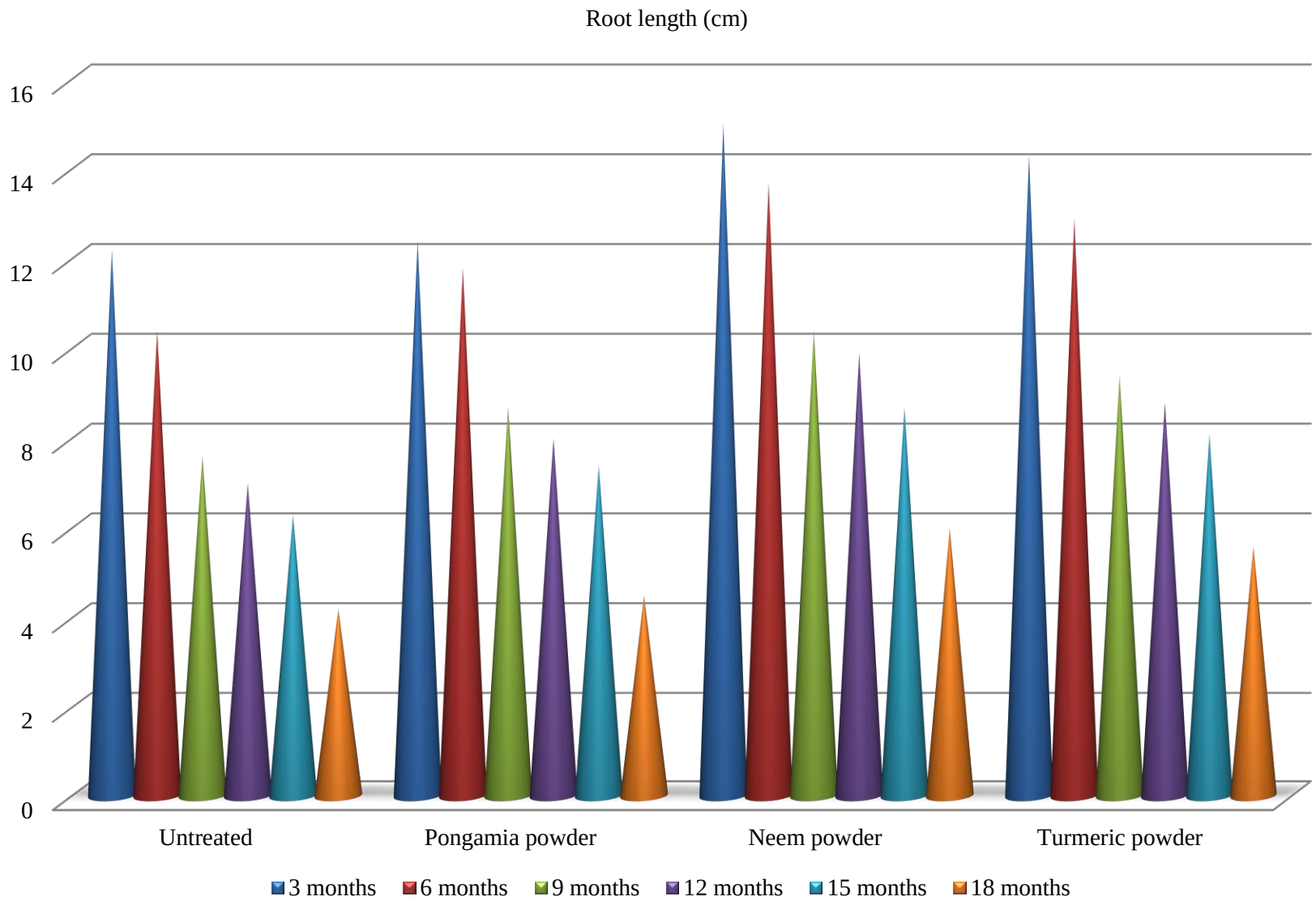

Fig. 4.3.3. Effect of botanicals and containers on root length in okra seeds stored under ambient conditions

Table 4.3.4. Effect of botanicals and containers on seedling dry weight (g)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.252	0.248	0.257	0.252	0.225	0.229	0.228	0.227	0.214	0.218	0.226	0.219
T_2	0.269	0.276	0.279	0.275	0.248	0.254	0.261	0.254	0.226	0.233	0.227	0.229
T_3	0.303	0.310	0.311	0.308	0.286	0.288	0.294	0.289	0.259	0.268	0.264	0.264
T_4	0.287	0.294	0.295	0.292	0.274	0.281	0.285	0.280	0.253	0.242	0.257	0.250
MEAN	0.278	0.282	0.286		0.258	0.263	0.267		0.238	0.24	0.244	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.006	0.005	N.S		0.004	0.004	N.S		0.002	0.002	0.004	
S.E (m)	0.002	0.002	0.003		0.002	0.001	0.003		0.001	0.001	0.001	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.203	0.208	0.216	0.209	0.174	0.181	0.191	0.182	0.159	0.163	0.176	0.166
T_2	0.221	0.222	0.228	0.224	0.196	0.203	0.205	0.201	0.171	0.178	0.183	0.178
T_3	0.240	0.249	0.245	0.245	0.216	0.222	0.211	0.216	0.196	0.199	0.190	0.195
T_4	0.229	0.230	0.237	0.232	0.206	0.215	0.216	0.212	0.176	0.180	0.184	0.180
MEAN	0.223	0.227	0.231		0.198	0.205	0.206		0.176	0.180	0.183	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.003	0.003	0.005		0.004	0.003	0.006		0.004	0.003	0.007	
S.E (m)	0.001	0.001	0.002		0.001	0.001	0.002		0.001	0.002	0.001	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

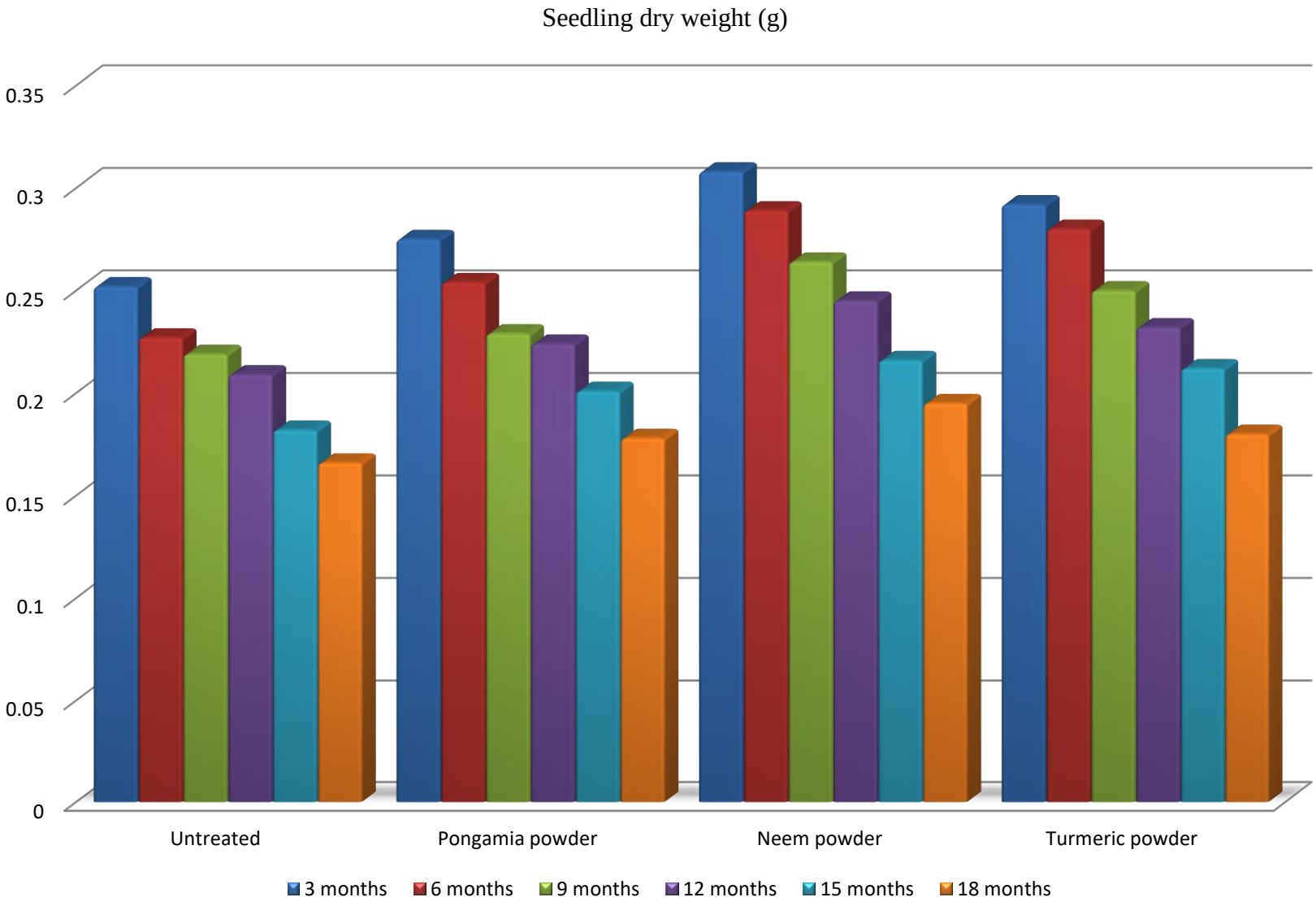

Fig 4.3.4. Effect of botanicals and containers on seedling dry weight of seeds stored under ambient conditions

