PERFORMANCE OF VARIOUS OKRA GENOTYPES FOR GROWTH, YIELD AND QUALITY ATTRIBUTES UNDER FOOTHILL CONDITION OF NAGALAND

Thesis

submitted to

NAGALAND UNIVERSITY

in partial fulfillment of requirements for the Degree

of

DOCTOR OF PHILOSOPHY

in

HORTICULTURE

by

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Nagaland

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TO MY PARENTS
For raising me to believe that anything was possible

AND TO MY HUSBAND
For making everything possible

DECLARATION

I, Nuksungla Walling hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis had not been submitted by me for any research degree in any other university/institute.

This is being submitted to Nagaland University for the degree of Doctor of Philosophy in Horticulture

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CERTIFICATE – I

This is to certify that the thesis entitled **“Effect of various okra genotypes for growth, yield and quality attributes under foothill condition of Nagaland”** submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy (Agriculture) in Horticulture is the record of research work carried out by Mr. /Ms. Nuksungla Walling Registration No. 558/2013 under my personal supervision and guidance.

The result of the investigation reported in the thesis have not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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CERTIFICATE – II

VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN HORTICULTURE

This is to certify that the thesis entitled “Effect of various okra genotypes for growth, yield and quality attributes under foothill condition of Nagaland” submitted by NUKSUNGLA WALLING Admission No. Ph-135/12 Registration No. 558/2013 to the NAGALAND UNIVERSITY in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Horticulture has been examined by the Advisory Board and External examiner on ………………............

The performance of the student has been found **Satisfactory/Unsatisfactory.**

Member	Signature
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(NUKSUNGLA WALLING)

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ABBREVIATIONS

At the rate of	@
Centimetre	cm
Critical difference	CD
Degree Celsius	^{O}C
Et alibi and others	*et al.*
East	E
Figure	Fig
Phenotypic coefficient of variation	PCV
Gram	g
Hectare	ha
Hours	hrs
id est (that is)	*i.e.*
Indian Institute of Vegetable Research	IIVR
Journal	J.
Kilogram	kg
Metre	m
Nitrogen	N
Non – Significant	NS
North	N
Number	No.

Per	/
Per cent	%
Phenotypic coefficient of variation	PCV
Phosphorus	P
Potassium	K
Relative humidity	RH
Species	spp.
South	South
Standard Error of Mean	S.Em±
Temperature	T.
Tonnes	T
Videlicet (namely)	*viz.*
Weight	wt.
West	W
Yellow Vein Mosaic Virus	YVMV

CHAPTER I

INTRODUCTION

INTRODUCTION

Vegetables are indispensable ingredient in the daily diets of humans as they offer numerous nutritional benefits. They are normally eaten fresh and in sauces and are used by the growing fast-food, hotel, and restaurant industry (Tyler *et al*., 1989). They are consumed almost daily and are traded by a broad range of market participants. There are a wide range of vegetables in the world including okra, garden eggs, radish, tomatoes, pepper and carrot (IBPGR, 1990; Gulsen *et al*., 2007). The world annual vegetable production, for processing alone, is estimated at 40 to 45 million tonness with total production reaching almost 700 million metric tons in 2001 (Ganry, 2009).

Okra (*Abelmoschus esculentus* L. Moench) is a member of the family Malvaceae. Okra is one of the world's oldest cultivated crops. The Egyptians made the first recorded reference to okra in 1216 A.D. The crop is native to Africa (Kochhar, 1986) and was also grown in Mediterranean region and its wild forms are found in India. The crop was taken to other parts of the world by the Portuguese (Sinnadurai, 1992). It is one of the most widely known and utilized species of the family Malvaceae (Bayer and Kubitzki, 2003; Naveed *et al*., 2009). Earlier, its botanical name was *Hibiscus esculentus* L. Moench under the section Abelmoschus of Hibiscus, established by Linnaeus in 1737. Okra is known by many local names in different parts of the world. For example, it is called lady's finger in England, gumbo in the United States of America and bhindi in India.

Okra is one of the most important fruit vegetables grown throughout the tropics and warm temperate zones. It is grown as a summer and rainy season crop in India (Baloch, 1994). It fails to grow on high hills and the areas which experience very low temperatures. It is extensively cultivated for its tender fruits in spring summer season for table purposes and for seed production in rainy seasons as kharif crop (Sharma and Prasad, 2015). It is robust, productive, fast growing, high yielding and seldom felled by pests and diseases. The okra plant shows considerable tolerance to drought and heat so, classified among the semi salt tolerant vegetable crop (Maas and Hoffman, 1977). It adapts to difficult conditions and can thrive where other food plants prove unreliable thus considered to as an eco-friendly crop. Okra is usually grown in any kind of soil but it thrives well in well-drained sandy and clay loam soils. It may be grown at elevations from sea level up to 300 meters. A well drained fertile soil with an adequate content of organic matter and reserves of the major elements are generally suitable for cultivation. Some cultivars are sensitive to excessive soil moisture. Others are slightly tolerant to salt. Optimum pH ranges from 6.6 to 8.0. According to the New England Vegetable Management Guide (New England Vegetable Management Guide, 2008-2009) recommendations for okra is to apply lime according to soil test to maintain a soil pH at 6.5 to 7.0 and in soils with high phosphorus levels and very high potassium levels, 145kg of N ha^{-1} and 56kg of P_2O_5 ha^{-1} should be applied to the soil. Most cultivars are adapted to high temperature throughout the growing period with little seasonal fluctuation. Seed will only geminate in relatively warm soils, no germination occurs below 16°C. The plant is best adapted to a climate with a long, warm growing season. The optimum temperatures are in the range of 20-30°C, with minimum temperatures of 18°C and maximum of 35°C. The crop grows well in hot weather, especially in the regions with warm nights (>20°C) (Ndunguru and Rajabu, 2004). Okra needs rather high quantity of water despite having considerable drought resistance. The plant forms a deeply penetrating tap root with dense shallow feeder roots reaching out in all directions in the upper 45 cm of soil. Soil clamminess is essential during the continuation of growing period (Benchasri, 2012).

