ASSESSMENT OF SEED QUALITY OF OKRA IN SUMMER AND RAINY SEASON (*Ablemoschus esculentus* (L) Moench)

By

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2008A57M

Thesis submitted to the Chaudhary Charan Singh Haryana Agricultural University in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

IN

VEGETABLE SCIENCE

COLLEGE OF AGRICULTURE
CCS HARYANA AGRICULTURAL UNIVERSITY
HISAR - 125004 (HARYANA)

2010

CERTIFICATE-I

This is to certify that this thesis entitled **"ASSESSMENT OF SEED QUALITY OF OKRA IN SUMMER AND RAINY SEASON (*Ablemoschus esculentus* (L) Moench)"** submitted for the degree of **Master of Science** in the subject of **Vegetable Science** of the **Chaudhary Charan Singh Haryana Agricultural University, Hisar** is a bonafide research work carried out by **Mr. Surjeet Chaudhary** under my supervision and that no part of the thesis has been submitted for any other degree.

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

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CERTIFICATE-II

This is to certify that this thesis entitled **"ASSESSMENT OF SEED QUALITY OF OKRA IN SUMMER AND RAINY SEASON (*Ablemoschus esculentus* (L) Moench)"** submitted by **Sureet Chaudhary** to the **Chaudhary Charan Singh Haryana Agricultural University, Hisar** in partial fulfillment of the requirement for the degree of **Master of Science** in the subject of **Vegetable Science** has been approved by the student's advisory committee after an oral examination.

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ACKNOWLEDGEMENT

I am beholden to the highly benevolent and merciful Almighty whose grace bestows upon us.

The very idea of this work makes me amused in thanking to all those who helped me in achieving this milestone of my academic pursuit. Although, thanks convey modicum of deep sense of gratitude from the core of heart, yet there is no better way than to express it.

I would like to extend my profound regards and deep sense of gratitude to my Major Advisor, Dr.S.K.Dhankhar,Scientist, Vegetable Science for his prudent guidance, encouragement and constructive suggestions all through the investigation and preparation of this manuscript. His benign co-operation and perfection has not only left an indelible impression in my mind but also has enlightened me spiritually. I am indebted to his timely advice, noble counseling and for providing the necessary facilities during my study.

With an overwhelming and genuine sense of obligations, I avail this opportunity to express my deepest indebtedness to Dr. D.P. Deswal, Professor, Department of Seed Science and Technology CCS HAU, Hisar, and Member, Advisory Committee (minor subject) who sustained his incessant and exhilarating support to me.

I take great pleasure in expressing my sincere gratitude to Dr.A.C.yadav Sr.Scientist, Department of Vegetable Science (Member, Advisory Committee, major subject), Dr.B.S.Panu (Dean PGS, Nominee) and Dr.B.K.Hooda Proff. Math & Stat (Member, Advisory Committee) for their affectionate behavior, sympathetic attitude, sagacious guidance and help during the investigation.

I would like to put on record my sincere thankfulness to Dr. B.S.Dudi, Professor and Head, Department of Vegetable Science for his keen interest, timely advice and providing me the necessary facilities during my study programme. I also extend my sincere thanks to Dr S.C. Khurana for providing valuable suggestions and critically going through the manuscript.

Feeling from the core of my heart moulded into words would not convey what I wish to express to my parents and family. I do not find sufficient words to acknowledge my deepest sense of gratitude to my esteemed parents for their blessing, Father Sh. Bhoop Singh, Mother Smt. Kamla Devi, Brother Amarjeet and sisters Bhavana and Amarjyoti for their ardent inspiration, which has been a benediction to me in all odds.

No words can appreciate the all round help rendered to me by my friends and colleagues Rajesh Chaudhary,Ajay Devol, Akshay Vats, Ravinder Antil, Mittal Rathor. I owe very much thanks to my seniors Dr. C.S. Saini , Dr. Chetak Bishnoi, Dr. Rohit Nain, Dr.Jagmohan Saini, for their valuable support.

I also convey my sincere thanks to all the teachers, office, and laboratory technical and supporting staff of the Departments of Vegetable Science, and Seed Science and Technology for generous help and moral support on every occasion.

My sincere thanks also go to CCS Haryana Agricultural University, Hisar for providing me an opportunity of higher studies, which will be highly helpful in my future career.

Place: Hisar **(SURJEET CHAUDHARY)**

Date:

CONTENTS

LIST OF TABLES

CHAPTER-I

INTRODUCTION

Consumption of vegetables is of paramount importance for meeting the present day challenges of health security to our ever increasing human population by providing natural and balanced diet. Vegetables form the most important component of nutritional requirement and are the cheapest and readily available source of essential elements, vitamins and minerals. Among vegetables, okra (*Ablemoschus esculentus* L. Moench), belongs to family malvaceae, is an important warm season vegetable crop grown throughout India for its tender green fruits in both summer and rainy seasons. It is good source of carbohydrate, protein, vitamins (A, B and C) and rich in calcium, potassium and minerals. Its immature green fruits are used for preparation of *curry* and soup. Stem and roots are used for clearing cane juice and making jaggary or brown sugar. Crude fiber obtained from mature fruits and stems are extensively being used in paper industry. India stands second after China with productivity of okra (9.9 t/ha) that shares 20.05% of total world production. In Haryana okra is grown on 14000 ha area that shares 2.54% of total area and its production is 9.4 lake tones (*Anonymous*, 2007-08).

The most important single factor affecting crop production is the quality of seed and that is why testing of seeds before sale and distribution for sowing has now become an essential pre condition. High quality seed is the product of careful planning and attention given to the seed crop from sowing to harvest and during storage for subsequent planting. Seed possesses maximum vigour at the time of physiological maturity (Meena *et al.,* 1994) and there after it gradually ages and decline in viability and vigour. The loss of vigour precedes loss in germination. It has been well recognized that seed deterioration contributes heavily towards problem in agricultural production (McDonald, 1999). In deteriorating seed, changes occur at the cellular level to bring changes in physiological and biochemical parameters, which are reflected in delayed germination, reduced seedling growth rate, decreased tolerance to adverse germination conditions and loss of germinability (Abdul-Baki and Anderson, 1972), besides membrane deterioration, low oxygen uptake and high CO_2 output (Kharlukhi and Aggarwal, 1983).

Seed quality refers to high germination percentage and vigour, minimum of inert matter, weed and other crop seeds and seeds are free from diseases. Generally seed quality is determined by its purity and germination in laboratory to predict the planting value of seed. However, field conditions are not always optimum. Therefore, the standard germination test in laboratory often over estimates the field performance of the seed lots.

In northern plain okra seed production is done in rainy season because of environmental conditions, which are beneficial for better vegetative growth, roguing against YVMV and seed yield. Yadav *et al.* (2001) at Hisar reported that rainy season crop (13^{th} June sown crop) produced higher seed yield with better vigour and viability of seeds. However, there is severe infestation of insect and diseases in rainy seasons, which significantly effect the production of seed and its quality. The incidence of insect and diseases does not occur during summer season. Sen and Mukharji (1998) reported that environmental conditions of summer seasons of the okra crop was most beneficial for growth, fruit set, development and seed quality. So there is need to study and to compare quality of seed produced during summer and rainy seasons.

Therefore, present investigation was undertaken with the following objectives:

1. To compare the seed quality of okra genotypes of summer and rainy seasons
2. To find out most suitable vigour test for prediction of field emergence for summer and rainy seasons.

CHAPTER-II

REVIEW OF LITERATURE

Seed is the basic input in agriculture and quality seed is the key to successful agriculture. Seed possesses highest viability and vigour at physiological maturity (Meena *et al*., 1994) and thereafter, there is gradual ageing and decline in viability and vigour. The viability and vigour are the most important attributes of the seed quality, which are controlled by both genetical and environmental factors.

Seed viability and vigour tests have been used extensively in a number of crops to predict the planting value of the seed. Also, the climatic conditions of India greatly affect the storage capacity of the seed lot because of high temperature and high relative humidity, which in turn deteriorate the quality of seed under ambient storage conditions (Basu, 1976).

Not much information is available on the behavior of okra genotypes with regard to quality assessment of summer and rainy seasons. Therefore, the work done on the other vegetable crops is also reviewed for the basic concept.

2.1 VIABILITY TEST

2.1.1 STANDARD GERMINATION TEST

The germination is the resumption of growth by the embryo and development of a young plant from the seed. Germination in the laboratory test is the emergence and development from the seed embryo of those essential structures, which for the kind of the seed being tested indicate the ability to develop into a normal plant under favorable conditions in the soil (ISTA, 1999).

Germination process occurs in three phases. Phase-I involves uptake of water by the seeds followed by Phase-II in which active metabolisms begins (ATP production, initiation of RNA and protein synthesis, DNA repair) and in Phase-III visible germination which starts with cell expansion then DNA, replication which leads to mobilization of reserved food sufficient for radical protrusion (Come and Thevenot, 1982 and Bewley and Black, 1985). The germination test is universally accepted and used as a seed quality test. The methodology of the test has been standardized so that the results are reproducible within and among laboratories.