Table 4.3.5. Effect of botanicals and containers on vigour index-I

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	2,298	2,362	2,476	2,379	1,892	1,941	2,058	1,964	1,457	1,553	1,682	1,564
T_2	2,427	2,563	2,604	2,531	2,143	2,207	2,250	2,200	1,682	1,712	1,799	1,731
T_3	2,959	3,076	3,122	3,052	2,672	2,697	2,772	2,714	1,997	2,145	2,261	2,135
T_4	2,747	2,914	2,881	2,847	2,360	2,444	2,478	2,427	1,831	1,860	1,880	1,857
MEAN	2,608	2,729	2,771		2,267	2,322	2,390		1,742	1,818	1,906	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	51	46	N.S		40	35	N.S		36	31	63	
S.E (m)	17	15	30		13	11	23		12	10	21	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	1,252	1,316	1,405	1,324	982	1078	1157	1072	643	699	740	694
T_2	1,458	1,575	1,721	1,584	1245	1276	1352	1291	701	737	807	748
T_3	1,863	1,920	2,039	1,940	1483	1555	1632	1557	1013	992	1059	1021
T_4	1,679	1,771	1,820	1,757	1324	1383	1502	1403	872	897	994	921
MEAN	1,563	1,646	1,746		1259	1323	1411		807	831	900	
C.D (5%)	T	C	TXC		T	C	T XC		T	C	TXC	
	35	31	60		27	24	54		29	25	56	
S.E (m)	13	9	20		9	8	16		10	8	17	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

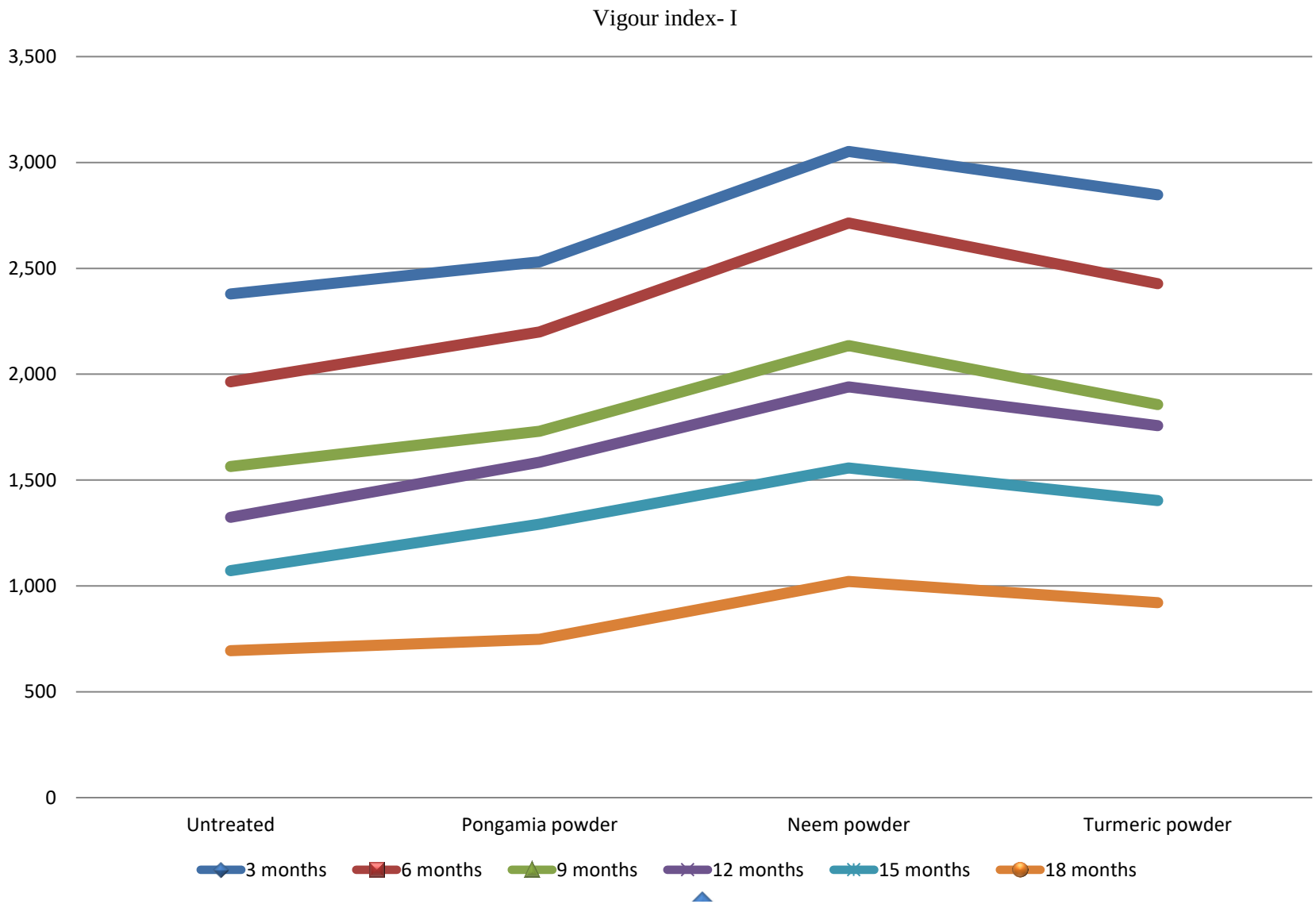

Fig. 4.3.5. Effect of botanicals and containers on vigour index-I of seeds stored under ambient conditions

4.3.6. Vigour index-II

Table and figure 4.3.6 revealed the maximum vigour index-II was observed in neem leaf powder treated seeds T_3 (14.03) followed by turmeric leaf powder treated seeds T_4 (12.79), pongamia leaf powder treated seeds T_2 (12.09) and minimum was observed in control T_1 (11.09). Containers effect was significant throughout and metal box proved superior over other two containers. The highest interaction (14.18) was recorded in seeds treated with neem leaf powder (T_3) kept in poythene bag (C_1).

4.3.7. Electrical conductivity (µS/cm/g)

Table and figure 4.3.7 showed values of electrical conductivity were increased and attained maximum after 18 months of storage. The minimum value was observed in seeds treated with neem leaf powder T_3 (1.042 µS/cm/g) followed by turmeric leaf powder T_4 (1.051 µS/cm/g), pongamia leaf powder (1.064 µS/cm/g) and maximum was observed in control T_1 (1.100 µS/cm/g). Containers effect was significant and lowest electrical conductivity was recorded in metal box (C_3) as compared to hermetic (C_2) and polythene bag (C_1). The best interaction (1.037 µS/cm/g) was observed in seeds treated with neem leaf powder (T_3) and kept in metal box (C_3).

4.3.8. Catalase activity (mg protein^{-1} min^{-1})

The highest catalase activity was recorded in seeds treated with neem leaf powder T_3 (172.1 mg protein^{-1} min^{-1}) followed by turmeric leaf powder T_4 (167.2 mg protein^{-1} min^{-1}), pongamia leaf powder T_2 (143.7 mg protein^{-1} min^{-1}) and lowest was recorded in control T_1 (134.8 mg protein^{-1} min^{-1}) at the end of storage period. Among containers metal box (C_3) was found at par with hermetic bag (C_2) . The interaction effect of treatments with containers was found highest (176.0 mg protein^{-1} min^{-1}) in seeds treated with neem leaf powder (T_3) and seeds were kept in hermetic bag (C_2) as revealed in table and figure 4.3.8.

Table 4.3.6. Effect of botanicals and containers on vigour index-II

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	21.06	21.00	22.04	21.37	18.20	18.60	18.85	18.55	16.79	17.49	18.33	17.54
T_2	22.98	23.71	24.24	23.64	20.48	21.02	21.75	21.08	18.31	19.03	18.34	18.56
T_3	27.20	27.83	28.17	27.73	24.95	25.03	26.07	25.35	21.52	22.69	22.41	22.21
T_4	25.38	26.04	25.99	25.80	23.32	24.01	24.29	23.87	20.97	19.58	21.25	20.60
MEAN	24.15	24.64	25.11		21.74	22.16	22.74		19.40	19.70	20.08	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.55	0.48	N.S		0.42	0.36	N.S		0.30	0.26	0.52	
S.E (m)	0.18	0.16	0.32		0.14	0.12	0.25		0.10	0.08	0.17	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	15.61	15.97	16.95	16.18	12.41	13.31	14.16	13.29	10.50	10.90	11.89	11.09
T_2	17.02	17.56	18.62	17.73	14.68	15.36	15.51	15.18	11.36	12.25	12.65	12.09
T_3	19.55	20.75	20.47	20.26	16.63	17.46	16.88	16.99	14.18	14.06	13.83	14.03
T_4	18.14	18.83	19.41	18.79	15.84	16.15	16.80	16.26	12.59	12.72	13.06	12.79
MEAN	17.58	18.28	18.86		14.89	15.57	15.84		12.16	12.48	12.86	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.35	0.31	0.63		0.35	0.30	0.61		0.31	0.27	0.54	
S.E (m)	0.12	0.10	0.21		0.12	0.09	0.19		0.10	0.09	0.18	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