It is now grown in all parts of the tropics and during the summer in the warmer parts of the temperate region (Baloch, 1994). It is a semi woody, fibrous herbaceous annual with an indeterminate growth habit. The plants form a deeply penetrating taproot with dense shallow feeder roots reaching out in all direction in the upper 45 cm of the soil. The seeds are dicotyledonous and kidney shaped with epigeal germination (Nonnecke, 1989). Okra is mainly a self pollinated crop however, insects such as honey bees and bumblebees do cross-pollination occasionally. The plant is cultivated throughout the tropical and warm temperate regions around the world for its fibrous fruits or "pods." The plant bears numerous dark green colored pods measuring about 5-15 cm in length. The fruits are a green capsule containing numerous white seeds when immature (Jesus *et al*., 2008) and the flowers and upright plants give okra an ornamental value (Duzyaman, 1997). The okra fruit can be classified based on the shape, angular or circular (Mota *et al*., 2005). It takes about 45-60 days to get ready-to-harvest fruits.

Okra is primarily a vegetable crop grown for its immature pods that can be consumed as a fried or boiled vegetable or may be added to salads, soups and stews (Crossley and Hilditch, 1951; Kashif *et al*., 2008).). The young immature green fruits and fresh leaves are primarily used as vegetables, consumed cooked or fried. Dried fruits of okra are ground into powder, stored and used in stews and soups (Siemonsma, 1982). Okra seeds are reportedly used as substitutes or additives in feed compounds (Purseglove, 1974), in the preparation of okra seed meal and a number of baked products (Martin and Roberts, 1990) and in blood plasma replacement (Vickery and Vickery, 1979). The cultivated okra is popular due to its nutritive and medicinal values and is said to be useful against fever, catarrhal attacks, genito-urinary disorders, spermatorrhoea, gonorrhea, leucorrhoea and chronic dysentery (Nadkarni, 1927). Okra plays an important role in the human diet by supplying fats, proteins, carbohydrates, minerals and vitamins. The okra provides an important source of vitamins and minerals (Norman, 1992; Lamont, 1999). Hamon and Charrier (1997) have also reported significant levels of carbohydrate, potassium and magnesium. The seeds of okra are reported to contain between 15% and 26% protein and over 14% edible oil content (NARP, 1993). Okra fruit is a good source of vitamin A, B and C. The content of calcium in its fruits is very high (66 mg/100g of edible portion) compared to that in other fruit vegetables. It is an excellent source of iodine. It is also rich in protein and mineral nutrients. When cooked, okra pod contains approximately 86.1% water, 2.2% protein, 0.25 fats, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Knot and Deanon, 1987, Purseglove, 1992). It is considered as a rich source of dietary fibre. Nearly half of the okra pod is soluble fibre in the form of gums and pectin, which helps in lowering serum cholesterol (Jenkins *et al.*, 2005) and thus reducing the risk of coronary heart disease (Jeff, 2002). The other half is insoluble fibre, which helps to keep the intestinal tract healthy (Jeff, 2002) and prevents the symptoms of irritable bowel syndrome. Okra is reported to have good alkaline pH which contributes to its relieving effect in gastrointestinal ulcer by neutralizing digestive acid (Wamanda, 2007). Mucilage from Okra have been reported to be effective as blood volume expander and has the potential to alleviate renal disease, reduce proteinuria and improve renal function (Siemonsma and Kouame, 2004). The mucilaginous extract of okra is often used to clarify sugarcane juice from which jaggary or brown sugar is manufactured (Prasad and Nath, 2002). The stem of the plant provides non-digestible strong linear fibre, which finds uses in the paper, packaging and textile industries (Baloch, 1994). It is one of the green vegetables with highest levels of anti-oxidants (beta carotenes, xanthin and lutein). The seeds from fully mature and ripened okra pods are sometimes used for chicken feed. These have been used on a small scale for the production of oil (Oyelade *et al*., 2003). Its ripe black or brown white-eyed seeds are sometimes roasted, ground and used as a substitute for coffee in Turkey (Mehta, 1959). Moreover, its mucilage is suitable for certain medical and industrial applications. Therefore, young fruits of okra have reawakened beneficial interest in bringing this crop into commercial production.

Among fruit vegetables, okra fruits have good demand throughout the year. The world okra production, as of 2014, was estimated at 9.62 million tonnes with India leading the production by 66.3% followed by Nigeria (21.2%), Sudan (2.91%) and Ivory Coast (1.45%). India is the largest producer of okra in the world. It occupies fifth position, next to tomato in terms of production in India. India ranks first in okra production which contributes 67% of the total world production (Indian Horticulture database, 2017). West Bengal occupies the maximum area under okra (77400 ha) followed by Gujarat (73790 ha) and Odisha (63960 ha). Maximum okra production was in West Bengal (913320 t) followed by Gujarat (73790 t) and Bihar (770630 t). The productivity of okra was highest in Andhra Pradesh (17.45 t/ha) followed by Jammu & Kashmir (17.08 t/ha) and Assam (15.82 t/ha). In North East India, Assam occupies the first position both in terms of area (12110 ha) and production (191700 t) followed by Mizoram, area (3630 ha) and production (25020). In Nagaland, the total area under okra is 210 ha with a production of 1670 t with a productivity of 7.95 t/ha (Horticulture Statistics at a Glance, 2017). About 10 - 15 t ha^{-1} of yield can be obtained under good management (NARP, 1993). However, the productivity (11.60 t ha^{-1}) is much less than the potential productivity. Several reasons for low productivity include use of local unimproved cultivars, less adoption of existing commercial varieties/hybrids, and heavy incidence of biotic stresses particularly yellow vein mosaic disease. Therefore, much concentrated efforts are necessary to improve its yield and yield components. Hence, evaluation of the potentialities of the existing cultivars is essential because it depicts the genetic diversity of the base materials on which depends the promise for further improvement. The success of a breeding programme for the improvement of quantitative attributes depends to a great extent on the magnitude of genetic variability existing in the germplasm. Burton (1952) suggested that genetic variability along with heritability should be considered for assessing the maximum and accurate effect of selection. Studies on the variability using genetic parameters like genotypic coefficient of variation (GCV), heritability and genetic advance is essential for initiating an efficient breeding programme. High yield can be achieved by selection of those characters that have high heritability values coupled with high genetic advance. Selection is an indispensable component of the variety development process. Breeders search for dependable parameters that are less affected by the environment. Again, selection of the trait invariably affects a number of associated traits, which evokes the necessity in finding out the interrelationship of various yield components both among themselves and with yield. Therefore, knowledge of correlation and causation among yield and yield components is of paramount importance in okra breeding programme.