Krishnakumary and Mini (2003) found that the germination percentage, shoot length and vigour index were maximum in seed obtained from fruits of 9^{th} and 10^{th} nodes. The value for all these parameters was lower in seeds obtained from fruits of upper (2-3 nodes) and bottom nodes. Verma *et al*. (1998) found the best quality seed (germination% and seed vigour) in okra from the capsules on the third and fourth nodes. Solanki *et al*. (1980) reported that keeping of seeds germinating paper and sand media in at temperature of 30 and 25^{0}C, were the best for germinating the seeds of summer squash and okra, respectively. However, they did not observe any significant difference between the two media and further reported that coefficient velocity of germination was the best index for predicting the best quality of seed.

Palinisamy and Ramasamy (1987) assessed the germinability of stored seed on the basis of normal seedling after 12 days at 25±2 ^{0}C in sand media. Similarly, the percent viability of ambient stored seeds of tomato, chilli, brinjal and bhindi was estimated on the basis of normal seedlings by Jayraj *et al.* (1987). The primary and secondary umbels in carrot plant produced the highest germinating seeds while lower percentage of seed yield and more number of non viable seeds were obtained from tertiary umbels (Hawthorn *et al*., 1962; Nath and Kalvi, 1969 and Yadav, 1995).

Standifer *et al*. (1989) dried seeds of 4 okra cultivars (Emeraled, Gold Cost, Clemson Spineless and Louisiana Green Velvet) to moisture content of 3,5,7,9 and 11 percent. They found that germination of seeds at 3 percent moisture content was unacceptable for field use. Further seeds of cv. Emeraled at 7 % moisture or Gold Cost and Clemson Spineless at 9 % had over 90 % germination with in 6 days. Seeds of cv. Louisiana Green Velvet showed progressive improvement in germination with increasing moisture content. Coelho *et al.* (1984) and Nakagawa *et al.* (1991) found that, when large size seeds of okra kept in cloth bags for one month in open storage at 27 ^{0}C and 67 % RH, had better germination, while dry storage at 26 ^{0}C and 49 % RH increased the percentage of hard seeds. Bisognin *et al.* (1991) noticed in the bottle gourd seeds the best conditions for the standard germination test were obtained at a constant 30 ^{0}C and on the paper wetted at 2.5 times its DW. The total time required for a complete test was 8 days for both paper and sand substrates. Under the best conditions 97% germination was obtained.

Pagamos and Nawata (2007) reported that more than 20% of the chilli seeds produced under the high temperature regime were flat with a dark brown color and did not germinate. The genotypic differences were highly significant in both the summer and rainy seasons for number of seeds per fruit, seed yield per fruit and seed vigour index. The genotypic difference for seed germination was highly significant only in the rainy season (Singh and Ram, 2005). Kanwar and Bhuvaneswari (2004) reported that the chilli seeds grown in the winter had the greatest 1000 seed weight, where as those grown in the spring had the highest seed germination % and seed vigour. Shakuntla *et al.* (2007) found that the germination test were suitable to know the vigor of brinjal seeds. Patil *et al*. (1987) reported that the yellow green seeds which sank in water had the highest germination and vigour index. Black seeds which floated in water gave the poorest results. Nakamura *et al*. (1956) observed that light inhibited seed germination of bitter gourd (Balsam Pear) at low temperature. According to Singh and Chopra (1964) seed scarification resulted in 92% increased seed germination in bitter gourd. Zhuang *et al.* (2009) reported that seed germination decreased with the increased ageing temperature and duration in bitter gourd and it was 53% under 45^{o} C when aged for 144hr.

2.1.2 DEHYDROGENASE ACTIVITY TEST

The dehydrogenase activity is also known as tetrazolium reduction ability. The activity of dehydrogenase enzyme is directly correlated with the seed vigour. To estimate the activities of these enzymes, Kittock and Law (1968) gave an indirect method i.e. by colorimetric estimation of foramzan (product in reaction of tetrazolium solution with dehydrogenase enzyme). The estimation can differentiate between the vigour levels of different lots. The dehydrogenase activity is generally used as reliable index for the evaluation of seed viability (Abdul Baki and Anderson, 1972). Narwal (1995) reported that the absorbance decreased dramatically in all the varieties of okra after six month of ambient storage.

2.2 VIGOUR TEST

2.2.1 SEED VIGOUR

Vigour index offers the possibility of categorizing seed lots into classes of seed quality. Abdul-Baki and Anderson (1973a, 1973b) established vigour levels by germinating the seeds in standard germination test for five days and then normal germination and length of hypocotyls was determined. Vigour index for each such lot was established by multiplying normal germination by hypocotyl length. Seed vigour is recognized as an important seed quality parameter, which is distinct and separate from germination test. So loss of vigour precedes viability and its evaluation is the first step in predicting seed quality (Vijayakumar, 2003).

Yadav and Dhankar (2001) reported that vigour index-I and vigour index-II were positively and significantly correlated with standard germination, seedling length and seedling dry weight and negatively correlated with electrical conductivity in okra. Panobianco and Marcos (2001) worked on controlled deterioration (19, 21 and 24% water content, at 45 ^{0}C and 24 hr period). Result showed that treatment with 24% water content for 24 hr at 45 ^{0}C was best to detect vigour differences among tomato seed lots.

Khan *et al*. (2004) subjected onion seed to accelerated ageing treatment at 45 ^{0}C and 100% relative humidity for 0, 3, 5 and 7 days in a controlled chamber. Seeds lost their germinability, vigour and viability progressively with ageing treatment. The loss of viability in seeds after ageing appeared related to increased membrane destruction (loss of membrane integrity). This membrane integrity loss may be responsible for the decreased germinability, vigour and viability. Kumar *et al.* (2007) reported that the germination, seedling vigour, seedling dry weight and field emergence decreased with increase in period of accelerated ageing, which ultimately affected the plant height, dry matter production per plant, leaf area per plant, number of fruits per plant, number of seeds per fruit and seed yield.

Malik *et al.* (2004) reported that the seed quality in terms of seed test weight, germinability and seed vigour was significantly affected by pod ripening, nodal position on mother plant and storage period in okra. Venkata *et al*. (1997) observed that pinched plants recorded higher speed of germination, shoot length, root length, vigour index and crude protein over non pinched plants in okra. Santos *et al*. (2007) suggested that the tetrazolium test provided consistent data for the assessment of viability and vigour of tomato seeds.

Pagamos and Nawata (2007) found that standard germination of chilli seeds developed under high temperature condition was lower than that developed under normal temperature. Das *et al*. (2007) studied the effect of accelerated ageing on cucumber seeds at 35 to 40 ±1 ^{o}C, RH 100 % for 20 days. This process brought about progressive loss of seed viability and vigour and amino acids at 40 ^{o}C than at 35 ^{o}C.

2.2.2 ELECTRICAL CONDUCTIVITY TEST

The conductivity test measures the amount of electrolytes, which leach out from seeds as they deteriorate. It has been used to measure seed viability (Presely, 1958). This test was later developed into a vigour test for the prediction of field emergence of wrinkled garden peas (Mathews and Bradnock, 1967, 1968)

Narwal (1995) Found that all varieties of okra loose their membranes permeability after 180 days of storage in ambient conditions, which increased the electrical conductivity values. Krishnasamy and Ramarajpalaniappan (1989) studied the level of association between seed leachates and field emergence potential in tomato and brinjal. Seed leachates measured by electrical conductivity increased steadily from 2-12 hr of soaking in both species. Association of electrical conductivity with the field emergence potential was significant for all soaking durations (2, 4, 6, 8, 10 and 12 hr) in both species.

Doijode (1990) reported increase in electrical conductivity of seed leachates from 84 to 221 after 20 days of ageing in vegetable seeds. A comprehensive study on ambient storage of seed in polythene bags of several vegetables including okra revealed that seed moisture content, germination%, seedling root and shoot fresh weight, dry weight and peroxides activity decreased with length of storage. Electrical conductivity values of seed leachates and levels of free reducing sugars in leachates showed a positive relationship with loss of seed viability (Saxena *et al*., 1987).

2.2.3 ACCELERATED AGEING TEST

Seed ageing has come to be recognized as major cause of reduced vigour and viability in many species. Maximum seed quality occurred at physiologically maturity after, which seed vigour and viability declined both during ageing on the plants and during storage. Seed samples are placed under stress conditions of high temperature (40 – 45 ^{0}C) and high relative humidity (100%) for a certain period of time. A standard germination test is conducted after seed have been stressed. The decline in germination during this accelerated ageing is related to the initial degree of deterioration of the seed lots. The basic assumption of this test is that the germination % after accelerated ageing is correlated with vigour of the lot and hence its capacity to perform under field conditions (AOSA, 1983).

The okra seeds were subjected to 41 ^{0}C and 100% relative humidity for 48, 96, 144, 192, 240 or 288 hr. There after the seed were germinated. Among the treatments, 144 hr accelerated ageing was the best period for evaluating okra seed vigour (Torres and Carbalho, 1998). Seeds of bottle gourd (*Lagenaria siceraria*), sponge gourd (*Luffa acutangula*) and round melon (*Cucumis melo*) were artificially aged at 45 ^{0}C and 100% relative humidity for 9 days. Accelerated ageing showed significant effect on loss of germination percentage, seedling growth, dry weight and other vigour parameters in all three species (Devi *et al*., 2006).