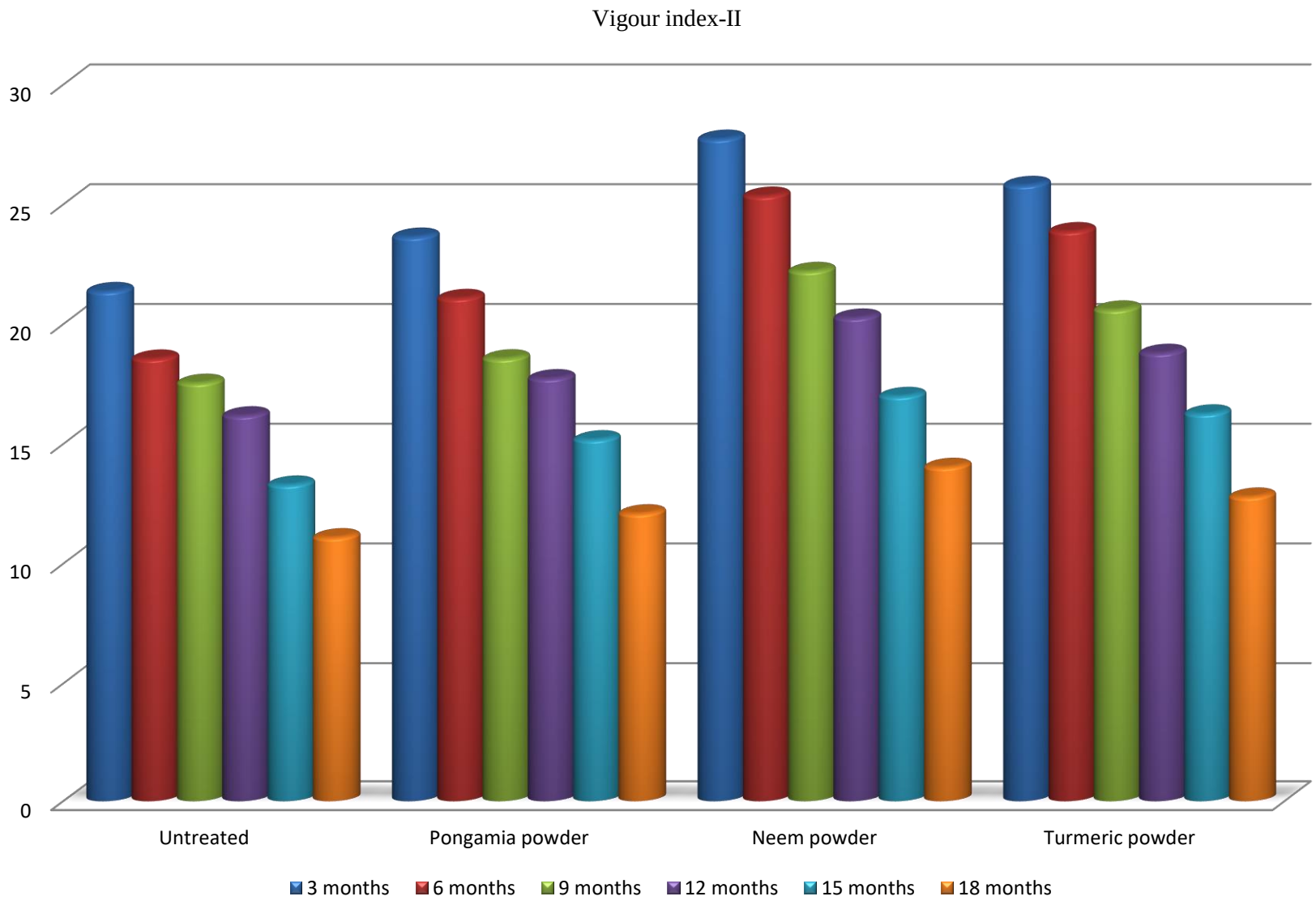

Fig 4.3.6. Effect of botanicals and containers on vigour index-II of seeds stored under ambient conditions

Table 4.3.7 Effect of botanicals and containers on electrical conductivity (µS/cm/g)

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.673	0.674	0.668	0.672	0.709	0.695	0.691	0.698	0.734	0.724	0.732	0.730
T_2	0.660	0.650	0.648	0.653	0.676	0.674	0.667	0.673	0.709	0.700	0.691	0.700
T_3	0.533	0.523	0.521	0.526	0.591	0.585	0.577	0.584	0.684	0.681	0.679	0.681
T_4	0.601	0.591	0.589	0.594	0.642	0.636	0.632	0.637	0.694	0.683	0.690	0.689
MEAN	0.617	0.610	0.607		0.655	0.647	0.642		0.705	0.697	0.698	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.006	0.005	N.S		0.005	0.004	N.S		0.004	0.004	0.007	
S.E (m)	0.002	0.002	0.003		0.002	0.001	0.003		0.001	0.001	0.002	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.866	0.862	0.852	0.860	0.926	0.929	0.917	0.924	1.100	1.106	1.094	1.100
T_2	0.826	0.836	0.829	0.830	0.889	0.900	0.894	0.894	1.059	1.068	1.065	1.064
T_3	0.816	0.808	0.802	0.809	0.879	0.873	0.866	0.873	1.050	1.041	1.037	1.042
T_4	0.823	0.814	0.807	0.814	0.884	0.880	0.872	0.879	1.054	1.053	1.045	1.051
MEAN	0.833	0.83	0.823		0.894	0.895	0.887		1.066	1.067	1.060	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.004	0.003	0.006		0.004	0.003	0.005		0.003	0.003	0.007	
S.E (m)	0.001	0.001	0.002		0.001	0.001	0.002		0.001	0.002	0.002	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

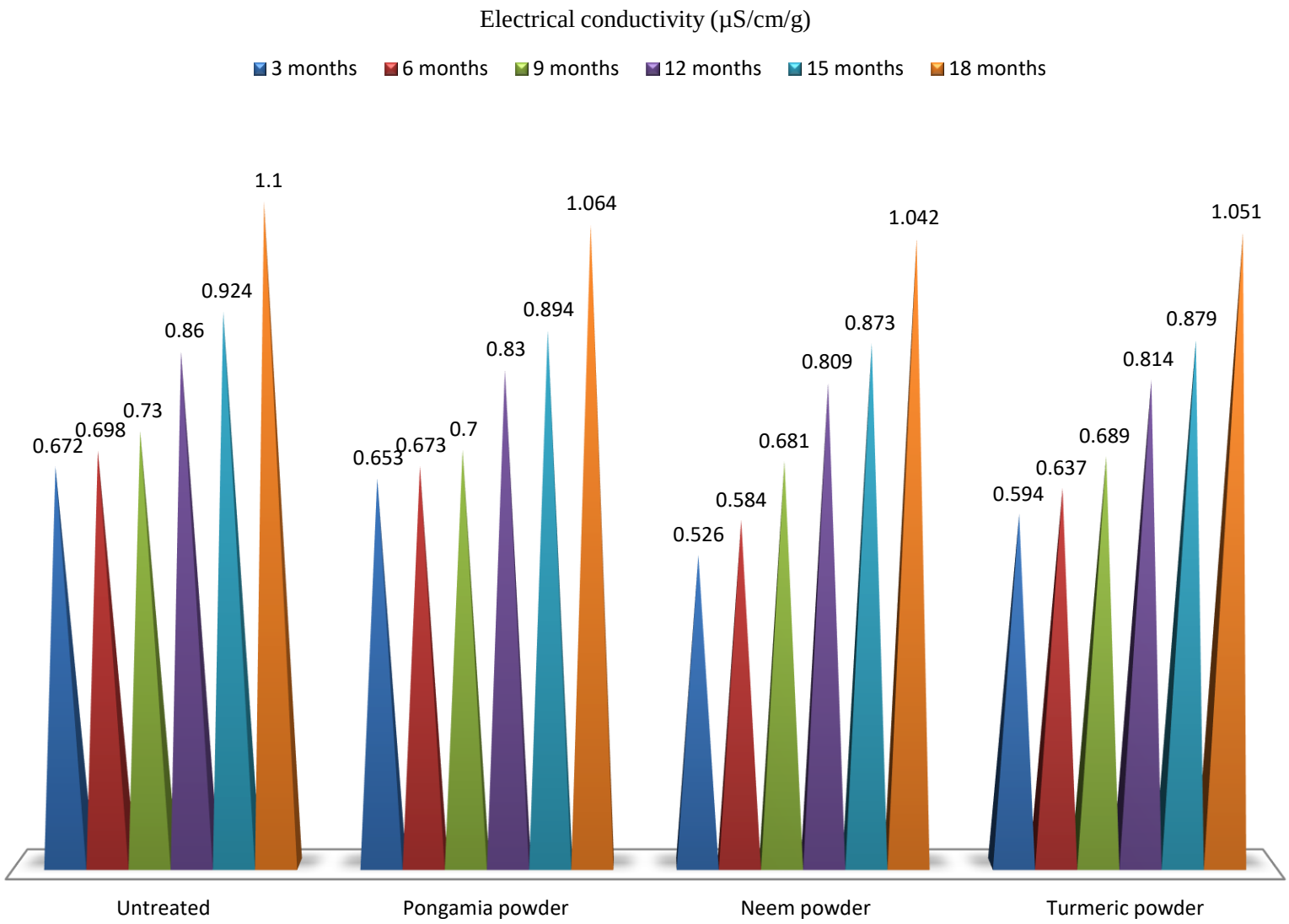

Fig. 4.3.7. Effect of botanicals and containers on electrical conductivity of seeds stored under ambient conditions

Table 4.3.8. Effect of botanicals and containers on catalase activity (mg protein^{-1} min^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	295.5	298.0	300.0	297.8	261.5	267.0	266.5	265.0	205.3	208.7	217.3	210.4
T_2	299.0	307.0	309.0	305.0	280.5	289.5	294.0	288.0	215.7	216.7	223.7	218.7
T_3	321.0	323.5	329.5	324.7	312.5	315.5	319.0	315.7	252.7	257.0	241.7	250.4
T_4	310.0	314.5	314.0	312.8	299.0	304.5	307.0	303.5	235.3	244.0	239.7	239.7
MEAN	306.4	310.8	313.1		288.4	294.1	296.6		227.3	231.6	230.6	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	5.9	5.1	N.S		5.1	4.4	N.S		2.3	2.0	4.0	
S.E (m)	1.9	1.6	3.3		1.6	1.4	2.8		0.7	0.6	1.3	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	195.7	201.3	209.3	202.1	153.0	159.7	170.3	161.0	128.0	131.7	144.7	134.8
T_2	210.0	216.7	220.7	215.8	166.3	176.3	179.0	173.9	138.3	146.0	146.7	143.7
T_3	234.0	240.7	225.7	233.4	198.0	204.0	193.0	198.3	173.0	176.0	167.3	172.1
T_4	221.7	233.3	228.7	227.9	192.7	202.3	203.3	199.4	162.0	170.3	169.3	167.2
MEAN	215.3	223.0	221.1		177.5	185.6	186.4		150.3	156.0	157.0	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	3.2	2.7	5.5		2.9	2.6	5.3		4.0	3.4	6.9	
S.E (m)	1.0	1.0	2.0		1.0	0.9	1.8		1.3	1.1	2.3	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