Crop improvement through successful selection programme is only achieved using valid information about the correlation and genetic variability of traits of interest knowing full well that improvement in any crop is dependent on the amount of genetic variability in the population. Duzyaman and Vural (2002) reported that, phenotypically varied genotypes most probably of diverse source are often regarded as more effective in obtaining capable crosses. Therefore the aim of this study is to evaluate the nature of genetic variability, heritability and characteristics association of some quantitative traits in a cultivated variety of okra for possible improvement in quality of yield and yield components so as to enhance productivity and subsequently improve income generation to the local producers. This study would afford us the opportunity to assess qualitative and quantitative variations among collections of the okra genotypes through morphological evaluation and thus exploit such variations in breeding programmes to develop improved, high yielding varieties. Core collections identified would be exploited for their improvement and consequently provide the foundation on which to enhance their use.

Sustainability with consistent performance of any crop under predictable and unpredictable environment is of main concern while screening the phenotypically stable genotypes. The attempts are generally made to judge the observed variability for their extent of heritability, the transmissibility of character in future generation. To improve particular attribute including yield characteristics information on genetic variability and inter-relationship among different traits are necessary, as improvement is proportional to its magnitude of genetic variability present in the germplasm. Genetic diversity is one of the important tools to qualify genetic variability in both self and cross pollinated crops (Murty and Arunachalam 1966; Gaur *et al.* 1978). This permits the selection of genetically divergent parent to obtain desirable recombinants in the segregating generations. Considerable effort is currently being made to improve various yield attributes such as the number of fruits per plant, fruit length and fruit diameter. The weights of the fruit and the number of fruits per plant have been consistently identified as very important components of fruit yield. Correlation between yield and its contributing attributes are essential to find out the guidelines for the selection of genotype. Therefore, the present study was undertaken to analyze the study genetic variability and correlation among component traits in genetic divergence in twenty eight (28) okra genotypes for making effective selection in improvement of this important crop.

Okra occupies a prominent position among vegetables due to its wide adaptability, year round cultivation and export potential. However, the crop has no proper imprint in the production scenario in the North Eastern region of India in general and Nagaland in particular. Nagaland, like any other North Eastern states is bestowed with the agro-climatic conditions which is suitable for cultivation of all types of vegetable grown in the region. Lack of proper knowledge about the cultivars best suited to the agro-climatic condition, the potential of okra as fresh vegetable is not fully exploited and is still insufficient even to meet the domestic needs of the people. Hence, there is a logistic need for evaluation of commercial and newly developed varieties under hill conditions to increase the productivity of the crop so that the growers can get remunerative price from such potential vegetable crop.

Before the recommendation of any okra cultivar to be grown in the region, it is pertinent to evaluate the available okra cultivars giving emphasis on the aspects of genotypic suitability and yield. Varietal performance of okra varies from place to place due to the varied agro climatic and physiographic conditions and thus the growth and yield of a variety does not remain same for all the regions. Considering the aforementioned facts, a pertinent need was felt to undertake an experiment on evaluation of okra cultivars so as to ascertain and recommend the cultivar best suited for the agro climatic condition of the foothills of Nagaland and therefore the present investigation was undertaken with the following objectives.

1. To study the growth and yield attributes of okra genotypes.
2. To study the quality attributes of okra genotypes.
3. To study the incidence of pest and diseases on various okra genotypes.
4. To determine the genetic variability of the genotypes.
5. To screen out the best okra genotype under existing agro-climatic condition.

CHAPTER II

REVIEW

OF

LITERATURE

REVIEW OF LITERATURE

2.1 Growth attributes

Nandi (1990) reported that in a field trial of seven (7) okra (*Abelmoschus esculentus*) varieties conducted at G. Udayagiri during kharif 1985, the earliest maturing variety was AE180 and Pusa Sawani was the tallest with 150.50 cm. Similarly, in field trials conducted by Damarany and Farag (1994) for thirteen (13) cultivars of okra, Blondy was the earliest flowering cultivar with 46.90 and 44.20 days respectively.

Diaz-Franco *et al.* (1998) compared fruit color of four okra hybrids (*Abelmoschus esculentus*) with the same characteristics of ‘Clemson Spineless 80’ variety under early and late seasons. Cultivars ‘Green Best’, ‘Cajun Delight’ and North & South’ produced most very dark-green and dark-green fruits; whereas ‘Clemson Spineless 80’ and “Annie Oakley II’ produced mostly light green fruits.

Sood (1999) carried out a study on forty-eight diverse okra genotypes and found that IC-45791 was the earliest to flower among the genotypes. IC-14026 and IC-45796 had the highest duration of availability of edible pods with 66 days.

Amjad *et al.* (2001) evaluated four exotic okra cultivars, *viz.* Pusa Sawani, Parbhani Kranti, Hybrid Bhindi Sakshi and Krishma 51 for their performance against a local cultivar Sabz Pari and reported that plant height at flowering was not affected significantly among the cultivars. Khan *et al.* (2002) also evaluated five different cultivars of okra *viz.* Penta Green, Pusa Sawani, Local Cultivar, Pusa

Green and Clemson for their performance under the agro-climatic conditions of Dera Ismail Khan. Minimum number of days to flowering with 36.33 days was obtained from the Pusa Green cultivar and days taken to germination remained non-significant for different okra cultivars.