Kumar *et al.* (2007) reported that the germination, seedling vigour, seedling dry weight and field emergence decreased with increase in period of accelerated ageing, which ultimately affected the plant height, dry matter production per plant, leaf area per plant, number of fruits per plant, number of seeds per fruit and seed yield. The decline in seed germination and vigour during accelerated ageing as well as storage treatments were influenced by chronological age of seed rather than initial germination percentage. Muhammed and Anjum (2002) also found that as the ageing period increased, the germination percentage, germination speed and seedling growth decreased.

Nagarajan *et al*. (2004) suggested that the seed deterioration in terms of loss of viability and vigour was faster in seed lots of higher initial moisture compared to seed lots of low initial moisture. Similarly, the seed membrane integrity as measured by electrical conductivity of seed leachates was maintained for longer period in seeds conditioned to lower moisture content (Agrawal and Sinha, 1980).

Doijode (1986) reported loss of viability in okra seeds after 72 hours of accelerated ageing. Seed germination and dry weight of seedlings were inversely proportional to the duration of ageing period and electrical conductivity, whereas, percentage loss of sugars was negatively correlated with seed viability. Bhering *et al*. (2003) reported that accelerated ageing test at 100% relative humidity was more efficient than the alternative method (76% relative humidity) for seed vigour evaluation in watermelon. Accelerated ageing at 41 ^{0}C and 100% relative humidity for 48 hr was the most consistent procedure for seed vigour evaluation.

Doijode (1992) studied the effect of accelerated ageing treatment at 40 ^{0}C and 95% relative humidity for 12 days on brinjal. An increase in leaching of metabolites and reduction in dehydroginase activity was associated with a decrease in seed vigour. Tomato seeds were held at 42 ^{0}C and 95-100% RH for 24, 48, 72 or 96 hr to determine the best accelerated ageing period for evaluating seed vigour. Treatment for 72 hr was most suitable for the indices studied. No correlation was observed between the results from accelerated aging test and those obtained with field emergence test (Nascinento *et al.,* 1993). Overall germination percentage declined as duration of ageing treatment increased, although the extent of the decrease was genotype dependent (Shyam *et al*., 1996).

Dutra and Vieria (2006) concluded that the combination 41 ^{0}C of and 96 hours should be used to evaluate the physiological potential of pumpkin and zucchini seeds. Ageing led to decline in seed vigour more sharply at 40 ^{0}C than at 35 ^{0}C. Higher conductance of seed leachate and more content of sugars and amino acids in seed leachate were recorded at 40 ^{0}C than at 35 ^{0}C in cucumber seeds (Das *et al.,* 2007).

2.2.4 SEEDLING DRY WEIGHT

The measurement of seedling dry weight has been suggested as a parameter of vigour by AOSA vigour testing committee (Woodstoke, 1976). Currah and Salter (1973) observed 25 percent increase in seedling weight and seed yield by grading of carrot seeds. Alsadon *et al*. (1995) found that the tomato seeds also produced less vigorous seedlings after ageing with significant reduction in seedlings height, fresh weight and dry weight. Dry weight of root and shoot appeared to be more reliable index for vigour determination as compared to their length (Sinha and Agarwal, 1980).

2.2.5 TEST WEIGHT

Physical characteristics of seed, like seed size, seed weight and seed coat colour appeared to play role towards seed quality. Singh and Gill (1983) reported that yellow-green and grey-green seeds of okra cv. Pusa Sawani were superior in 100- seed weight, germination and root and shoot length in comparison to black colour seeds. They further suggested that okra seed lot could be upgraded by putting the bulk seed in plain water for few minutes and discard those, which float on the surface of water. A positive and significant association between test weight and seedling vigour in three grades of okra seeds were observed by Palanisamy and Ramasamy (1985). Munde (2002) reported that 1000 grain weight, volume, bulk density and kernel density of okra seed increased linearly with the increase in moisture content.

Highest field emergence was observed in large size seed of primary umbel in carrot, high germination percentage, seed viability, seedling length and dry matter content and the seed germinated at a faster rate as compared to small size seeds of tertiary umbels (Yadav, 1995). The correlation between fruit weight and seed quality in watermelon cv. Crimson Sweet was studied in field experiments at Veles in semiarid conditions. Results showed that there is a significant correlation between the weight of fruits and the number of seeds (r=0.57), and between fruit weight and seed weight (r=0.54). The correlation between fruit weight and 1000-seed weight was very poor (r=0.24), without any statistical significance. There were no significant differences for seed germination (Jankulovski *et al*., 1997).

2.3 LABORATORY AND FIELD PERFORMANCE INTERACTION

The germination test is conducted under controlled optimum conditions and thus the results differ from the field conditions on many instances, so a test consisting of many tests may be needed for testing viability and vigour of seeds. Baskin (1971) reported that germination after artificial ageing was closely related to field emergence even under adverse conditions. Germination test results, which establish the maximum plant producing potential of seed lots were also found correlated with field emergence under favorable field conditions (ISTA, 1985). Pandey *et al*. (1990) established association between laboratory vigour test and field emergence in cucurbits. Lottio and Quagliotti (1991) determined quality of 15 okra seed lots on the basis of 1000 seed weight, standard germination, tetrazolium staining, electrical conductivity of seed leachates, accelerated ageing and field emergence in a growth chamber at sub optimal temperatures. They found that the results of standard germination were correlated with vigour and best correlation with field emergence. Though the other tests required less time but reported to be less accurate for vigour estimation.

Nascimento (1991) evaluated watermelon seeds for germination %, field emergence and 1000-seed weight. Generally the minimum, median and maximum germination was 46, 87 and 98%, respectively, and the corresponding figures for field emergence was 45, 73 and 84%. The brick-gravel test [brick-grit test], accelerated ageing test and controlled deterioration test of seed vigour gave better indications of probable field emergence for muskmelon cultivars Hara Madhu, Mathuria and Kharra, watermelon cultivars Sugar Baby, Farrukhabadi and Radan, and cucumber cultivars Super Green, Green Express and Kalyanpur Hara than the standard germination test, the leachate conductivity test or the seedling growth test (Pandey *et al*., 1990).

2.4 IMPACT OF DIFFERENT SOWING DATES (SUMMER AND RAINY SEASONS) ON SEED QUALITY

In okra seed crop, which is grown during rainy season under north Indian conditions, the pods are generally allowed to mature on plant and harvested when they dry. This practice, however, expose the mature pods to rain and insect pests, which not only the damage seed but also lower its seed viability (Kanwar and Saimbhi, 1987). Similarly, Singh and Gill (1988) concluded that delay in harvesting increased the number of damaged seeds and lowered seed weight and germination percentage. Seed germination % deteriorated with an increase in the number of rainy (Stimulated) days and the deterioration was much greater in cv. Punjab Padmini than in Pusa Sawani.

Maximum seed yield was harvested when crop was sown from 15-20 June comparison to 30th June, 15th July or 30th July. Singh *et al*. (1986 and 1988). Bhuibhar *et al*. (1989) obtained highest seed yield and best quality seed of 4th July as compared to 19th July or 3rd August in cv. Pusa Sawani. Singh *et al*. (1994) reported that mid June sown crops resulted in higher seed yield as it escaped from the attack of yellow vein mosaic virus and disease in cv. Pusa Sawani. Sowing of okra cv. Pusa Sawni in March, April or May produced the best quality seeds as compared to May to November sown under Tamilnadu conditions (Palanisamy *et al*., 1986). Uddin *et al*. (2006) recorded the highest seed yield and seed quality (84.56% germination and 27.02 seed vigour index) from April sown crop.

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled 'Assesment of seed quality of okra in summer and rainy season' was conducted at Vegetable Research Farm and in Laboratory of Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar from March, 2009 to April, 2010.

3.1 Weather conditions

The meteorological data were obtained from Department of Agrometeorology, CCS Haryana Agricultural University, Hisar, which is situated at Latitude: 29˚10N, Longitude 73˚43E, and at an elevation of 210m above mean sea level. Meteorological data on temperature (ºC), relative humidity (%) and rainfall (mm) during the crop seasons are given in table 3.1.

3.2 Detail of cultural operations

3.2.1 Raising of seed crop

Okra seeds of all the three varieties were sown at the Vegetable Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar. The seeds were sown in a randomized block design with four replications during summer season on 10th March, 2009 and rainy season on 27th June, 2009. Recommendations of the region were followed for raising a healthy seed crop. Seeds were collected at maturity to study the influence of growing season on quality of seed.

3.3 Treatments

The experiment was consist of follow combinations.

A. Varieties	B. Seed Seasons	C. Replication
1. Varsha Uphar	1. Summer	Four
2. Hisar Naveen	2. Rainy	
3. BB-1		

Completely randomized design was followed in the estimation of quality for laboratory and randomized block design for field parameters.

3.4 Laboratory observations

3.4.1 Standard germination test (%)

100 seeds per replication for each genotype and season were placed on sufficient moistened rolled towel papers (B.P.) at 25^{o}C temperature with 90-95% RH in the seed germinator for 10 days. On 10th day the number of normal seedlings were counted and expressed as percent germination.