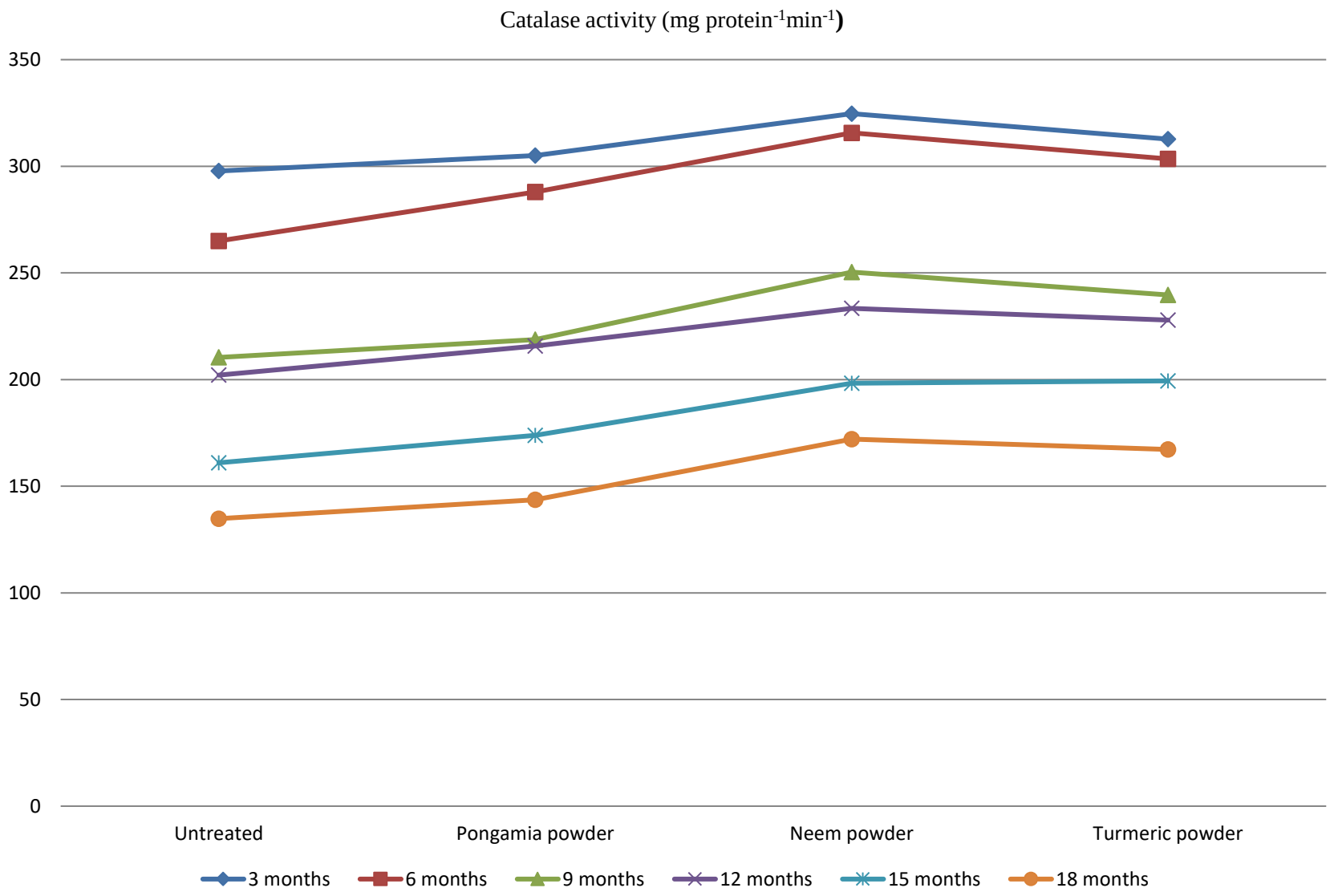

Fig 4.3.8. Effect of botanicals and containers on catalase activity of seeds stored under ambient conditions

4.3.9. Superoxidase dismustase activity (mg protein^{-1} min^{-1})

The S.O.D activity was declined and maximum activity was showed by neem leaf powder treated seeds T_3 (105 mg protein^{-1} min^{-1}) followed by turmeric leaf powder T_4 (94.4 mg protein^{-1} min^{-1}), pongamia leaf powder T_2 (87.7 mg protein^{-1} min^{-1}) and lowest was seen in control T_1 (71.0 mg protein^{-1} min^{-1}). Among containers, metal box was found superior than hermetic and polythene bag and the values were significant during entire storage. The best interaction (106 mg protein^{-1} min^{-1}) was seen in neem leaf powder treated seeds (T_3) kept in hermetic bag (C_2) as showed in table and figure 4.3.9.

4.3.10. Dehydrogenase activity (OD g^{-1} ml^{-1})

The decline in D.H.A was observed in each interval of storage. After 18 months of storage, the maximum D.H.A activity was seen in seeds treated with neem leaf powder T_3 (0.43 OD g^{-1} ml^{-1}) followed by turmeric leaf powder T_4 (0.33 OD g^{-1} ml^{-1}), pongamia leaf powder T_2 (0.29 OD g^{-1} ml^{-1}) and minimum was seen in control T_1 (0.20 OD g^{-1} ml^{-1}1). Containers effect was significant during storage and metal box proved superior over polythene and hermetic bag. The highest interaction (0.45 OD g^{-1} ml^{-1}) was recorded in seeds treated with neem leaf powder (T_3) and stored in metal box container (C_3) at the end of storage indicated in table and figure 4.3.10.

4.3.11. Peroxidase activity (mg protein^{-1} min^{-1})

Table and figure 4.3.11 indicated the highest peroxidase activity was recorded in seeds treated with neem leaf powder T_3 (572 mg protein^{-1} min^{-1}) followed by turmeric leaf powder T_4 (543 mg protein^{-1} min^{-1}), pongamia leaf powder T_2 (501 mg protein^{-1} min^{-1}) and lowest was recorded in control T_1 (446 mg protein^{-1} min^{-1}) at the end of storage. Among containers metal box (C_3) was found at par with hermatic bag (C_2). The highest interaction (580) was recorded in seeds treated with neem leaf powder (T_3) stored in metal box (C_3).

Table 4.3.9. Effect of botanicals and containers on superoxidase dismustase activity (mg protein^{-1} min^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	279.0	287.5	289.5	285.3	256.5	266.0	270.5	264.3	171.7	178.7	187.3	179.2
T_2	284.0	292.5	294.0	290.2	265.0	269.0	274.5	269.5	188.7	193.3	199.3	193.8
T_3	303.0	310.5	312.0	308.5	286.5	290.5	294.5	290.5	234.0	238.7	231.3	234.7
T_4	291.0	299.0	301.0	297.0	278.0	280.0	283.0	280.3	210.3	212.7	213.3	212.1
MEAN	289.3	297.4	299.1		271.5	276.4	280.6		201.2	205.8	207.8	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	6.1	5.2	N.S		4.6	4.0	N.S		2.2	1.9	3.9	
S.E (m)	1.9	1.6	3.3		1.5	1.3	2.6		0.7	0.6	1.3	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	128.5	129.0	135.5	131.0	79.0	87.7	96.7	87.8	65.0	69.0	79.0	71.0
T_2	142.0	141.5	141.5	141.7	93.7	98.0	107.3	99.7	82.6	86.6	94.0	87.7
T_3	149.0	153.0	153.5	151.8	111.7	115.7	119.3	115.6	105.6	106.0	103.3	105.0
T_4	183.5	187.5	199.0	190.0	98.7	106.7	108.7	104.7	91.6	95.0	96.6	94.4
MEAN	150.8	152.8	157.4		95.8	102.0	108.0		86.2	89.1	93.2	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	4.0	3.4	7.2		3.2	2.8	5.7		3.9	3.4	6.9	
S.E (m)	1.2	1.1	2.2		1.1	0.9	1.9		1.3	1.1	2.3	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