Düzyaman and Vural (2003) examined numerous okra genotypes of American, African, Indian, European and Turkish origin for their pod properties and nutritive contents. Pod thickness was considerably high in the genetic material from Africa with up to 2.84 cm in diameter in the case of line 1051 from Togo. However, pods of the improved cultivars from the USA and India had a more attractive appearance with diameters varying between 1.15 - 1.50 cm. Similarly, Tewari and Singh (2003) conducted a study to identify and select the promising elite okra hybrids (among F1 hybrids NOH-24, VLC-1, NOH-101, DVR-3, DVR-4, MBORH-913, AROH-21, SPHB-316, Versha, Vijaya, SOH-54, HOE-202, AROH-9, AROH-10, KOH-5 and HOE-301).The number of days taken to first flower varied from 30.90 in MBORH-913 to 36.10 in HOE-301. Plant height was highest in SPHB-316 with 189.7 cm. The number of leaves per plant was highest in SPHB-316 with 26.60 leaves.

Patil *et al*. (2005) carried out a study with seven (7) new promising genotypes (GK-II-4-1-2, GK-IV-1-2-14, GK-IV-1-3-2, GK-IV-2-4-13, GK-IV-3-3-3, GK-IV-3-4-4 and GK-IV-4-3-7) and 3 open-pollinated cultivars *i.e.* Arka Anamika, Parbhani Kranti and Varsha Uphar as the controls. The highest plant height of 161.45 cm was recorded in GK-IV-3-3-3. Similarly, Chaudhary *et al*. (2006) conducted an experiment where five okra hybrids were grown with the okra variety Antara as a check. The results indicated that the growth parameters differed within different hybrids and check variety. The vegetative characters *viz.* plant height and internodal length showed positive effect on yield of okra.

Hussain *et al.* (2006) also conducted an experiment with five cultivars of okra *i.e.* Malav-27, Sabz Pari, Super Green, Pusa Sawani and Punjab Selection in order to study the response of okra cultivars to different sowing times. Maximum plant height of 1.48 m was recorded in cultivar Malav-27 whereas the minimum days to emergence were observed in cultivar Malav-27 with 10.89 days and minimum days to first picking was recorded in cultivar Punjab Selection with 75.56 days. In another experiment, Sachan (2006) conducted field studies to screen six okra cultivars (Pusa Sawaney, Saatdhari, Punjab-7, K-21, Parbhani Kranti and Arka Anamika) for their yield performance. Arka Anamika recorded the highest plant height with 90.62 cm and Parbhani Kranti recorded the second highest plant height 89.79 cm and the highest first fruit height from the bottom at 24.00 cm. Based on the overall performance in growth, pod yield, quality and disease resistance, Saatdhari proved to be the most promising cultivar with minimum disease incidence under mid-agro climatic conditions of Sikkim respectively. Similarly, among twenty-five genotypes of okra evaluated by Sarkar *et al*. (2006), Bankim Selection-2, Sungrow Selection, Nandini and Selection-5 showed earliness in flowering.

Katung (2007) had undertaken a study to compare the performance of okra during the wet and the dry seasons of Northern Nigeria. Two okra varieties ('White velvet' and 'Ex-Borno') were evaluated in order to determine their productivity. The variables measured at the reproductive stage were plant height, number of leaves/plant, leaf area and days to first flower. Significant differences were observed for all variables among seasons and among varieties. The wet season conditions were most favourable for increased growth and leaf formation, as compared with the dry season environment which resulted in less vegetative growth. The interaction of season x variety was highly significant for plant height and significant for leaf area.

Phad *et al*. (2008) studied the performance of hybrids of okra along with two checks *i.e.* Parbhani Kranti and Pusa Swani. The higher yield performance of the hybrids was to a greater extent due to more number of leaves and more number of branches per plant and to a lesser extent due to plant height. On the other hand, Singh *et al*. (2008) evaluated thirty four genotypes of okra for various phenotypic characters including yield under the agro-climatic conditions of Varanasi. The genotypes *viz.* MOS-04-13, VRO-5, MOS-04-07, MOS-04-01 and MOS-04-02 were earlier in fruit setting, the first flower appeared on 5.66, 4.35, 3.82, 4.29 and 4.25 nodes.

An experiment was undertaken by Maity and Tripathy (2009) to evaluate the F_1 hybrids of okra under reduced level of chemical fertilizers. The results indicated significant differences among the hybrids for vegetative growth characters such as plant height, number of primary branches/plant and nodes/plant; reproductive behaviour of the plant *i.e.* days to 50% flowering. Based on the results it may be concluded that under the agro climatic conditions of West Bengal, the hybrids NOH-15, Makhamalli, Sun 40, Sun 08, Mahyco Bhendi No.12, Mahyco Bhendi No.10, Mahyco Bhendi No.1 as well as Vijaya (99.36 – 107.43 q/ha) can be recommended for commercial cultivation under reduced level of chemical fertilizers during summer.

Okonmah (2011) in this experiment investigated effects of different levels of pig manure on growth and yield of three cultivars of okra (Anwai local, V-35 and TAE-38) in Asaba soil. Data for height (cm), stem girth (cm), number of leaves and total leaf area (cm2) were collected at intervals of 4, 6, 8, 10 and 12 weeks after planting. Among the cultivars, TAE-38 performed better than the other cultivars according to the evaluation from the growth indices. Whereas Rahman *et al* (2012) conducted an experiment to evaluate the performance of five different varieties of okra *viz.* Arka Anamika, Puja, Anmol, Sabz-Pari and Sharmeeli under the agro-climatic conditions of Dera Ismail Khan. The result showed minimum days to flowering, days to fruit setting and maximum plant height was found in Arka Anamika cultivar. Thus, Arka Anamika is recommended for its cultivation under the agro-climatic conditions of Dera Ismail Khan.

Oppong-Sekyerre *et al*. (2012) collected twenty-five accessions of okra from different parts of Ghana to evaluate their horticultural characteristics and performance. The accessions KNUST/SL1/07Nkrumahene, DA/08/02Dikaba and GH 5787 Asontem, GH6102 Fetri and 'Asontem' showed number of days from sowing to first-flowering at between 44.00 and 48.00 days, first flowering and fruiting nodes at between 5.00 and 6.00th nodes and green immature fruit colour. Rahman (2012) also conducted an experiment to evaluate the performance of five different varieties of Okra viz. Arka Anamika, Puja, Anmol, Sabz-Pari and Sharmeeli under the agro-climatic conditions of Dera Ismail Khan. The result showed minimum days to flowering, days to fruit setting and maximum plant height was found in Arka Anamika cultivar. Whereas Singh and Jain (2012) carried out a field experiment on fourteen okra hybrid. The plant height was highest in SOHO-2 and more number of branches/plant was recorded in SOHO-2.