3.4.2 Tetrazolium test (%)

The tetrazolium viability test as described by Moore (1985) was followed. In this test seeds were moistened in a beaker for 12-15 hrs at room temperature. These seeds were cut laterally and stained in 0.5% tetrazolium solution (0.5% solution of 2, 3, 5 triphenyl tetrazolium chloride) and kept for 4-5 hrs at 38^{o} C. The solution was poured off and seeds washed briefly in water and examined under magnifications. The number of seeds stained entirely red were considered as viable seeds and expressed in percentage.

Table 3.1 Average weather data of Hisar during the experimentation season (2009-10)

	Max temp. ^{0}C	Mini temp. ^{0}C	RH (M*)	RH (E*)	Rainfall (mm)
March,2009	32.42	12.30	84.97	30.52	0.00
April,2009	35.63	17.17	62.73	25.23	0.46
May,2009	37.91	22.96	60.61	33.00	1.70
June,2009	36.03	25.46	81.53	60.13	4.10
July,2009	36.24	26.53	81.97	58.19	4.78
Aug,2009	33.72	25.23	90.55	72.29	4.16
Septembe,2009	33.62	22.44	87.17	54.10	3.20
October,2009	33.93	18.55	83.74	36.10	0.17
November,2009	28.62	10.30	89.47	33.50	0.00
December,2009	23.15	6.72	93.94	48.94	0.00
January,2010	18.59	3.19	90.29	37.58	0.11
February,2010	21.25	4.16	86.00	36.82	0.00
March,2010	30.30	10.60	88.00	35.90	0.00
April,2010	35.30	13.70	65.00	18.00	0.50

* M= Morning *E = Evening

3.4.3 Speed of germination

The number of seedlings emerged were counted on each day and the speed of germination was calculated as described by Maguire (1962).

$$\frac{\text{No. of seedlings emerged}}{\text{First day of count}} + \text{------} + \frac{\text{No of seedlings emerged}}{\text{Final day of count}}$$

3.4.4 Seedling length (%)

On 10th day at the time of recording standard germination, ten normal seedlings were randomly selected from each replication for measuring root and shoot length.

3.4.5 Seedling dry weight (mg)

Normal seedlings selected for measuring root and shoot length were further kept for taking seedling dry weight. For dry weight, seedlings were first kept under sunlight for some time and after that the seedlings were kept in hot air oven at 60^{0}C for 48 hrs and then weight was recorded in milligrams (mg).

3.4.6 Seed vigour index

From the observations under various tests the vigour index was calculated.

It was calculated as follows:

Seed vigour index-I = Standard germination x Seedling length (cm)

Seed vigour index-II = Standard germination x Dry weight (mg)

2.1.7 Accelerated aging test (%)

The method was developed by Delouche (1962) at the Seed Technology Laboratory, Mississippi State University. The accelerated ageing test involved the exposure of seeds to adverse conditions for a specific period (Delouche and Baskin, 1973).

In this test single layer of seeds was taken on the wire mesh, which was fitted in the plastic bore whose bottom was filled with 40 ml of distilled water. This base was then transferred to the accelerated ageing chamber, which was set at 40±1^{o}C temperature with RH of about 100 per cent for 24, 36, 48 and 72 hrs. After accelerated ageing of each duration, the seeds of each variety and season were tested for germination by paper towel (B.P.) method at 25^{o}C as per standard germination procedures and percentage of germination was calculated (based on normal seedlings only).

3.4.8 Electrical conductivity test (dSm^{-1})

50 normal seeds were soaked in a 100ml beaker containing 75ml of distilled water and kept at 25 ^{0}C (AOSA, 1983). The electrical conductivity (dSm^{-1}) was measured after 24hrs with conductivity meter.

3.4.9 Dehydrogenase activity (DHO) test (OD)

The method was suggested by Kittock and Law (1968). Reduction of 2,3,5-triphenyl tetrazolium chloride to red formazan by dehydrogenase enzymes in seed embryos is the basic principle for topographical tetrazolium test for seed viability but the method described here is a quantitative method, which may be used to determine varying dehydrogenase activity between seed lots of similar viability and therefore, it is a measure of seed vigour. To conduct DHA test, the representative seed sample of each lot was grounded to pass through 20-mesh screen. The 200 mg flour was soaked in 5 ml of freshly prepared 0.5% 2,3,5-triphenyl tetrazolium chloride solution having pH 7.0. After shaking, the mixture was incubated at a temperature of 35°C for 2 hours. Then it was centrifuged at 10,000 rpm for 3 minutes and the supernatant poured off. The formazan was extracted with 10 ml acetone for 16 hours at room temperature. It was then centrifuged for 3 minutes at 10,000 rpm and acetone solution containing formazan was transferred to the cuvette. The absorbance reading of the solution was taken at 520 nm wave length using Systronics Spectrophotometer 169.

3.4.10 Test weight (g)

Weight of 1000 seeds was recorded, which is test weight.

3.4.11 Seed density (g/cc)

One hundred seeds from each genotype and season were taken and weighed on electrical balance. These seeds were dipped in distilled water. Volume of distilled water displaced by seeds was recorded and seed density was calculated by using the following formula. The density of seeds was expressed as g/cc

$$\text{Seed density} = \frac{\text{Weight of 100 seeds (g)}}{\text{Volume of distilled water displaced by seeds (cc)}}$$

3.5 FIELD PARAMETERS

One hundred seeds of each variety and season were sown in a factorial randomized block design, with four replications during April, 2010 at the research farm of Department of Vegetable Science, CCS Haryana Agricultural University, Hisar. The following observations were recorded in the field.

3.5.1 Field emergence (%)

The number of seeds germinated was recorded daily until it completed on 16th day.

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

3.5.2 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.

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

3.6 STATISTICAL ANALYSIS

The observations recorded in both the field and laboratory were subjected to the statistical analysis. The following model was used for the statistical analysis of all the field and the laboratory parameters.

Two factor CRD

Factor A = Season Having level P

Factor B = Variety Having level q

Modal : $Y_{ijk} = \mu+\alpha_i+\beta_j+ (\alpha\beta_{ij})+e_{ijk}$

μ = General mean

α_i = effect of ith level due to season

β_j= effect of jth level due to variety

$\alpha\beta$= is the interaction effect

$e_{ijk} \sim (o, \sigma e^2)$

Total no. of observation = pqr

,

S.E. for A = S.E. (m)

, S.E. (d) =

C.D. = S.E. x t error d.f. , 0.5%

S.E. for B = S.E. (m)

, S.E. (d) =

C.D. = S.E. x t error d.f. , 0.5%

S.E. for AxB

S.E. (m) =

, S.E. (d) =

C.D. = S.E., T error d.f. , 0.5%’

ANOVA FOR CRD

S.V.	d.f.	S.S.	M.S.	Fcal
Treatment	Pq-1		MT	
A	p-1		MA	MA/ME
B	(q-1)		MB	MB/ME
AB	(P-1) (q-1)		MAxB/ME	M_{AxB}
		-A.S.S.-B.S.S.		
Error	Pq (r-1)	Total R.S.S.-Treat S.S.	ME	
Total	Pqr-1			

Two factor RBD

Modal : $\mu+\alpha_i+\beta_j+r_k+(\alpha\beta_{ij})+e_{ijk}$

μ = General mean

α_i = effect of ith level due to season

β_j= effect of jth level due to variety

rk= effect due to kth block

$(\alpha\beta_{ij})$ = interaction effect

$e_{ij1} \sim (o, \sigma e^2)$

ANOVA FOR RBD

S.V.	d.f.	S.S.	Fcal	M.S.
Blocks	(r-1)		MR	MR/ME
Treatment	(pq-1)		MT	MT/ME
A	(p-1)		MA	MA/ME
B	(q-1)		MB	MB/ME

AB	(P-1) (q-1)		M_{AxB}	MAB/ME
Error	Pq (r-1)	-T.S.S.-A.S.S. By subtraction	ME	ME
Total	Pqr-1			

S.E. for A = S.E. (m)

, S.E. (d) =

C.D. = S.E. x t error d.f. , 0.5%

S.E. for B = S.E. (m)

, S.E. (d) =

C.D. = S.E. x t error d.f. , 0.5%

S.E. for AxB

S.E. (m) =

, S.E. (d) =

C.D. = S.E., T error d.f. , 0.5%'

Correlation coefficient (r) and Regression coefficient (b)

Correlation (r) and regression (b) analysis among various field and laboratory parameters was worked out by following the standard procedure.

Correlation coefficients (r)

Whereas

r = Correlation coefficient

xy =

xy = Covariance between x and y

x and y = standard deviations of x and y respectively

Regression coefficient (b)

b =

Whereas

b = is regression coefficient

CHAPTER-IV

EXPERIMENTAL RESULTS

The present investigation entitled 'Assessment of seed quality of okra in summer and rainy season' was conducted in the laboratory of Seed Science and Technology and in the field of Vegetable Science of Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 2009-10. Observations recorded on various parameters of viability and vigour test of okra were analyzed using appropriate statistical techniques. The results obtained have been furnished in this chapter under the following sub heads:

4.1 Mean performance

4.2 Correlation analysis

4.3 Regression analysis

4.1 Mean performance: The mean value of various viabilities and vigor parameters are presented in this section.

4.1.1 Standard germination (%)

The results indicated significant difference due to varieties, seasons and interaction (Table 4.1.1). Among the varieties tested, Varsha Uphar had the highest germination (82.50) followed by Hisar Naveen (79.00). The three varieties compared differed significantly from one another. Comparing the seasons germination was significantly higher in the seeds obtained from rainy season crop. The interaction between the varieties and seasons was significant indicating that the behavior of three varieties tested was different in two seasons with respect to standard germination. Among the treatment combinations highest germination was recorded in Varsha Uphar, where seed was obtained from rainy season crop (87.50) and this treatment combination was significantly superior to all the remaining treatment combinations. Lowest germination was recorded in the variety BB -1, where seed was obtained from summer season crop (73.50).