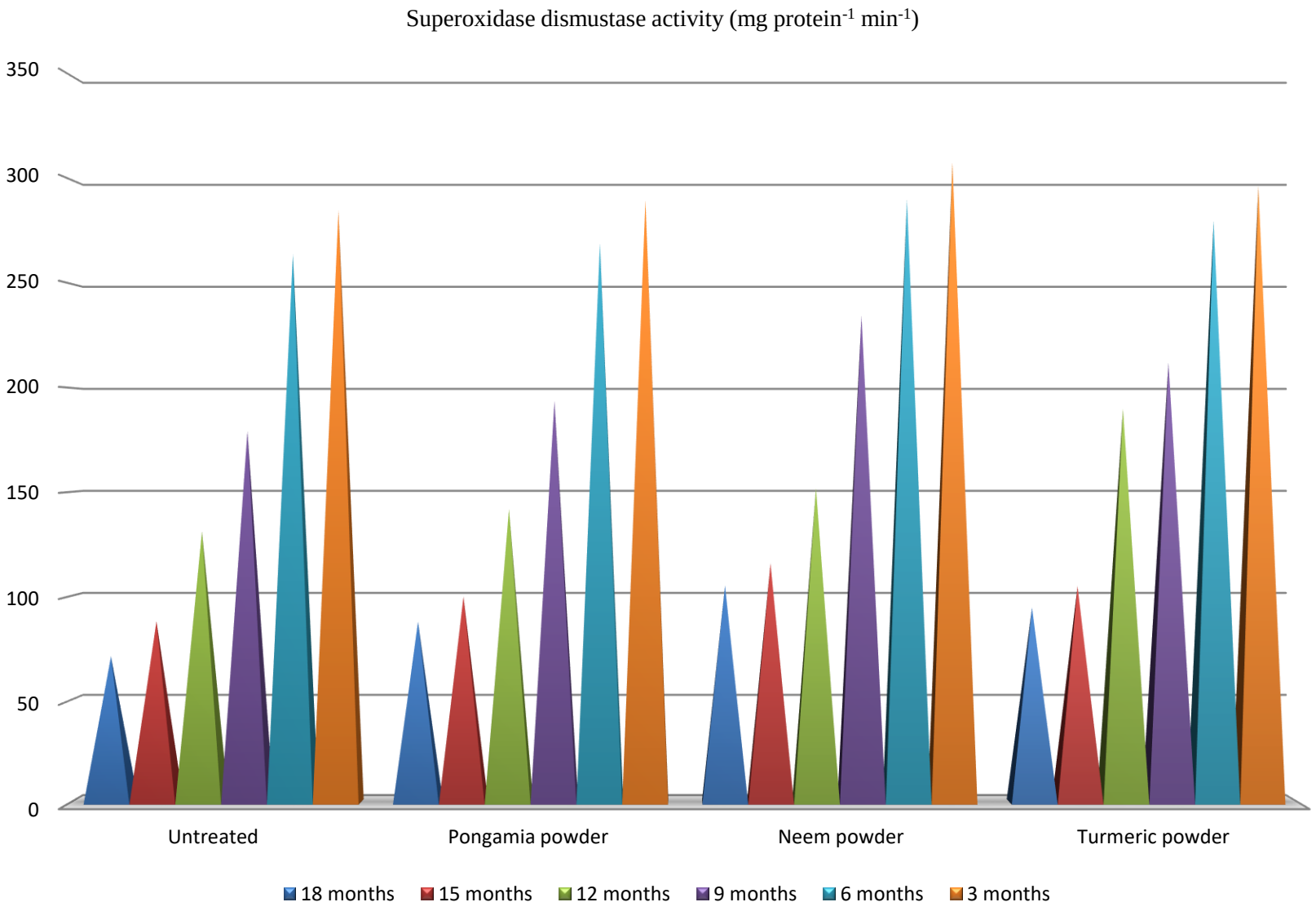

Fig. 4.3.9. Effect of botanicals and containers on superoxidase dismustase activity of seeds stored under ambient conditions

Table 4.3.10. Effect of botanicals and containers on D.H.A activity (OD g^{-1} ml^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	1.26	1.32	1.34	1.31	1.20	1.22	1.24	1.22	0.85	0.86	0.94	0.88
T_2	1.39	1.44	1.51	1.44	1.31	1.33	1.35	1.33	0.93	0.92	1.03	0.96
T_3	1.55	1.66	1.75	1.65	1.39	1.42	1.43	1.41	1.08	1.09	1.15	1.11
T_4	1.46	1.55	1.65	1.55	1.35	1.34	1.40	1.36	0.96	0.99	1.04	0.99
MEAN	1.41	1.49	1.56		1.31	1.33	1.36		0.95	0.97	1.04	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.052	0.045	N.S		0.022	0.019	N.S		0.027	0.023	0.046	
S.E (m)	0.017	0.014	0.029		0.007	0.006	0.013		0.009	0.008	0.016	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	0.31	0.32	0.40	0.34	0.28	0.29	0.38	0.31	0.20	0.19	0.20	0.20
T_2	0.35	0.35	0.46	0.39	0.37	0.40	0.44	0.40	0.25	0.29	0.33	0.29
T_3	0.60	0.61	0.68	0.63	0.52	0.55	0.58	0.55	0.43	0.40	0.45	0.43
T_4	0.56	0.57	0.55	0.56	0.41	0.44	0.48	0.44	0.32	0.31	0.37	0.33
MEAN	0.46	0.46	0.52		0.39	0.42	0.47		0.30	0.30	0.34	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	0.028	0.024	0.048		0.031	0.027	0.054		0.021	0.018	0.037	
S.E (m)	0.010	0.008	0.017		0.011	0.009	0.019		0.007	0.006	0.013	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder

*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

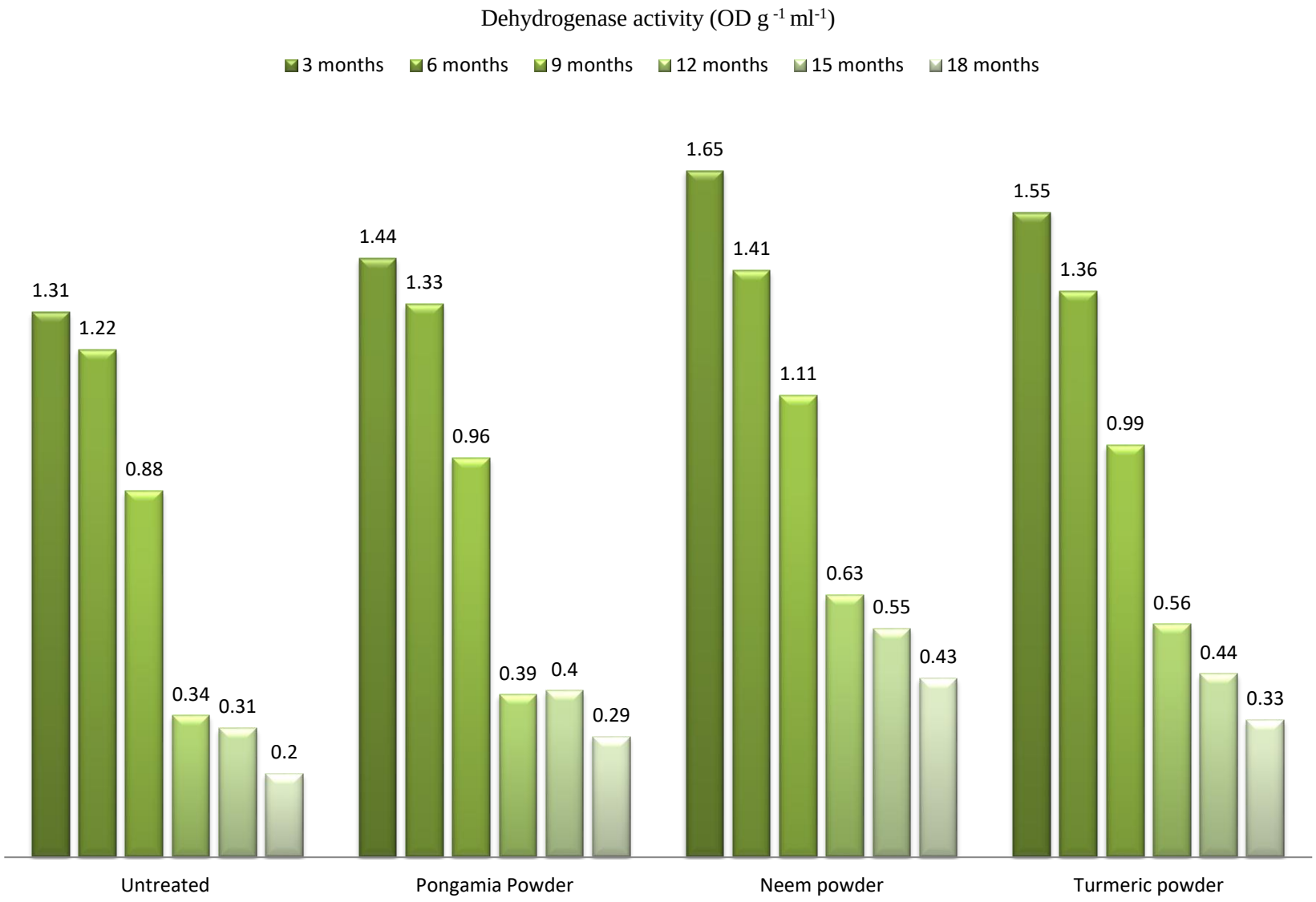

Fig. 4.3.10. Effect of botanicals and containers on dehydrogenase activity of seeds stored under ambient conditions

Table 4.3.11. Effect of botanicals and containers on peroxidase activity (mg protein^{-1} min^{-1})

	3 MONTHS				6 MONTHS				9 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	1,406	1,411	1,421	1,412	1,262	1,268	1,270	1,267	1,023	1,032	1,048	1,034
T_2	1,472	1,486	1,494	1,484	1,302	1,312	1,316	1,310	1,113	1,120	1,120	1,118
T_3	1,573	1,581	1,587	1,580	1,413	1,416	1,429	1,419	1,229	1,239	1,246	1,238
T_4	1,516	1,525	1,530	1,524	1,349	1,355	1,361	1,355	1,195	1,208	1,227	1,210
MEAN	1,492	1,500	1,508		1,331	1,338	1,344		1,140	1,150	1,160	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	6.8	5.9	N.S		8.6	7.5	N.S		5.8	5.0	10.1	
S.E (m)	2.2	1.9	3.8		2.7	2.4	4.8		2.0	1.7	3.4	

	12 MONTHS				15 MONTHS				18 MONTHS			
TREATMENT	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN	C_1	C_2	C_3	MEAN
T_1	741	749	758	749	579	603	626	602	430	446	463	446
T_2	793	810	812	805	613	647	662	641	497	505	503	501
T_3	913	926	937	925	721	741	752	738	562	574	580	572
T_4	891	894	892	892	689	711	726	709	530	544	554	543
MEAN	834	845	849		651	675	691		505	517	525	
C.D (5%)	T	C	TXC		T	C	TXC		T	C	TXC	
	7.4	6.4	12.7		5.0	4.3	8.6		6.0	5.1	10.2	
S.E (m)	2.5	2.2	4.4		1.7	1.4	2.9		2.0	1.7	3.5	

*T_1: Untreated T_2: Pongamia powder T_3: Neem powder T_4: Turmeric powder
*C_1: Polythene bag C_2: Hermetic bag C_3: Metal box