Alake *et al.* (2013) conducted an experiment with twenty-five genotypes grown over a period of 4 years in two agroecosystems. The plant characters days to flowering, final plant height, pod filling period and days to harvest were measured. Pod filling period was a stable character across agroecosystems. Though pluvial planted West African okra produced taller plants, fluxial planted okra flowered and matured earlier.

Armand *et al.* (2013) reported that the Local 1 and Local 2 (P) varieties respectively distinguished themselves by the high viscosity of their fruits; the Local 5 and Red of Thiès varieties had more nodes; the Clemson and Indiana varieties distinguished themselves by their precocity or early fruiting. It is therefore evident from this study that there exists among the local varieties, those having interesting characteristics that could be used for varietal improvement of okra. These results would permit breeders to put in place varieties which in addition to being productive and precocious also have satisfactory organoleptic properties like viscosity of the fruits. Dash *et al.* (2013) also conducted a field experiment to study the effect of three varieties of okra (BARI Dherosh-1, Arka Anamica and Annie Oakley) and planting date on the growth and yield of okra. Annie Oakley variety showed enhanced plant growth to other varieties cultivated. Another experiment was conducted by Naheed *et al.* (2013) with five different Okra cultivars *i.e*, Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani and they were evaluated for their comparative performance. Maximum plant height with 116.4cm was recorded in Sarhad Green and minimum height 112.3cm was recorded in cultivar Green Star. Days to flowering remained non-significant for the okra cultivars.

Chinatu *et al.* (2014) evaluated seven improved and two local varieties of okra (*A.caillei* A. Chev) and results showed that varieties which performed better vegetatively had more assimilates/photosynthates which led to higher reproductive characters performance. Futuless *et al.* (2014) also evaluated the performance of three Okra varieties *viz*. V1 (Improved), V2 (Serial) and V3 (Local). The parameters measured includes: vegetative parameters (plant height cm and number of branches per plant) and days to 50% flowering. Significant ($p<0.05$) differences were observed for all the parameters measured.

Salau and Makinde (2015) conducted field experiments in the tropical rainforest zone of Nigeria to investigate the effects of planting density on growth and fruiting duration of okra cvs. NHae 47-4, LD 88, and Jokoso. Cultivar NHae 47-4 had the highest LAI, fewest days to 50% flowering and first fruiting and longer harvest duration than ‘LD 88’ and ‘Jokoso’.

2.2 Yield attributes

Data on trials by Lan Chow Wing and Owadally (1980) with six (6) cultivars showed Perkins' Spineless to be the highest yielding producing 22.06 t/ha in one trial and 19.94 t/ha in another. Clemson's Spineless was the next best with 19.92 t/ha. Nandi (1990) also reported that in a field trial of 7 okra (*Abelmoschusesculentus*) varieties conducted at G. Udayagiri during kharif 1985, Bhubaneswar 1 gave the highest yield with 15.50 t/ha and 282.70 g/plant and individual fresh pod weight of 20.33 g. The number of pods/plant was 13.90 and Pusa Sawani had the highest pod number/plant with 18.80.

Matthew *et al*. (1993) selected six resistant/tolerant okra varieties from various regions of India and were compared with Pusa Sawani. AROH1 had the highest mean yield with 7.83 kg followed by Arka Anamika and Sel4. Similarly, Sharma *et al*. (1993) reported that Punjab Padmini and Punjab-7 were high yielding cultivars. Singh *et al.* (1993) also recorded data for eight (8) cultivars and mean yield over the two years was highest for Prabhani Kranti with 9.1 t/ha followed by Punjab 7 and Punjab Padmini with 9 and 8.8 t/ha respectively.

In field trials conducted by Damarany and Farag (1994) for thirteen (13) cultivars of okra, Blondy produced the most pods per plant and the greatest total yield of pods. According to the data tabulated by Dhar (1995) in 7 okra varieties, Pusa Sawani produced the greatest number of fruits/plant with 10.50 fruits/plant and had the highest pooled yield with 27.8 t/ha.

Diaz-Franco *et al.* (1998) compared length, weight, diameter and marketable yield of four okra hybrids (*Abelmoschus esculentus*) with the same characteristics of ‘Clemson Spineless 80’ variety under early and late seasons. It was noticed an increase on weight and number of very small fruits during the late season, and “Clemson Spineless 80’ registered the highest very small fruit yield. The highest production of medium size fruits was recorded during the early season, and ‘Annie Oakley II’ had better fruit yields. The smallest fruit diameter was observed in “North & South’. The best fruit length and weight was produced in the early season. Similar marketable fruit yield was found in both season, however, a total of 27 harvests were needed in the early season, and 42 harvests in the late season.

Sannigrahi and Choudhury (1998) evaluated 7 okra cultivars (Arka Abhay, Arka Anamika, BO1, BO2, Parbhani Kranti, Punjab 7 and Pusa Sawani) for growth and yield characteristics. Arka Anamika and Arka Abhay were the most suitable for commercial cultivation in Assam compared with Pusa Sawani. On the other hand, Jan (1999) evaluated five okra cultivars (Parbhani Kranti, MI-5, Sel-2, Arka Animaka and Arka Abhay) where MI-5 and Arka Abhay showed very poor performance due to low numbers of tillers and pods/plant, low pod size and low pod weight, leading to reduced yields.

Shepherd and Winston (1999) evaluated the performance of different okra hybrids (Varsha, Vijaya and Adhunik), including an open-pollinated local cultivar (Prabhani Kranti) as control, to select okra hybrids suitable for cultivation. Adhunik was the most suitable hybrid for the cultivation in Allahabad region during the kharif season. Prabhani Kranti showed a better performance than Varsha and Vijaya. Whereas, Sood (1999) carried out a study on forty-eight diverse okra genotypes and yield was highest in genotypes IC-39135, IC-9856 and Punjab Padmini. IC-39135 also had the highest number of nodes per plant. LC-12 had the highest fruit weight.