4.1.2 Viability (%) estimated by tetrazolium test

Viability of seeds estimated through tetrazolium test ranged from 80.50 to 94.50 and was significantly influenced by varieties as well as seasons (Table 4.1.2). With respect to varieties the maximum viability was expressed by Varsha Uphar (90.50) followed by Hissar Naveen (86.50) and minimum (85.00) was recorded in BB -1. These three varieties differed from one another significantly. Seeds from rainy season crop recorded significantly higher viability (91.50) compared with the seeds from summer season crop (83.16). However, interaction between varieties and seasons for this parameter was not significant

Table 4.1.1 Effect of seed production seasons and varieties in okra on standard germination (%)

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	77.50	75.50	73.50	75.50
Rainy (S2)	87.50	82.50	80.50	83.50
Mean (V)	82.50	79.00	77.00	

C.D. at 5% level for season =1.10, variety = 1.35, interaction = 1.91

Table 4.1.2 Effect of seed production seasons and varieties in okra on viability (%) estimated by tetrazolium test.

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	86.50	82.50	80.50	83.16
Rainy (S2)	94.50	90.50	89.50	91.50
Mean (V)	90.50	86.50	85.00	

C.D. at 5% level for season =1.10, variety = 1.35, interaction = NS

4.1.3 Dehydrogenase activity test (OD)

Dehydrogenase activity ranged from 1.72 to 1.97 and was significantly influenced by the varieties compared in the present investigation (Table 4.1.3). Among the varieties tested, Varsha Uphar had the highest value of dehydrogenase activity (1.95) and was significantly superior to remaining two varieties and BB -1 recorded lowest value (1.73) of dehydrogenase activity and was significantly different from Hissar Naveen. Value of dehydrogenase activity was higher in the lot obtained from rainy season, however, it did not differ significantly from the lot obtained from summer season. Interaction between varieties and seasons for dehydrogenase activity was not significant.

Table 4.1.3: Effect of seed production seasons and varieties in okra on dehydrogenase activity (OD)

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	1.94	1.85	1.72	1.83
Rainy (S2)	1.97	1.85	1.75	1.86
Mean (V)	1.95	1.85	1.73	

C.D. at 5% level for season = NS, variety = 0.05, interaction = NS

4.1.4 Speed of germination

The speed with which the seed germinated in the laboratory varied from 22.81 to 25.72 and was significantly influenced by varieties as well as seasons (Table 4.1.4). Among the varieties, Varsha Uphar showed highest speed of germination (25.26) followed by Hisar Naveen (24.00), lowest speed of germination (22.97) was recorded in BB -1. These three varieties differed significantly among themselves. Speed of germination for the seeds obtained from rainy season (24.43) was significantly higher as compared to the seeds obtained from summer season (23.72). The interaction between varieties and seasons was not significant.

4.1.5 Seedling length (cm)

Seedling length ranged from 24.83 to 28.16 and was significantly influenced due to varieties as well as seasons (Table 4.1.5). Among the varieties maximum value of seedling length was recorded for Varsha Uphar (27.27) followed by Hissar Naveen (26.29) and difference between these two varieties was significant. BB-1 recorded lowest (25.41) seedling length and was significantly inferior to remaining two varieties for this parameter. Seedlings from rainy season crop recorded significantly higher length (27.05) compared with the seedlings from the summer season crop (25.60). The interaction between the varieties and seasons was not significant.

Table 4.1.4 : Effect of seed production seasons and varieties in okra on speed of germination

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	24.81	23.54	22.81	23.72
Rainy (S2)	25.72	24.46	23.13	24.43
Mean (V)	25.26	24.00	22.97	

C.D at5% level for season = 0.62, variety = 0.76, interaction = NS

Table 4.1.5: Effect of seed production seasons and varieties in okra on seedling length (cm)

Seasons	Varieties			
	Varsha Uphar (V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	26.38	25.58	24.83	25.60
Rainy (S2)	28.16	27.01	25.98	27.05

Mean (V)	27.27	26.29	25.41	

C.D at 5% level for season = 0.48, variety = 0.59, interaction = NS

4.1.6 Dry matter of seedlings (mg)

The range of dry matter accumulation varied from 1.17 to 1.28 and was significantly influenced by varieties (Table 4.1.6). Varsha Uphar had the highest dry matter accumulation (1.27) followed by Hisar Naveen (1.23) and BB-1 (1.18) respectively. Differences in dry matter accumulation due to seasons were not significant. The interaction between varieties and seasons was also not significant.

Table 4.1.6: Effect of seed production seasons and varieties in okra on dry matter of seedlings (mg)

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	1.26	1.22	1.17	1.21
Rainy (S2)	1.28	1.24	1.19	1.23
Mean (V)	1.27	1.23	1.18	

C.D at 5% level for season = NS, variety =0.06, interaction= NS

4.1.7 Seed vigour index-I

Seed vigour index-I calculated by multiplying standard germination % with the seedling length (cm), was significantly influenced by varieties, seasons as well as interaction (Table 4.1.7). Among the varieties, Varsha Uphar had highest value and was significantly superior to remaining two varieties, it was followed by Hissar Naveen which was significantly better than BB-1. Seeds from rainy season crop recorded seed vigour index-I value of 2261.7 and was significantly superior to summer season crop. Regarding interaction, Varsha Uphar grown during rainy seasons recorded highest value (2465.0) and was significantly better than all the remaining combinations. Lowest value (1826.1) was recorded with the seeds of BB-1 when grown during summer.

Table 4.1.7: Effect of seed production seasons and varieties in okra on seed vigour index-I

Seasons	Varieties			
	Varsha Uphar (V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	2045.5	1931.7	1826.1	1934.4
Rainy (S2)	2465.0	2227.8	2092.2	2261.7

Mean (V)	2255.3	2079.7	1959.1	

C.D. at 5% level for season= 50.0, variety= 61.2, interaction = 86.2

4.1.8 Seed vigour index-II

The range of seed vigour index-II calculated by multiplying standard germination % with the dry weight seedling (mg), varied from 86.30 to 112.02 (Table 4.1.8) and differences in the values due to varieties as well as seasons were significant. It was highest in Varsha Uphar (103.2) followed by Hissar Naveen (97.30). Lowest value for seed vigour index-II was recorded in BB-1. These three varieties differed from one another significantly. Seeds obtained from the crop raised during rainy season recorded higher values for all the three varieties with a mean value of 103.53 and it was significantly superior to crop raised during summer season. Interaction between varieties and seasons was not significant.

Table 4.1.8: Effect of seed production seasons and varieties in okra on seed vigour index-II.

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	97.66	92.32	86.30	92.09
Rainy (S2)	112.02	102.28	96.21	103.53
Mean (V)	103.20	97.30	91.25	

C.D. at 5% level for season =4.33, variety = 5.30, interaction = NS

4.1.9.1 Standard germination (%) after accelerated ageing for 24hrs

Standard germination (%) after accelerated ageing for 24hrs ranged from 70.25 to 84.25 (Table 4.1.9.1) with a mean value of 76.33 thus showing a reduction of 3.17% (Table 4.1.1 and Table 4.1.9.1). Results showed a significant difference between varieties and seasons. Among the verities, Varsha Uphar had the highest germination (79.50) followed by Hisar Naveen (75.62). Differences between these two varieties was significant and both these varieties were superior to BB-1.The results of seasonal comparison showed that after accelerated ageing for 24 hours seed taken from rainy season crop recorded significantly higher standard germination compared with the seed taken from the crop raised during summer season. Interaction between varieties and seasons for this parameter was not significant.

Table 4.1.9.1: Effect of seed production seasons and varieties in okra on standard germination (%) after accelerating ageing for 24hrs.

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	74.75	71.50	70.25	72.16
Rainy (S2)	84.25	79.75	77.50	80.50
Mean (V)	79.50	75.62	73.87	

C.D. at 5% level for season =1.35, variety = 1.66, interaction = NS

4.1.9.2 Standard germination (%) after accelerated ageing for 36hrs

Standard germination decreased by 7.88% with increase in accelerated ageing from 24 to 36hrs (tables 4.1.9.1 and 4.1.9.2). Standard germination after 36 hrs of accelerated ageing ranged from 62.25 to 75.50 and differences due to varieties as well as seasons were significant. Among the varieties tested, Varsha Uphar had the highest germination (71.00) followed by Hisar Naveen (68.00) and differences between these were significant. BB-1 recorded lowest germination and was significantly inferior to the remaining two varieties. After 36hrs of accelerated ageing also seed obtained from the crop sown during rainy season (72.75) was significantly superior to the seed obtained from the crop grown during summer (64.16). Interaction between varieties and seasons was not significant for this parameter also.