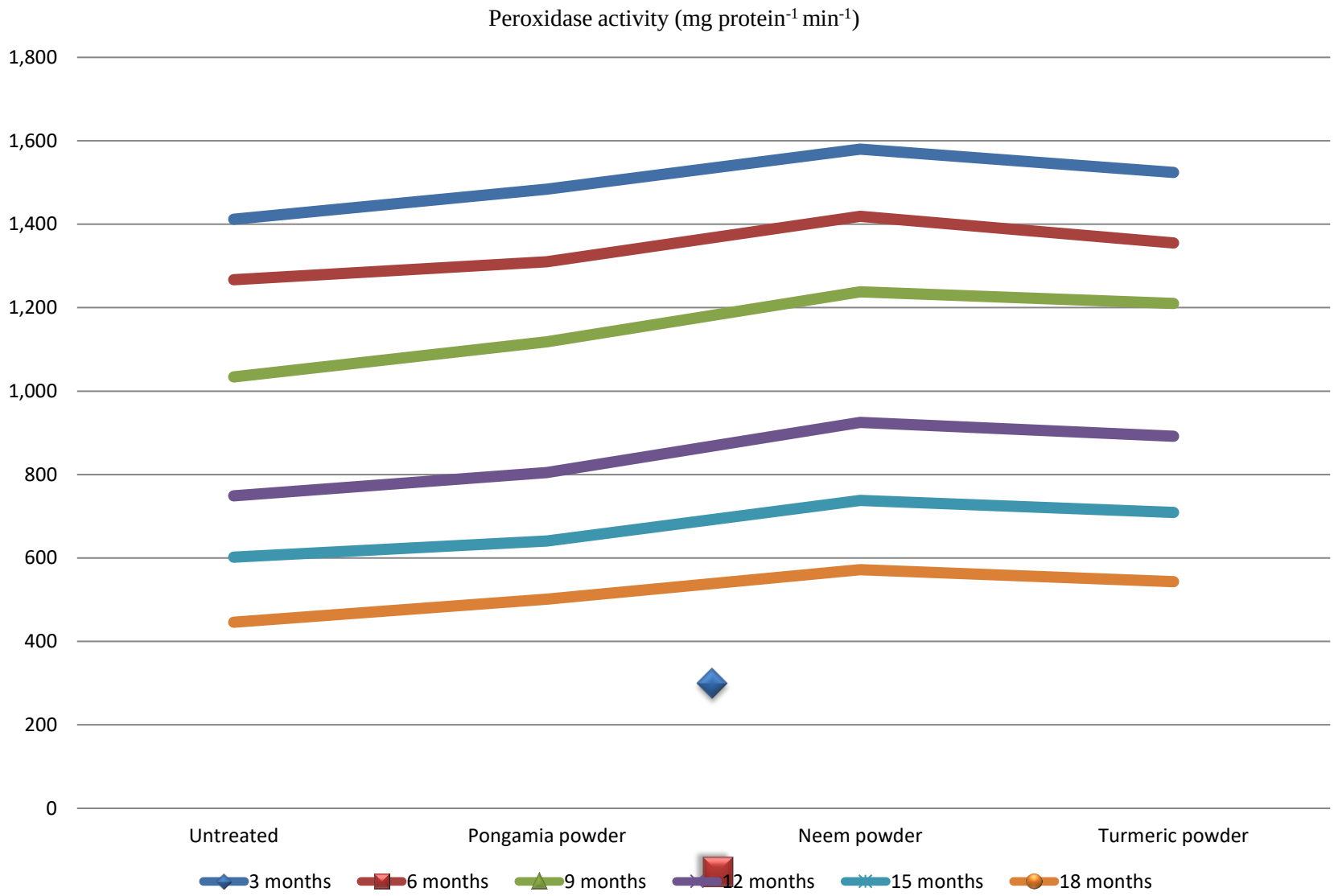

Fig. 4.3.11. Effect of botanicals and containers on peroxidase activity of seeds stored under ambient conditions

CHAPTER V

DISCUSSION

Okra has a prominent position among vegetables due to its high nutritive and medicinal value, year-round cultivation, high yield, ease of cultivation and wider adaptability to varying weathers, resistance to various diseases and pests and also the export potential. The quality of fruits largely depends upon the tenderness and fiber content of the fruits. The yield is directly correlated with the length, thickness of fruit and number of fruits produced per plant. Though these factors are governed by the genetic constitution of the plant however, the stage at which the fruit is plucked is equally important. The picking stage of fruit is also important from the quality point of view.

Seed being a biological or living entity, deterioration in its quality is inevitable and it occurs with advance in ageing, which is universal in all living organisms. Seed deterioration is the reduction in its quality attributes that begins immediately after attaining physiological maturity even on mother plant. Seed treatment and storage containers are the inexpensive and safest method to control seed diseases. Treating seeds with chemicals and botanicals have fungicidal toxicity or antagonistic effect which eliminates most of the seed borne micro-flora. It has also been reported that the seed treatments successfully improved the field performance and storability of different vegetable crops.

Keeping in view the above, an attempt has been made to study the effect of picking stages, seed treatments and containers on seed quality of okra. The results obtained from this exploration have indicated that the stage of picking, seed treatment and containers had a significant and positive impact on most of the recorded parameters, *i.e.* fruit length at maturity, seed yield per fruit, test weight, number of seeds per fruit at harvesting, germination, seedling length, seedling dry weight, vigour index-I & II, electrical conductivity, catalase, superoxidase dismustase, dehydrogenase and peroxidase activity of okra seeds. The results of present investigation have been discussed further in the paragraphs by giving appropriate reasons and supported by the earlier findings.

Experiment 1: To find out the best picking stage for better seed quality

The flowering on 1st, 6th and 11th node was seen on 38.33, 54.66 and 66.66 days respectively after sowing. The fruits collected from different nodes of okra plants showed considerable differences in parameters recorded during the study. The maximum fruit length was recorded in fruits collected from middle nodes followed by upper nodes and minimum was recorded in fruits of lower nodes. While in case of number of seeds per fruit, the highest

number of seeds was counted in fruits of middle nodes closely followed by fruits of lower nodes and the lowest number of seeds was counted in upper node fruits. When recorded for test weight, the superiority was shown by seeds of middle node fruits followed by seeds of lower node fruits and least weight was found in seeds of upper nodes. The observations recorded for seed yield per fruit revealed that the highest yield of seed per fruit was obtained from middle node fruits followed by lower node fruit seeds and the lowest seed yield per fruit was obtained in upper node fruits. The results are in conformity with Malik *et al.,* (2000), Prabhakar *et al*., (2003), Yadav and Dhankhar (2001) , Ibrahim and Oladiran (2011) in okra and Kumar *et al*., (2015) in pumpkin. The results also found similarity with Hedau *et al.,* (2010) who reported that the pods from the lower and middle positions produced the best quality seeds in okra.

The germination percentage of seeds of different node fruits was found varied and significantly higher germination was recorded in seeds of middle nodes followed by seeds of lower nodes. Whereas upper node seeds along with control recorded lowest. This may be due to poor maturity and shriveled seeds as affected by insects at later periods of harvesting. These findings are in line with those of Bhatt and Rao (1998), Rao *et al.,* (2004) and Verma *et al.,* (2004) in okra.

The significantly superior seedling length was measured in seeds obtained from middle nodes followed by lower nodes. The lowest seedling length in upper nodes as well as in control was might be due that the fruits at lower and middle nodes get maximum share of assimilate and water during fruit formation, seed development and maturation and higher nodes lag behind in the competition for assimilate as the time available for assimilation of storage reserves was quite less. The similar findings were also reported by Grewal *et al.,* (1972) & Francis and Opondo (2011) in okra.

The significantly higher vigour index-I & II was observed in seeds collected from middle nodes followed by seeds collected from lower nodes. Whereas lowest was observed in seeds collected from control. The results are corroborated with earlier findings of Ibrahim and Oladiran (2011) in okra. The reason may be attributed that lower and middle position fruits remained longer period of time on plant and thus absorbed more minerals and nutrients which ultimately decreases towards top of the plant, which results in lower seed weight, reduced vigour and viability in the seeds of upper position fruits.

Experiment 2: To study effect of fungicides and containers on longevity of treated seeds

The germination percentage was decreased gradually with the passage of storage time. All the treatments showed better germination as compared to control (T_1). The

significantly higher germination was recorded in treatment T_7 and lowest was recorded in control after 18 months of storage was might be due to the seed deterioration. Containers effect was found significant during storage and the highest was showed in metal box (C_3) followed by hermetic bag (C_2) and polythene bag (C_1). The best interaction was observed at the end of storage in seeds which were treated with Azoxystrobin (T_7) and stored in metal box (C_3). The decline in germination was may be due to increase in moisture content which ultimately leads to increase in seed respiration, membrane leakage due to increased temperature and relative humidity (Abdul-Baki and Anderson, 1972). The results are in accordance with Arif (2006) concluded that germination percentage decreased gradually as storage period increased. The results are conformity with earlier findings of khalequazzaman *et al.,* (2012) in frenchbean, Khandil *et al.,* (2013) and Ghimire (2003) in onion and okra seeds.

Shoot and root lengths of the okra seeds were also found in decreasing trend starting from the initial to final month of storage. All the treatments recorded higher shoot and root lengths as compared to control (T_1). The highest shoot and root lengths were observed when seed treatment is done with T_7 and lowest shoot and root lengths were observed in control T_1. The containers effect was observed significant and metal box (C_3) proved superior. The best interaction in case of shoot and root lengths were found in seeds treated with Azoxystrobin (T_7) and kept in metal box (C_3) after 18 months of storage. Seedling characters like shoot and root lengths were found varied over storage period (Monira *et al.,* 2012). The results are corroborated with Hunje (2002) in chilli. Raiker *et al.,* (2011) stated that rice seeds stored in polythene bag recorded significantly higher shoot and root lengths.

Seedling dry weight also followed the same pattern of decreasing values as observed in germination, shoot length and root length. After 18 months of storage, the highest seedling dry weight was recorded in treatment T_7 and lowest was recorded in control T_1. The container C_3 (metal box) was found superior mean than the other two hermetic bag (C_2) and polythene bag (C_1). The maximum seedling dry weight was recorded when the seeds were treated with Azoxystrobin (T_7) and kept in metal box (C_3) after 18 months of storage. The results found similarity with findings of Singh and Dadlani (2003) & Monira *et al.,* (2012) in soybean.