Amjad *et al.* (2001) evaluated four exotic okra cultivars, *viz.* Pusa Sawani, Parbhani Kranti, Hybrid Bhindi Sakshi and Krishma 51 for their performance against a local cultivar Sabz Pari. Plant height at flowering was not affected significantly among the cultivars. Green pod length was the maximum in Hybrid Bhindi Sakshi followed by Sabz Pari and both were statistically at par. Sabz Pari ousted all the exotic cultivars for average weight per green pod, green pod yields per plant and per hectare. Regarding seed production, the highest number of seeds per pod, 1000-seed weight and seed yields per plant and per hectare were also recorded in Sabz Pari.

Khan *et al.* (2002) evaluated five different cultivars of okra *viz.* Penta Green, Pusa Sawani, Local Cultivar, Pusa Green and Clemson for their performance under the agro-climatic conditions of Dera Ismail Khan. Maximum pods per plant, highest pods weight per plant and in return the maximum yield of the pods was obtained from the Pusa Green cultivar. Different parameters like pod size and number of pods per plant remained non-significant for different okra cultivars.

Olczyk *et al.* (2002) reported that there is a need for comparison of the open pollinated standard variety 'Clemson Spineless' with newer, hybrid varieties. Average season marketable yields were significantly higher for the hybrids than the OP variety. Yield differences among the hybrids were not significant. Crop value was also significantly higher for the hybrids and for the OP variety. These results suggested that earliness, total yield, and crop value of okra in Miami Dade County may be increased by use of hybrid varieties.

Debnath and Nath (2003) conducted a field experiment in Kalyani, West Bengal, to select the suitable okra cultivars (Parbhani Kranti, Seven Dhari Green, D-1-87-5, Arka Abhay, P-7, Lorm-1, VRO-3, VRO-4, AM-4-5, JNDO-5, KS-410, VRO-5 and VRO-6) in relation to yield. Arka Abhoy showed the highest mean fruit yield (5190 kg/ha) followed by Parbhani Kranti (5045 kg/ha), whereas AM-4-5 showed the lowest mean yield (185 kg/ha).

Düzyaman and Vural (2003) examined numerous okra genotypes of American, African, Indian, European and Turkish origin for their pod properties and nutritive contents. Pod thickness was considerably high in the genetic material from Africa with up to 2.84 cm in diameter in the case of line 1051 from Togo. However, pods of the improved cultivars from the USA and India had a more attractive appearance with diameters varying between 1.15 - 1.50 cm. Singh *et al*. (2003) also reported that among 5 okra hybrids (DVR-1, DVR-2, Shree, HIHBO 83 and HIHBO 90), DVR-2 recorded the longest pods and highest number of pods, plant height, stem diameter, dry weight of shoots, and fresh and dry weight of roots per plant, whereas DVR-1 recorded the highest pod weight per plant and total pod yield/ha. Similarly, Tewari and Singh (2003) conducted a study to identify and select the promising elite okra hybrids (among F1 hybrids NOH-24, VLC-1, NOH-101, DVR-3, DVR-4, MBORH-913, AROH-21, SPHB-316, Versha, Vijaya, SOH-54, HOE-202, AROH-9, AROH-10, KOH-5 and HOE-301). The number of edible pods per plant was highest in SPHB-316 (34.7). The highest average pod yield was observed in AROH-10 with 184.5 q/ha and DVR-3 with 183.6 q/ha, recording as much as 63% higher yield over the control with 113.3 q/ha. Based on the overall performance of all hybrids, SPHB-316, AROH-10 and DVR-3 are recommended to the farmers for commercial cultivation in the Tarai region of Uttaranchal.

Makhadmeh and Ereifej (2004) studied the pods of a landrace and seven foreign genotypes of okra (*Hibiscus esculentus* L.). The average fruit mass of different genotypes showed a trend similar to that found in fruit volume; Vigorpak had the highest fruit mass and volume, whereas Mosel had the lowest. Number of pods per plant showed very wide range for all genotypes, which ranged between 17 and 31. Patil *et al*. (2005) also carried out a study with 7 new promising genotypes (GK-II-4-1-2, GK-IV-1-2-14, GK-IV-1-3-2, GK-IV-2-4-13, GK-IV-3-3-3, GK-IV-3-4-4 and GK-IV-4-3-7) and 3 open-pollinated cultivars, i.e. Arka Anamika, Parbhani Kranti and Varsha Uphar as the controls. The highest number of fruits per plant, average fruit weight and maximum fruit length was recorded in GK-IV-3-3-3 . GK-IV-3-3-3 recorded the minimum fruit breadth. This genotype recorded a total yield of 175.21 q/ha, which was superior to the other genotypes and the controls.

Chaudhary *et al*. (2006) conducted an experiment where five okra hybrids were grown with the okra variety Antara as a check. The number of pods plant^{-1} and weight of pods plant^{-1} significantly increased the yield of okra hybrids. All hybrids except Tulsi recorded significantly higher pod yield as compared to check Antara. Hussain *et al.* (2006) also conducted an experiment with five cultivars of Okra i.e. Malav-27, Sabz Pari, Super Green, Pusa Sawani and Punjab Selection in order to study the response of okra cultivars to different sowing times. Maximum number of picking, number of pods per plant, fruit diameter and yield per hectare was recorded in cultivar Malav-27.