Table 4.1.9.2: Effect of seed production seasons and varieties in okra on standard germination (%) after accelerated ageing for 36hrs.

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	66.50	63.75	62.25	64.16
Rainy (S2)	75.50	72.25	70.50	72.75
Mean (V)	71.00	68.00	66.37	

C.D. at 5% level for season =1.29, variety = 1.59, interaction = NS

Table 4.1.9.3: Effect of seed production seasons and varieties in okra on standard germination (%) after accelerated ageing for 48hrs

	Varieties			
Seasons	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	50.50	47.75	45.50	47.51
Rainy (S2)	59.75	55.50	53.25	56.16
Mean (V)	55.12	51.62	49.37	

C.D. at 5% level for season =1.29, variety = 1.59, interaction = NS

4.1.9.3 Standard germination (%) after accelerated ageing for 48hrs

With increase in accelerated ageing from 36 to 48hrs, standard germination decreased from 68.5 (Mean of all treatment) to 51.8 (Tables 4.1.9.2 and 4.1.9.3). Values for standard germination after accelerated aging for 48 hrs. ranged from 45.50 to 59.75. Results showed significant differences between varieties and seasons. Among the varieties tested, Varsha Uphar had the highest germination (55.12) followed by Hisar Naveen (51.62) and BB-1 recorded lowest germination of 49.37. These three varieties differed from one another significantly. The results of seasonal comparison showed that standard germination after accelerated ageing for 48 hours of all the tested varieties was higher in rainy season with a mean value of 56.16, which was significantly different from the mean value of 47.51 recorded for summer season. Interaction between varieties and season was not significant.

4.1.9.4 Standard germination (%) after accelerated ageing for 72hrs

With increase in accelerated ageing to72hrs, values for standard germination further decreased and ranged from 30.50 to 46.75 with a overall mean of 38.16 (Table 4.1.9.4). Results showed significant differences between varieties and seasons. Among the varieties tested, Varsha Uphar had the highest germination (40.50) followed by Hisar Naveen (37.62), while lowest germination was recorded in BB-1. Varsha Uphar was significantly superior to both the varieties. Varsha Uphar recorded higher germination after stress condition of 72 hours in both summer (34.25) and rainy season (46.75). The results of seasonal comparison showed that standard germination was higher in rainy season as compared to summer season. Interaction between varieties and seasons was not significant

Table 4.1.9.4: Effect of seed production seasons and varieties in okra on standard germination (%) after accelerated ageing for 72hrs.

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	34.25	31.75	30.50	32.16
Rainy (S2)	46.75	43.50	42.25	44.16
Mean (V)	40.50	37.66	36.37	

C.D at 5% level for season =1.35, variety = 1.66, interaction = NS

Table 4.1.10: Effect of seed production seasons and varieties in okra on Electrical conductivity (dSm^{-1})

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	0.95	0.98	1.06	1.00
Rainy (S2)	0.84	0.89	0.95	0.88

Mean (V)	0.90	0.94	0.98	

C.D at 5% level for season = 0.01, variety = 0.01, interaction = 0.01

4.1.10 Electrical conductivity (dSm^{-1})

Results of electrical conductivity indicated significant differences due to varieties, seasons as well as interaction (Table 4.1.10). Among varieties, Varsha Uphar was best as it had low amount of leachates and was significantly superior to Hisar Naveen and BB-1. BB-1 was considered as poor because it had high amount of leachates and was significantly different from Hisar Naveen. The result of seasonal comparison showed that electrical conductivity of all the tested varieties was lower in rainy season compare to summer season with a mean of 0.88 and 1.00 for rainy and summer season, respectively and differences due to seasons were significant. Interaction between varieties and seasons was significant. Lowest electrical conductivity (0.84) was recorded in Varsha Uphar, when seeds were obtained from rainy season crop it was highest in the varieties BB-1 (1.06), when seeds were obtained from summer season crop.

4.1.11 Seed density (g/cc)

Seed density ranged from 1.69 to 1.82 and was significantly influenced by varieties (Table 4.1.11). Among the varieties tested, maximum value of seed density was recorded for Varsha uphar (1.81) followed by Hisar Naveen (1.72) and BB-1 (1.69). Varsha Uphar was significantly superior to both the varieties. Varsha Uphar recorded higher seed density during both the seasons. Growing season could not influence seed density significantly. The interaction between varieties and seasons was also not significant.

Table 4.1.11: Effect of seed production seasons and varieties in okra on seed density (g/cc)

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	1.80	1.70	1.69	1.73
Rainy (S2)	1.82	1.73	1.70	1.75
Mean (V)	1.81	1.72	1.69	

C.D at 5% level for season =NS, variety = 0.05, interaction = NS

4.1.12 Test weight (g)

The results indicated significant differences due to varieties, seasons as well as interaction (Table 4.1.12). Maximum mean test weight was obtained in variety Varsha Uphar (59.73) followed by Hisar Naveen (58.34) and BB-1 (57.00) and these three varieties differed significantly from one another. Varsha Uphar had higher test weight in both the seasons.

Mean test weight for the seed obtained from the crop raised during rainy season was 59.32 and it was significantly higher compared to summer season. Interaction between varieties and seasons was also significant. Test weight was highest in Varsha Uphar (61.28) when crop was raised during rainy season and it was lowest in BB-1 (56.73) when raised during summer season.

Table 4.1.12 : Effect of seed production seasons and varieties in okra on test weight (g)

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	58.20	57.28	56.73	57.40
Rainy (S2)	61.28	59.41	57.28	59.32
Mean (V)	59.73	58.34	57.00	

C.D at 5% level for season = 0.58, variety = 0.72, interaction = 1.01

2.1.13 Field emergence (%)

The results indicated significant differences due to varieties, seasons as well as interaction (Table 4.1.13). Among the varieties tested, Varsha Uphar had the highest field emergence (78.50) followed by Hisar Naveen (74.25). All the three varieties differed among themselves. Varsha Uphar showed its superiority for field emergence in both the seasons and its emergence was 74.50 and 82.50 during summer and rainy season, respectively. The results of seasonal comparison showed that field emergence of all the tested varieties was higher when seeds were obtained from rainy season compare to summer season, with a mean value of 78.16 and 72.08 for rainy and summer season, respectively. Interaction between varieties and seasons for field emergence was significant. Highest field emergence (76.50) was recorded in for the seeds of Varsha Uphar obtained from rainy season crops, while lowest emergence (63.50) was recorded in BB-1 where seeds were obtained from summer season crops.

Table 4.1.13 : Effect of seed production seasons and varieties in okra on field emergence (%)

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	74.50	72.00	69.75	72.08

Rainy (S2)	82.50	76.50	75.50	78.16
Mean (V)	78.50	74.25	72.62	

C.D at 5% level for season =1.15, variety = 1.42, interaction = 1.95

Table 4.1.14: Effect of seed production seasons and varieties in okra on seedling establishment (%)

Seasons	Varieties			
	Varsha Uphar(V1)	Hisar Naveen (V2)	BB1 (V3)	Mean (S)
Summer (S1)	66.50	64.50	63.50	64.83
Rainy (S2)	76.50	72.50	71.50	73.50
Mean (V)	71.50	68.50	67.50	

C.D at 5% level for season =1.21, variety = 1.48, interaction = 2.03

2.1.14 Seedling establishment (%)

The seedling establishment showed significant differences due to varieties, seasons as well as interaction (Table 4.1.14). Variety Varsha Uphar Showed highest seedling establishment for the seeds of summer (66.50) as well as rainy (76.50) season. Mean value of establishment for Varsha Uphar was 71.50, which was significantly higher than the remaining two varieties. BB1 recorded lowest mean establishment of 67.50. Comparing the seasons, rainy season with a mean value of 73.50 was significantly superior to summer season. The interaction between the varieties and seasons for this parameter was significant. Highest establishment (76.50) was recorded in Varsha Uphar, where seed was obtained from rainy season crop and lowest (63.50) was recorded in BB1, where seed was obtained from summer season.

4.2. Correlation analysis

Correlation coefficient analysis was employed to find out the association among various seed viability and vigour parameters.

4.2.1 Correlation coefficient

Correlation coefficient analysis was employed to find out the association among various seed viability and vigour parameters. It is evident from the table (4.2.1) that all the parameters were significantly correlated with standard germination and field emergence except dry weight of seedling, seed density, dehydrogenase activity test and speed of germination.

The standard germination showed positive and significant association with field emergence (0.98**), tetrazolium test (0.96**), seedling length (0.96**), test weight (0.97*), accelerated ageing (0.96**), seed vigour index-I (0.99**), seed vigour index -II (0.96**) and seedling establishment (0.98**). While it was negatively correlated to electrical conductivity (-0.96**).

Table 4.2.1: Correlation coefficient among different viability and vigour parameter in okra.