In case of vigour index- I & II, the values were found in descending order. The highest vigour index- I & II was observed with T_7 treatment and the lowest was in control (T_1). The superior interaction was recorded when seeds were treated with azoxystrobin (T_7) and stored in metal box (C_3). Balesevic-tubic *et al.,* (2010) stated that differences in vigour indices during storage were might be due to lipid changes of seed during storage and decrease in phospholipids and polyunsaturated fatty acids. The results are conformity with findings of

Raiker *et al.*, (2011) in rice, Reddy and Biradarpatil (2012) in groundnut, Chaudhary *et al.*, (2013) in chilli and Nabila *et al*., (2016) in wheat.

The values of electrical conductivity were found increased by the passage of storage time and recorded highest after 18 months of storage. The lowest value was observed in treatment T_7 followed by treatments T_4, T_5, T_3, T_6, T_8, T_2 and highest was in control (T_1) after 18 months of storage. Containers effect was found significant in all months of storage. The lowest electrical conductivity value was found when seeds were stored in metal box (C_3) followed by hermetic bag (C_2) and polythene bag (C_1). The lowest interaction value of electrical conductivity was found in seeds treated with azoxystrobin (T_7) stored in metal box (C_3). The increase in electrical conductivity was due to increase in solute leakage as membranes altered during ageing. The membrane weakens by damage of phospholipids which causes exit of electrolytes and enzymes (Zamani *et al.*, 2010) and Nabila *et al*., (2016) in wheat.

The enzyme activities *viz.*, catalase, superoxidase dismustase, dehydrogenase and peroxidase showed significant variation in response to various treatments during ambient room storage of okra seeds. Enzyme activities were found decreased with passage of storage time and the lowest was recorded at the end of 18 months of storage in all the treatments. In case of dehydrogenase activity, it was found decreased with every interval of storage. The highest was observed in T_7 treatment and the lowest was observed in control T_1. The decrease in activity of dehydrogenase with the advancement of ageing was also stated by Radha *et al*., (2014) in sunflower, Verma *et al*., (2003) in *Brassica* spp. and Kumar *et al*., (2019) in chilli and brinjal.

The present study showed the decrease of antioxidant enzymes in okra seeds. During storage catalase, superoxidase dismustase and peroxidase enzyme activities were found declined and lowest was recorded at the end of storage. The highest catalase, superoxidase dismustase and peroxidase activity was recorded in T_7 treatment and lowest in T_1 control at the end of 18 months of storage. The decrease in antioxidant enzymes was attributed to increase in lipid peroxidation and ageing (Bailly *et al*., 1996). The decrease in activity of enzymes during storage was might be due to free radical production in the presence of even traces of oxygen. In the absence of active enzymes, scavenging free radicals and degradation products of thermo-liable lipid peroxidation accumulates with the ageing of seeds and results in complete loss of viability (Rao *et al.*, 2006).

The enzymes go through configrational changes such as folding and unfolding of ultrastructure and polymer formation due to condensation and degradation to subunits *i.e*. absorbance of dehydrogenase enzyme was declined with the progress of storage in sunflower.

As study reveals that ageing coincides with protein denaturation or inactivation of enzymes. Similar trend of decrease in catalase, SOD and peroxidase enzymes was reported by Rao *et al*., (2006) in Onion, Loycrajjou *et al.,* (2008) in arabidopsis, Bhanuprakash *et al*., (2010) in onion, Cakmak *et al.,* (2010) in alfalfa, Yin *et al.,* (2014) in rice and Far *et al.,* (2015) in maize.

Experiment 3: To assess the effect of botanicals and containers on longevity of treated seeds

Botanicals have been used as seed treatment for invigoration of seed for quite long time. In the present study, leaf powders of neem, pongamia and turmeric were used for invigorating okra seeds. Plant products are known to contain various antioxidants which quench the free radical attack during ageing of seed and ultimate loss would lead to death of seeds. The antioxidants present in plant products plays a major role in improving the performance of seeds (Ramya *et al.,* 2011).

Germination of seeds was found decreased with the passage of storage time. The highest decrease was observed after 18 months followed by 15 months of storage. The treated seeds showed higher germination than control during entire period of storage. The highest germination at the end of storage was showed by neem leaf powder treatment T_3 followed by turmeric treatment T_4, pongamia treatment T_2 and lowest was in control T_1. Among containers, the maximum mean values were showed by the seeds kept in metal box. The best interaction was recorded in seeds treated with neem leaf powder (T_3) stored in metal box (C_3) after 18 months of storage. It is assumed that some of the micronutrients were present in botanicals which are favorable for seed invigoration as stated by Sasthri (2010). A study conducted by Lowell (2005) reported that leaf extracts contain saponin like substance which acts as precursor for GA_3 and invigorates the seed. Botanicals act as catalyst for production of reactive oxygen species (ROS) in a slow and sustained manner for maintenance of viability. Similar findings were observed by Patil (2000) in chickpea and Manaddi (2002) in cowpea.

The shoot and root lengths predicts their growth and performance of a seedling. The shoot and root lengths were declined after each month till the end of storage. The treated seeds showed higher shoot and root lengths than the untreated one (control) during entire storage. Neem powder treatment gained maximum shoot and root lengths as compared to the turmeric, pongamia powder treatment and the lowest was observed under control at the end of storage. Containers effect was significant and higher mean values were obtained in metal box (C_3). At the end of storage, maximum interaction was recorded in neem leaf powder treated seeds (T_3) kept in metal box (C_3). Similar studies were conducted by Devarani and Rangaswamy (1998) in sorghum, Meena *et al*., (2017) in groundnut and Natuhai *et al.,* (2018) in onion.

The dry weight of seedlings is a physiological manifestation of seed vigour which was influenced by growth substances, metabolites and enzyme activity (Heydecker, 1972). Leaf powder treated seeds showed higher dry weight than the untreated one (control) over entire storage. The maximum dry weight was recorded for neem leaf powder treatment T_3, followed by turmeric, pongamia leaf powder treatment and the minimum was under control T_1. Containers effect was significant and metal box proved superior to other two containers. The highest interaction was recorded with neem leaf powder treated seeds (T_3) kept in hermetic bag (C_2). The similar findings were recorded by Khatun and Bhuiyan (2011) in chickpea and Layek *et al.,* (2006) in gram. The decline in seedling dry weight was might be due to hydrolysis of reserved metabolites, activation of endogenous enzymes and breakdown of food reserves during the period of storage as stated by Nisha (2006) in wheat and Paramasivam (2005) in groundnut.

There is gradual decline of vigour index- I & II over 18 months of storage. The treated seeds with leaf powders showed better performance than control. The maximum vigour index-I & II was recorded with treatment T_3 followed by T_4, T_2 and the minimum was recorded in T_1 control. Among containers, superiority was shown by metal box (C_3). The interaction of vigour index- I was observed maximum with neem leaf powder treated seeds (T_3) kept in metal box (C_3). The decline in vigour index with increase in storage time was also reported by Vyakarnahal *et al.,* (2007) and Baura *et al.,* (2009) in chilli. The increase in vigour index was might be due to presence of micronutrients, vitamins, antioxidants, polyphenols and flavanoids in botanicals reported by Manimekalai (2006) in blackgram.

The values of electrical conductivity were increased with storage time and attained maximum after 18 months of storage. The treated seeds showed lower electrical conductivity as compared to control throughout the storage. After 18 months of storage, the minimum value was observed in seeds treated with neem leaf powder T_3 followed by turmeric leaf powder T_4, pongamia leaf powder and maximum was observed in control T_1. Containers showed significance and lowest was recorded in metal box (C_3). The interaction was lowest in seeds treated with neem leaf powder (T_3) and kept in metal box (C_3). Results found similarity with Kavitha (2002) in blackgram and Sundaralingam (2005) in rice, Kumari *et al.,* (2014), Kumar *et al.,* (2008) in fenugreek and Goel *et al.,* (2003) in cotton. The minimum value of electrical conductivity was might be due to quenching of free radicals which generally maintains the membrane integrity (Kavitha, 2002).

There is decline in D.H.A activity with advancement of storage time. The treated seeds with leaf powders showed higher activity as compared to control during entire storage period. After 18 months of storage, the maximum D.H.A activity was seen in seeds treated

with neem leaf powder T_3 followed by turmeric leaf powder T_4, pongamia leaf powder T_2 and minimum was seen in control T_1. Containers effect was significant during storage and metal box proved superior over polythene and hermetic bag. The highest interaction for D.H.A value was recorded in seeds treated with neem leaf powder (T_3) and stored in metal box container (C_3). The increase in activity was might be due to the presence of antioxidants (Pandey and Barve, 2011) phenols and flavonoids (Annegowda *et al*., 2010).

The catalase enzyme activity was found gradually decreased over 18 months of storage. The treated seeds showed higher catalase activity than the non-treated one (control) during entire storage. The highest catalase activity was recorded in seeds treated with neem leaf powder T_3 followed by turmeric T_4, pongamia T_2 and lowest was recorded in control T_1 at the end of storage period. Containers showed the significant values and among them, metal box (C_3) was superior. The highest interaction for catalase activity was seen in seeds treated with neem leaf powder (T_3) and kept in hermetic bag (C_2). The enzyme catalases are good scavenging enzymes involved in free radical mechanism on lipid peroxidation which protects mitochondrial components from oxidative damages reported by Chander and Kapoor (1990). The decrease in catalase activity was mainly associated with ageing, accompanied by an increase in lipid peroxidation and loss of vigour and viability reported by Oliver *et al.,* (1990) in maize and Bailly *et al.,* (2002) in sunflower.