In another experiment, Sachan (2006) conducted field studies to screen six okra cultivars (Pusa Sawaney, Saatdhari, Punjab-7, K-21, Parbhani Kranti and Arka Anamika) for their yield performance. Arka Anamika recorded the highest number of pods per plant. Parbhani Kranti recorded the second highest number of nodes per plant and number of pods per plant. Saatdhari recorded the highest pod weight and green pod yield. Based on the overall performance in growth, pod yield, quality and disease resistance, Saatdhari proved to be the most promising cultivar obtaining the maximum green pod yield per hectare. Similarly, Sarkar *et al*. (2006) evaluated twenty-five genotypes of okra and the highest yield was recorded for Sagun. The cultivars with high yield potential were Arka Anamika, HR-Selecion, Sungrow Selection and Varsa Uphar. Also, Singh *et al*. (2006) evaluated the performance of 3 improved open-pollinated cultivars of okra, namely Kashi Vibhuti (VRO-5), Kashi Pragati (VRO-6) and Kashi Satdhari (IIVR-10), along with 2 hybrids, namely Kashi Bhairav (DVR-3) and Kashi Mahima (DVR-4) in frontline demonstration trials in districts of eastern Uttar Pradesh and compared with some existing cultivars, such as Parbhani Kranti and Pusa Sawani. All the improved cultivars/hybrids had higher yield than the existing cultivars in all the districts. Kashi Bhairav recorded the highest average yield of 211.00 q/ha in Mirzapur.

Katung (2007) had undertaken a study to compare the performance of okra during the wet and the dry seasons of northern Nigeria. Two okra varieties (‘White velvet’ and ‘Ex-Borno’) were evaluated in order to determine their productivity. The variables measured at the reproductive stage were fruit weight/plant and fruit yield (t/ha). Significant differences were observed for all variables among seasons and among varieties. The wet season conditions were most favourable for increased fruit yield, as compared with the dry season environment which resulted in less reproductive growth. The interaction of season x variety was highly significant for fruit weight/plant, fruit yield and significant for number of fruits/plant. The variety ‘White velvet’ produced more fruits than ‘Ex-Borno’.

Phad *et al*. (2008) studied the performance of hybrids of okra along with two checks i.e. Parbhani Kranti and Pusa Swani. The highest yield of 166.83 q/ha was obtained from hybrid NBH-225. The higher yield was to a greater extent due to more number of fruits, more number of leaves and more number of branches per plant and to a lesser extent due to plant height and weight of fruit. On the other hand, Singh *et al*. (2008) evaluated thirty four genotypes of okra for various phenotypic characters including yield under the agro-climatic conditions of Varanasi. The lines MOS-04-11, MOS-04-03, MOS-04-06 and MOS-04-07 have the potential to be considered as high yielding genotypes and out of them MOS-04-11 and MOS-04-03 were outstanding. The genotype MOS-04-11 yielded more than 170 q/ha and ranked top which was due to optimum number of fruits and maximum average fruit weight. Tripathy and Maity (2008) conducted another experiment to evaluate the F1 hybrids of okra showed that under the agro climatic conditions of West Bengal, the hybrids NOH-15, Makhamalli, Sun 40, Sun 08, Mahyco Bhendi No. 12, Mahyco Bhendi No. 10, Mahyco Bhendi No. 1 as well as Vijaya (99.36-107.43 q/ha) can be recommended for commercial cultivation under reduced level of chemical fertilizers during Kharif.

A field experiment was conducted by Dilruba *et al*.(2009) showed that combined effect of 06 April sowing with Ripen-15 produced the highest yield with 15.98 t ha while 22 March sowing with no hormone gave the lowest yield with 9.10 t ha. Therefore, 06 April sowing with Ripen-15 is best for better growth and yield of okra. An experiment was also undertaken by Maity and Tripathy (2009) to evaluate the F1 hybrids of okra under reduced level of chemical fertilizers. The results indicated significant differences among the hybrids for fruit characters like fruit length, girth, weight, fruits/plant and marketable fruit yield. Based on the results it may be concluded that under the agro climatic conditions of West Bengal, the hybrids NOH-15, Makhamalli, Sun 40, Sun 08, Mahyco Bhendi No.12, Mahyco Bhendi No.10, Mahyco Bhendi No.1 as well as Vijaya can be recommended for commercial cultivation under reduced level of chemical fertilizers during summer. Similarly, Temkar *et al*. (2009) evaluated twenty-three hybrids and cultivars of okra for yield performance which showed that Mahyco-7, Varsha and Lushi among hybrids and AROH-10, AROH-9, DVR-2 and Parbhani Kranti among cultivars were high yielding.

On the other hand, evaluation of improved okra varieties in Bayelsa state was carried out by Wariboko and Ogidi (2010) at two locations to evaluate the performance and adaptability of improved okra varieties (Early Gem, LD 88, Arka Pawpaw, Ola 99/12, Ola 99/LB and Kenta Local) which showed that Arka Pawpaw and Kenta had higher fruit yields of 8.91 and 8.17 t ha^{-1} respectively, than others.

Jamala *et al* (2011) evaluated the performance of three okra *Abelmoschus esculentus* L. Moench varieties under irrigation on the floodplain soils of Mubi, north eastern Nigeria. V1 (improved) recorded the highest fresh fruit yield of 10.7 tons/ha as compared to V3 (local) that recorded the lowest fresh fruit yield of 4.9 tons/ha. It was observed that V1 (improved okra) responded well at this floodplain and performed better in terms of yield output in this region. In another experiment, Okonmah (2011) investigated effects of different levels of pig manure on growth and yield of three cultivars of okra (Anwai local, V-35 and TAE-38) in Asaba soil. Results from across the cultivars showed that TAE-38 differed significantly for results from number of pods and fresh pod weight. From cultivar TAE-38 the highest amounts for number of pod and fresh pod weight were recorded. The experiment demonstrated that TAE-38 had comparably higher yield and better performance than the other cultivars tested in Asaba soil and was found to be the most highly recommended cultivar to benefit from an application of pig manure at a level of 15t/ha. The experiment demonstrated that this combination gave a better result than that of the other levels and can therefore be adopted for cultivation in the agro-ecological zone of the study area.