	S.G (%)	F.E (%)	Tz (%)	S.L (cm)	D.W (g)	T.W (g)	S.D (g/cc)	E.C (dSm-1)	AAT 72hr (%)	SVI-I	SVI-II	DHA (OD)	SPG	S.E (%)
S.G (%)	1.00	0.98**	0.98**	0.96**	0.71	0.97**	0.65	-0.96**	0.96**	0.99**	0.96**	0.61	0.76	0.98**
F.E (%)		1.00	0.97**	0.97**	0.79	0.97*	0.76	-.0.95**	0.90*	0.98**	0.98**	0.72	0.83*	0.94**
Tz (%)			1.00	0.92**	0.70	0.92**	0.64	-0.98**	0.97**	0.95**	0.94**	0.60	0.74	0.98**
S.L (cm)				1.00	0.88*	0.95**	0.83*	-0.93**	0.85*	0.98**	0.99**	0.81*	0.92**	0.89**
D.W (mg)					1.00	0.72	0.96**	-0.74	0.53	0.79	0.86*	0.98**	0.98**	0.60
T.W (g)						1.00	0.69	-0.90*	0.90*	0.98**	0.96**	0.64	0.79	0.94**
S.D (g/cc)							1.00	-0.64	0.45	0.73	0.81*	0.96**	0.96**	0.54
E.C (dSm-1)								1.00	-0.94**	-0.96**	-0.95**	-0.65	-0.75	-0.95**
AAT 72hr (%)									1.00	0.92**	0.87*	0.42	0.59	0.99**
SVI-I										1.00	0.98**	0.70	0.83*	0.96**
SVI-II											1.00	0.80	0.90*	0.91*
DHA (OD)												1.00	0.96**	0.49
SPG													1.00	0.66
S.E (%)														1.00

(S.G = Standard germination, Tz = Tetrazolium test, DHA = Dehydrogenase activity test, SPG = Speed of germination, S.L = Seedling length, D.W = Dry weight of seedling, SVI-I & SVI-II = Seed vigour index-I & II, AAT 72hrs = Accelerated ageing test, E.C = electrical conductivity, S.D = Seed density, T.W = test weight, F.E = Field Emergence, S.E = Seedling establishment.)

** Significant at 1% level of significance

* Significant at 5% level of significance

Field emergence showed positive and significant association with standard germination (0.98**), tetrazolium test (0.97**), seedling length (0.97**), test weight (0.97*), accelerated ageing (0.90*), seed vvigour index-I (0.98**), seed vigour index-II (0.98**) and seedling establishment (0.94**). While it was negatively correlated to electrical conductivity (-0.95**).

Positive and significant correlation of tetrazolium test was observed with standard germination (0.98**), field emergence (0.97**), seedling length (0.92**), test weight (0.92**), accelerating ageing (0.97**), seed vigour index-I (0.95**), seed vigour index-II (0.94**), and seedling establishment (0.98**). While it was negatively correlated to electrical conductivity (-0.98**).

The data indicated that electrical conductivity test had negative and significant correlation with standard germination (-0.96**), field emergence (-0.95**), tetrazolium test (-0.98**), seedling length (-0.93**), test weight (-0.90**), accelerating ageing (-0.94**), seed vigour index-I (-0.96**), seed vigour index -II (-0.95**) and seedling establishment (-0.95**).

Ageing test after 72hrs was shown to be significantly associated with standard germination (0.96**), field emergence (0.90**), seedling length (0.85*), test weight (0.90*), seed vigour index-I (0.92**), seed vigour index-II (0.87*), and seedling establishment (0.99**). While electrical conductivity test was found to be negatively correlated with ageing (-0.94**).

Seed vigour index-I and seed vigour index-II were positively and significantly correlated with standard germination (0.99**, 0.96**), field emergence (0.98**, 0.98**), tetrazolium test (0.95**, 0.94**), seedling length (0.98**, 0.99**), accelerated ageing (0.92**, 0.87**), seedling establishment (0.96**, 0.91*) and negatively correlated with electrical conductivity (-0.96**, -0.95**).

4.3 Regression analysis:

4.3.1 Relationship between field emergence (%) and different viability and vigour parameters

Regression analysis was done for six parameters which showed close relationship with field emergence and data are presented in Table 4.3.1. Field emergence ranged from 69.75 to 82.50, which represented good and medium levels of seed quality. Viability of these genotypes was further envisaged by different quick viability tests namely standard germination, tetrazolium test (Tz), dehydrogenase activity test (DHA), seed vigour index -II and electrical conductivity tests (EC). The result revealed that field emergence had significant and positive association with standard germination (r=0.98**), tetrazolium test (r=0.97**), dehydrogenase activity test (r=0.72), seed vigour index –II (0.9888) but it had significantly negative correlation with electrical conductivity (r = -0.95**), which is enviable for high seed viability. *S*eeing as standard germination, seed vigour index-II, Tz, DHA and EC had close relationship with laboratory, the concurrent variations of these tests were studied by regression analysis. The mean germination percentage obtained by field emergence (75.13), standard germination (74.52), Tz (74.53) and DHA (**76.81)** and EC (74.93) were at par. The actual mean is related to the estimated mean for all the tests as indicated by linear equation. The regression sum of squares was also highly significant. Therefore, germination percentage may be reliably predicted by knowing viability percentage and using the regression equation. Regression sum of square was also highly significant. The maximum value of R^2 (Coefficent of determination) was obtained for standard germination (0.98) followed by vigour index-II (0.97), tetrazolium test (0.91) and electrical conductivity (0.91) as these tests were also found highly correlated with field emergence indicating the reliability of these tests.

Table 4.3.1: Relationship between field emergence (%) and different viability and vigour parameters in okra

Type of test	Mean and Range Actual	 Estimated	Regression Y= a + bx	R^2
Standard germination (%)	79.50 (73.50-87.50)	74.52 (69.9-81.66)	Y = 8.16 + 0.84x	0.98
Tetrazolium test (%)	87.33 (80.50-94.50)	74.53 (69.07-80.27)	Y = 4.67 + 0.80x	0.91
Seedling length (cm)	26.33 (24.83-28.17)	74.03 (69.55-81.75)	Y = -21.07 + 3.65x	0.93
Electrical conductivity (dSm-1)	0.95 (0.85-1.06)	74.93 (80.61-68.69)	Y = 128.85- 56.75x	0.91
Accelerated ageing after 72hrs (%)	38.17 (30.50-46.75)	75.11 (70.68-80.09)	Y = 52.97 + 0.58x	0.78
Seed Vigour index-II	97.80 (86.30-112.0)	74.20 (68.68-81.02)	Y = 27.26+ 0.48x	0.97
Field Emergence (%)	75.13 (69.75-82.50)			

- Field emergence is dependant parameter
- Figure in parenthesis indicated the range value

CHAPTER-V

DISCUSSION

Okra is one of the important crop being cultivated in India and has a measure share in the wealth of vegetable crops. For higher production we require good quality seeds. There is awareness among the farmers regarding the use of quality seeds of improved cultivars, however, inadequate availability of quality seeds of improved cultivars is one of the constraints in improving the productivity of this crop.

A number of parameters to evaluate seed quality have been developed. Some of these parameters or tests have been referred as vigour test. These tests could be used reliably to predict crop establishment under field conditions. The concept of vigour was discussed by the ISTA and AOSA. Thus, seed vigour from the plant stand point of seed testing is the sum total of all seed attributes that favour plant stand establishment under varying field conditions. With this idea, various laboratory parameters were applied to okra in order to assess the seed quality of different varieties in term of field emergence.

Germination in the laboratory tests is the emergence and development from the embryo of those essential structures which for the kind of seed being tested indicate the ability to develop into a normal plant under favorable conditions in the soil (ISTA, 1999). The germination result which establish the maximum plant producing potential of seed lots were found correlated with emergence under favorable field conditions. There is optimum temperature for growth, fruit set and seed development for every crop and temperature lower and upper than the optimum may adversely influence these parameters. Pagamos and Nawata (2007) and Pagamos *et al*. (2007) reported significant reduction in quality of chilli seed where temperature was higher than normal at the time of seed development. Bhuibhar *et al.* (1989), Palanisamy *et al.* (1986) and Uddin *et al.* (2006) reported the effect of sowing time on quality of okra seed, because temperature was different at seed development.

In the present investigation standard germination, dehydrogenase activity, speed of germination, seedling length, dry weight of seedling, seed vigour, standard germination after accelerated ageing for different periods, seed density, test weight, field emergence and seedling establishment were higher in the seeds obtained from rainy season compared with summer season crop. Electrical conductivity of leachates was lower in the seeds obtained from rainy season crop. It may be due to the reason that crop grown during summer season had higher temperature at the time of seed development (May-June) compared with the temperature at seed development for rainy season (August- September) crop, which is more near to optimum. At higher temperature seed may have forced maturity and thus seeds from summer crop recorded lower test weight and seed density. For all these parameters there were significant differences among the varieties and Varsha Uphar showed its superiority to Hisar Naveen and BB-1, this may be attributed to the genetic constitution. Genotypic differences for germination, viability and vigour have also been reported by Singh and Ram (2005). Narwal (1995) had also reported superiority of Varsha Uphar as compared to Pusa Sawani, Punjab Padamani, Parbhani Kranti and P-7.