The peroxidase activity showed similar pattern of decline as seen in other enzyme activities *viz.,* catalase, superoxidase dismustase and dehydrogenase during storage. The treated seeds recorded higher activity as compared to control. The highest activity was recorded in seeds treated with neem leaf powder T_3 followed by turmeric T_4, pongamia leaf powder T_2 and lowest was recorded in control T_1 at the end of storage. Containers effect was significant and metal box was superior over hermetic and polythene bags. The highest interaction of peroxidase activity was recorded in seeds treated with neem leaf powder (T_3) and stored in metal box (C_3) after 18 months of storage. The decrease in peroxidase activity was might be associated with lipid peroxidation as stated by Li and Sun (1999) in cocoa.

The superoxidase dismustase activity was decreased with enhancement of storage. The maximum S.O.D activity was seen in neem leaf powder treated seeds T_3 followed by turmeric T_4, pongamia leaf powder T_2 and lowest was seen in control T_1. Among containers, metal box was found superior during entire storage. The maximum interaction was seen in neem leaf powder treated seeds kept in hermetic bag (C_2). The first enzyme involved in the antioxidant defense is the superoxide dismutase, a metalloprotein found in both prokaryotic and eukaryotic cells.

Marcos and Mcdonald (1998) and Renukamma (2003) reported that higher germination, seedling length and seedling dry weight was might attributed to higher vigour index-I & II. Enzymes acts as catalysts in biochemical activities and reduction in activity or quantity in seed may reduce the synthesis of amino acid, nucleic acid and other nutrients which are required for growth and development. The continuous free fatty acid accumulation causes the reduction in cellular pH and was determinant to cellular metabolism. It mainly causes the denaturation of enzymes and ultimately leads to loss of viability (Copeland and McDonald, 1995). The results found similarity with earlier findings of Tabatabaei (2014) in barley, Radha *et al.,* (2014) in maize, Kapilan and Thiagaraja (2015) in sunflower, Maruti and Paramesh *et al*., (2016) in soybean.

CHAPTER VI

SUMMARY AND CONCLUSION

Vegetables play an important role in providing food nutrition and economic security of the country. They supply proteins, carbohydrates, fats, vitamins, minerals which are an essential requirement of human body. Okra is one of the most commonly known and utilized species of the family Malvacae and has a prominent position among vegetables due to its high nutritive and medicinal value, year-round cultivation, high yield, ease of cultivation, wider adaptability to varying weathers, resistance to various diseases and pests and also the export potential. Seed is the core input in crop production on which the efficacy of other inputs and outputs depends.

Quality seeds are highly required for optimum plant stand in the field which in turn enhances the yield. The seed quality attributes declines with the passage of time. The hygroscopic nature of seed affects its quality by change in environmental conditions *viz*., relative humidity, temperature, moisture content, gaseous exchange and packaging material. Good storage is an essential requirement in seed programme for the maintenance of high germination and vigour from harvesting to next planting season is of prime importance. Seed deterioration cannot be reversed but the rate could be slowed down by packing the seeds in controlled conditions.

Seed treatment serves as the first line of defense which can improve germination, stand establishment, seedling emergence and plant vigour. Treating seeds with chemicals, botanicals have fungicidal toxicity or antagonistic effect which eliminates most of the seed borne micro-flora. Seed treatment and storage containers are the inexpensive and safest method to control plant diseases.

Therefore, the present study entitled "Effect of picking stages, seed treatments and containers on seed viability of okra" was carried out in the laboratories of Department of Seed Science & Technology, CCS Haryana Agricultural University, Hisar with the following objectives:

- To assess the best picking stages of okra for quality seed production
- To study the effect of fungicides and containers on longevity of okra seeds
- To assess the effect of botanicals and containers on longevity of okra seeds

Summary

Objective 1: The Varsha Uphar variety of okra was utilized for picking of mature pods from the lower, middle and upper portion of the plants divided on basis of node numbers. The

lower portion has 1st to 5th node, middle portion has 6th to 10th and upper portion has 11th to 15th node respectively. The parameters observed during field study were:

- Number of days taken to flowering at 1st, 6th and 11th node
- Fruit length at maturity and Seed yield per fruit
- Test weight and Number of seeds per fruit at harvesting

The mature pods from each portion have given three seed lots which were evaluated for seed quality parameters *viz.,* germination, seedling length**,** seedling dry weight**,** vigour indices (I&II), field emergence index and seedling establishment against a control *i.e*. seed harvested from the whole plant at maturity.

The salient achievements of objective were:

- ✓ The number of days taken to flowering at 1st, 6th and 11th node was seen on 38th, 54th and 66th days respectively after sowing. The length of the fruits was recorded maximum for the fruits formed on middle nodes (6th to 10th nodes).
- ✓ The seed yield per fruit and higher test weight was also higher on fruits formed on middle nodes.
- ✓ The number of seeds per fruit at harvesting time was counted maximum in fruits formed at middle nodes.
- ✓ The seeds harvested from the fruits developed at middle nodes showed higher germination, seedling length, dry weight of seedlings and vigour indices (I&II).
- ✓ Field parameters (field emergence index and seedling establishment) observations of seeds harvested from middle nodes were also on higher side as compared to lower, upper and control.

Objective two: The seed lot obtained from middle nodes fruit was stored in different containers (metal box, hermetic bag and plastic bag) with seven fungicides (seed treatment) along with a control. All the treatments were evaluated for seed quality parameters *viz.*, germination, shoot length, root length, seedling dry weight, vigour indices (I and II), electrical conductivity and activities of catalase, superoxidase dismustase, dehydrogenase and peroxidase with three replications over a ambient storage period of 18 months using OPSTAT software as two factorial analysis to assess the effect of seed treatments and containers on seed viability of okra.

The results of the study were:

- ✓ All the seed quality parameters decreased with the passage of storage time except the electrical conductivity which was found increased.

- ✓ All the treatments even control maintained the germination above Indian Minimum Seed Certification Standards (IMSCS) in all containers at the end of storage.
- ✓ Among seven fungicides used as seed treatment, azoxystrobin proved more effective for maintaining seed quality parameters.
- ✓ In containers metal box observed better performance over the hermetic and polythene bags.
- ✓ The interaction effect of azoxystrobin with metal box was found most excellent as compared to other interaction over entire period of storage.

Objective three: The seed lot obtained from middle node fruits was also stored in different containers (metal box, hermetic bag and plastic bag) with three botanical leaf powders (Pongamia, Neem and Turmeric) as seed dressing with control. All the treatment combinations were evaluated for seed quality parameters *viz.,* germination, shoot length, root length, seedling dry weight, vigour indices (I and II), electrical conductivity and activities of catalase, superoxidase dismustase, dehydrogenase and peroxidase with three replications over a ambient storage period of 18 months using OPSTAT software as two factorial analysis to assess the effect of botanicals and containers on seed viability of okra.

The consequences of the study were:

- ✓ All the seed quality parameters evaluated was found decreased over the storage period with exception of electrical conductivity, which was increased.
- ✓ The germination standards were maintained above Indian Minimum Seed Certification Standards (IMSCS) in all the containers with treated botanicals.
- ✓ Neem leaf powder treated seeds recorded higher seed quality followed by turmeric and pongamia leaf powder.
- ✓ Among the containers, metal box was found superior for maintaining the seed quality throughout the storage.
- ✓ The best interaction effect was observed in seeds treated with neem leaf powder and stored in metal box.

Conclusion

Based on the findings of the experiments, the following conclusions were drawn:

- There was significant variation among all the treatments.
- The fruits harvested from middle nodes recorded higher seed quality parameters.
- After 18 months of storage, all seed quality parameters were decreased gradually except electrical conductivity which increased.

- Among fungicides, the seed treatment with azoxystrobin was found better for all seed quality parameters.
- The best interaction effect of fungicide with container was found in azoxystrobin treated seeds stored in metal box.
- Among botanicals, neem leaf powder treated seeds showed better results followed by turmeric and pongamia.
- The interaction effect of botanicals with containers was recorded highest in neem leaf powder treated seeds stored in metal box.
- Among containers, metal box maintained higher seed quality parameters during storage followed by hermetic and polythene bag in both the treatments.
- The present study also reveals that fungicides treated seeds were better than botanicals treated seeds.

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ABSTRACT

Title of Dissertation	**"Studies on effect of picking stages, seed treatments and containers on seed quality of okra (*Abelmoschus esculentus* L. Moench)"**
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Admission No.	2017A36D
Title of the Degree	Doctor of Philosophy
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Keywords: Okra, Picking stage, Fungicides, Botanicals, Containers, Seed quality

The present study was carried out in the field and laboratories of Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar, Haryana during 2018-2020 to study the effect of picking stages, seed treatments and containers on seed viability of okra (*Abelmoschus esculentus* L. Moench). The best picking stage of okra for quality seed production was found on the fruits developed on middle nodes (6^{th} to 10^{th}) as compare to lower (1^{st} to 5^{th}) and upper nodes (11^{th} to 15^{th}). The seeds obtained from middle nodes were used for further studies. To study the effect of seed treatment with different fungicides and botanicals, seven fungicides (carbendazim, tebuconazole, difeconazole, flusilazole, chlorothalonil, azoxystrobin and vitavax power) and three botanicals (Pongamia, neem and turmeric) were used. The treated seeds were kept in three different containers *viz.*, Polythene bag, hermetic bag and metal box up to 18 months at ambient room conditions. Among the interaction effects of fungicide with containers, the seed treatment with azoxystrobin stored in metal box was found superior. While the interaction effect of botanicals with containers, the seed treatment with neem leaf powder stored in metal box was found best. During the entire period of this study, it was revealed that the germination was maintained above Indian Minimum Seed Certification Standards (>65%). All the seed quality parameters (germination, shoot and root length, seedling dry weight, vigour indices-I & II, catalase, superoxidase dismustase, dehydrogenase and peroxidase) were declined with the advancement of storage time except electrical conductivity. The present study also indicated that the fungicide treated seeds showed better performance than botanical treated seeds.

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I, hereby, declare that all the information given in the resume is true to the best of my knowledge.

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Signature of the student