Seed ageing has come to be recognized as major cause of reduced germination, vigour and viability in many species. Maximum seed quality occurred at physiological maturity after which seed vigour and viability declined both during aging on the plants and during storage. In present study, okra seeds lost their germination up to 50% when given 72hrs of artificial ageing at 40 ^{0}C with 100% RH. The decline in germination during this accelerated ageing is related to the degree of deterioration of the seed lots. The decline in seed germination and vigour during accelerated ageing as well as storage treatments were influenced by chronological age of seed rather than initial germination percentage (Agarwal *et al*., 1980). Agarwal and Sinha (1980) also reported decrease in seed germination and vigour during accelerating ageing as well as during storage.

In the present investigation interaction between varieties and seasons for all the parameters except standard germination seed vigour index-I, electrical conductivity of leachates, test weight, field emergence and seedling establishment was not significant indicating similar response of all the three varieties to the environmental stress.

The result of present investigation showed that the standard germination had mean values higher than the field emergence supporting the view that the standard germination test being conducted under optimum conditions often over estimate field emergence.

After taking correlation studies into consideration positive and highly significant correlation between laboratory germination and field emergence was obtained (0.98**). Therefore, the standard germination test can successfully be used as prediction criterion of field emergence.

In present investigation the higher germination % recorded in the seeds obtained rainy season than summer season crop. It may be due to difference in temperature at the development of seed as explained above Varsh Uphar was superior to other two varieties. Similar results have been reported by Yadav *et al.* (2001).

Tetrazolium test showed highly significant association with standard germination (0.98**) and field emergence (0.97**). Viable seeds were higher in rainy season as compared to summer season. Among varieties, Varsha Uphar recorded higher viable seeds in both the seasons. The tetrazolium test could be in close agreement with standard germination if properly conducted and evaluated. This test can also evaluate seed quality in better way as compared to the standard germination if some seeds are dormant in the lot.

The seedling length showed positive significant correlation with standard germination (0.96**) and field emergence (0.97**). While it show less correlation with tetrazolium test (0.92*). However, relationship between dry weight of seedling and field emergence was not significant. In present investigation seedling length and dry weight of seedling were higher in rainy season as compared to summer season crop. Test weight of rainy season seeds was higher than summer seasons seeds and showed positive and significant correlation with field emergence. Singh *et al.* (1986) recorded higher seed weight when crop was sown on 15th June. Palinasamy and ramasamy (1987) reported significant and positive correlation between seed quality and seedling vigour. Bhuibhar *et al.* (1989) obtained best quality seeds from 4th July sown crop as compared to 19th July or 3rd August sown crop. A positive and significant association between test weight and seedling vigour in three grades of okra seeds were observed by Palinasamy and Ramasamy (1985).

Electrical conductivity test has been used to measure seed viability (Presely, 1958). This test was later developed into a vigour test for the prediction of field emergence of wrinkled garden peas. (Mathews and Brabnock, 1967, 1968). The electrical conductivity was found to be negatively correlated with all the parameters in the present study. The electrical conductivity test measure the amount of electrolytes which leach out from the seeds as they deteriorate. Poor membrane, structure and leaky cells are usually associated with deteriorating and low vigour seeds. The electrical conductivity showed negative correlation with standard germination (-0.96**), field emergence (-0.95**) and tetrazolium test (-0.98**). The value of electrical conductivity is higher in summer seed production season compared to rainy season seeds. The lowest electrical conductivity value indicates good quality seeds. Similarly, Narwal (1995) found that all varieties of okra loose there membranes permeability after 180 days of storage in ambient conditions, with increase in the electrical conductivity values. Similar results were also found in tomato and brinjal (Krishnasmy and Ramasamy, 1989). Panobianco and Marcos (2001) found that the electrical conductivity test was less sensitive vigour test for tomato seeds. Doijode (1990) reported increase in electrical conductivity of seed leachates from 84 to 221 after 20 days of ageing in vegetable seeds.

Vigour index offers the possibility of categorizing seed lots into classes of seed quality which have more value than a specific numerical value. In present study seed vigour index-I and seed vigour index-II showed positive and significant correlation with standard germination (0.99**, 0.96**), field emergence (0.98**, 0.98**), tetrazolium test (0.95**, 0.94**) and seedling length (0.98**, 0.99**). Speed of germination also had positive and significant correlation with field emergence. Seed vigour index-I, seed vigour index-II and speed of germination had higher value in the seed obtained from rainy season as compared with summer season crop. Similarly, Yadav and Dhankhar (2001) also found positive and significant correlation of vigour index-I and vigour index-II with standard germination, seedling length and seedling dry weight.

Seedling establishment was significantly associated with field emergence. Vigorous seeds germinated rapidly. So the seed lots which had higher vigour measured through various tests in the present study recorded better establishment of seedlings in the field.

The result of regression analysis between field emergence and different viability and vigour parameters showed maximum reliability with standard germination followed by vigour index-II, seedling length, tetrazolium test and electrical conductivity test. The highest value of R^2 in multiple regression indicated that all the parameters may be used individually or together to get more accurate information.

CHAPTER-VI

SUMMARY AND CONCLUSION

The inadequate availability of quality seeds of the improved cultivars is one of the constraints in improving the productivity of okra. With the increasing awareness among cultivars about use of quality seeds, there is need to have some reliable parameters to evaluate seed quality. During the past decade seed viability and vigour testing of crop has gained importance in seed quality program. However, before these vigour tests can be used in quality control, they must meet certain criteria. Most important among them is that viability and vigour tests should be related to field performance. The standardization of viability and vigour tests is being achieved for many crops. Vigour testing of okra has not been extensively studied. Therefore, in the present study seeds obtained from three varieties of okra grown for seed production during summer and rainy seasons were evaluated for seed viability and vigour parameters to determine the inter-relationship between laboratory and field parameters, to asses the efficiency of different seed viability and vigour tests as a predictor of field potential. The analysis of variance reveled that there was significant variation due to varieties as well as seasons for almost all the viability and vigour parameters.

Standard germination, dehydrogenase activity, speed of germination, seedling length, dry weight of seedling, seed vigour, standard germination after accelerated ageing for different periods, seed density, test weight, field emergence and seedling establishment were higher in the seeds obtained from rainy season compared with summer season crop. Electrical conductivity of leachates was lower in the seeds obtained from rainy season crop. For all these parameters there were significant differences among the varieties and Varsha Uphar showed its superiority to Hisar Naveen and BB-1. Standard germination (%) reduced from 79.50 to 76.33, 68.45, 51.83 and 36.16 when seeds were subjected to accelerated ageing for 24, 36, 48 and 72 hrs. respectively. Interaction between varieties and seasons was significant only for standard germination, seed vigour index-I, electrical conductivity, test weight, field emergence and seedling establishment.

All these parameters studied about had significant correlation with standard germination and field emergence except dry weight of seedling, seed density, dehydroginase activity test and speed of germination. Correlation coefficient (r) values for field emergence were highest (0.98) when correlated with standard germination, seed vigour index-I and seed vigour index-II.

Thes reliable predictors of the field emergence were identified by the regression analysis. Standard germination, seed vigour index-II, seedling length, tetrazolium test and electrical conductivity test were found better predictor for field emergence. However, standard germination was found to be best indicator of field emergence. It may be concluded that for better quality of seed okra crop may be raised during rainy season. Field emergence can be predicted from standard germination, seed vigour index-II, seedling length, tetrazolium test and electrical conductivity.

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ABSTRACT

Title of Dissertation	:	**ASSESSMENT OF SEED QUALITY OF OKRA IN SUMMER AND RAINY SEASON (*Ablemoschus esculentus* (L) Moench.)**
Name of Degree Holder	:	**Chaudhary Surjeet**
Admission No.	:	2008A57M
Title of degree	:	Master of science
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Degree Awarding University	:	CCS Haryana Agricultural University, Hisar- 125004 (Haryana) India
Year of Award of Degree	:	2010
Major subject	:	Vegetable Science
Total No. of Pages in the Dissertation	:	36+vi
No. of words in the Abstract	:	245 Approx.

Key words: - okra, seed quality, viability, vigour and field emergence

Seed quality plays an important role in the crop establishment and overall performance of the crop. With an array of possible viability and vigour tests available, appropriate procedure to evaluate seed performance is a very difficult job but a necessity. Keeping this aspect in view present investigation was carried out to evaluate seed quality of three varieties of okra and comparative efficacy of seed viability and vigour test as predictor of field emergence.

Seeds of three varieties seeds obtained from summer and rainy season crop were subjected to various viability and vigour tests with four replications and observations were recorded on standard germination, dehydrogenace activity, tetrazolium test, seedling length, speed of germination, test weight, standard germination after accelerated ageing, seed density, seed vigour, seedling dry weight, field emergence and seedling establishment. Results revealed that, among varieties tested, Varsha Uphar was significantly superior to Hisar Naveen and BB-1 in all above quality parameters. The seeds obtained from rainy season were superior from the seeds obtained from summer season.

All the parameters were significantly correlated with field emergence (except dry weight of seedling, seed density and dehydrogenace activity). The electrical conductivity was significantly and negatively correlated with field emergence. Standard germination followed by vigour index-II showed highest reliability for prediction of field emergence. Correlation coefficient analysis and regression analysis revealed that viability and vigour parameters like standard germination, seed vigour, tetrazolium test, seedling length and electrical conductivity can be used as reliable predictor of field emergence in okra.

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

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