Field experiments were conducted by Ojo *et al.* (2012) during the dry seasons of 2010 and 2011 with the objective of evaluating the performance of okra cultivars in the Southern Guinea Savanna ecology of Nigeria. Five cultivars of okra (Guntu, Dogo and Ex-Ajia NH47 – 4 and LD 88) constituted the treatments. The highest values for pod length, pod diameter, number of pods/plant and 100 – seed weight observed for Ex – Ajia, NH47 – 4 and Dogo is an indication that these three varieties have the potential for good performance in the dry season and should be selected for dry season production in the southern guinea savanna ecology of Nigeria. On the other hand, Oppong-Sekyerre *et al*. (2012) collected twenty-five accessions of okra from different parts of Ghana to evaluate their horticultural characteristics and performance. The accessions KNUST/SL1/07Nkrumahene, DA/08/02Dikaba and GH 5787 Asontem, GH6102 Fetri and 'Asontem' showed the average number to total fruits per plant at 60.00 to 145.00 fruits.

Rahman *et al* (2012) conducted an experiment to evaluate the performance of five different varieties of Okra viz. Arka Anamika, Puja, Anmol, Sabz-Pari and Sharmeeli under the agro-climatic conditions of Dera Ismail Khan. The result showed maximum pods per plant, pod weight per plant, yield per plot and the total yield was found in Arka Anamika cultivar. Whereas, maximum average weight of a single pod (10.13 g) and pod length (9.70 cm) was recorded in cv. Sabz-pari. Thus, Arka Anamika is recommended for its cultivation under the agro-climatic conditions of Dera Ismail Khan. Singh and Jain (2012) also carried out a field experiments on fourteen okra hybrid. The longest pods were harvested from

RHROH-1 (16.8 cm), thick pods were recorded in HIHBO-90 (5.87 cm), and thin pods in Vijaya (4.35) cm. The hybrid cultivars viz. DVR-2, SOH-5 and HIHBO-83 were topper in fruit yield.

The results obtained from a study conducted by Armand *et al.* (2013) show that: the Local 5 and Red of Thiès varieties had more fruits. It is therefore evident from this study that there exists among the local varieties, those having interesting characteristics that could be used for varietal improvement of okra. Dash *et al.* (2013) also conducted a field experiment to study the effect of three varieties of okra (BARI Dherosh-1, Arka Anamica and Annie Oakley) and planting date on the growth and yield of okra. Significantly higher yield was obtained from Annie Oakley variety when shown on 15 February. Higher pod yield with 15 February sowing was mainly due to increased number of pods/plant, pod size and pod weight. Annie Oakley variety resulted in greater pod weight to other varieties cultivated.

An experiment was conducted by Naheed *et al.* (2013) with the objectives to screen out the high yielding cultivar of Okra. Five different Okra cultivars *i.e.* Sabz Pari, Sarhad Green, Green Star, Pusa Green and Pusa Sawani were evaluated for their comparative performance. Maximum pod diameter was recorded in Pusa Green and minimum pod diameter was recorded in Green Star. Maximum numbers of seed per pod were found in Green Star whereas minimum numbers of seed per pod were found in cultivar Pusa Sawani. Yield among different Okra cultivars were non-significant but highest yield was recorded in cultivar Sarhad Green. Different parameters *viz.* length of green pod, green pod yield per treatment and yield per hectare remained non-significant for the Okra cultivars.

Chinatu *et al.* (2014) evaluated seven improved and two local varieties of okra (*A.caillei* A.Chev) for yield and other agronomic traits. The ANOVA showed number of flowers, number of pods, pod length, weight of pods, 100 seed weight and fresh pod yield differed significantly in each year. In 2009, NGAE-96-012-1 and NGAE-96- 0067 had fresh pod yield of 7123.79 and 6382.84kg/ha, while in 2010 yield was 7052.98 and 6163.50kg/ ha, respectively. Very high fresh pod yields confirm that the improved varieties NGAE-96-012-1 and NGAE-96-0067 could be released to farmers in Umudike for improvement in okra fresh pod production.

Futuless *et al.* (2014) evaluated the performance of three Okra (*Abelmoschus esculentus* L. Moench) varieties *viz.* V1 (Improved), V2 (Serial) and V3 (Local). The parameters measured includes: fruit parameters: number of fruits, fruit length at harvest, harvested fruit weight and yield tons/ha. Significant differences were observed for all the parameters measured. V1 (Improved) recorded the highest fresh fruit yield of 10.7 tons/ha compared to V3 (Local) that recorded the lowest fresh fruit yield of 4.9 tons/ha. Salau and Makinde (2015) also conducted field experiments in the tropical rainforest zone of Nigeria to investigate the effects of planting density on pod yield of okra cultivars NHae 47-4, LD 88, and Jokoso. It was found that cultivar NHae 47-4 had higher yield than ‘LD 88’ and ‘Jokoso’.

2.3 Quality characters

In field trials conducted by Damarany and Farag (1994) for thirteen (13) cultivars of okra, Blondy produced the lowest value for dry matter percentage. Balady and Assiut strain gave the highest value for this characteristic (14.0 and

13.8%, respectively) and also for fibre content (13.8%). The cultivar with the highest protein content was Lee (23.8%).

Düzyaman and Vural (2003) examined numerous okra genotypes of American, African, Indian, European and Turkish origin for their pod properties and nutritive contents. The improved cultivars from the USA could also be judged as to have slow fibre development. Dry matter accumulation was higher in the Turkish and African material, varying between 18.15 - 17.2 % in the better ones, while this remained between 15.6 - 13.6 % in the Indian material, and 14.4 - 11.7 % in the USA material. Three lines from Turkey had top protein levels up to 4.55, 4.43 and 4.41 % in the case of Batı Trakya, Akköy and Denizli, respectively. Since okra is an important protein source in most developing countries, the material from Turkey might be extensively explored for its nutritive contents.

Makhadmeh and Ereifej (2004) studied the pods of a landrace and seven foreign genotypes of okra (*Hibiscus esculentus* L.) for their physical properties, chemical composition and mineral content. Mosel and Steen had higher protein content than the Landrace, being 23.19, 22.43, and 19.96% respectively. High variability was observed in chemical composition among different genotypes. However, the genotype having high carbohydrate content showed low fiber content. All mineral contents (Ca, Na, Cu, Mn, Zn, Mg, P, and K) varied significantly among the genotypes except for Fe content, which showed no significant differences between genotypes. Mosel genotype was found superior in its mineral contents, whereas other genotypes might be considered good source for proteins, fiber, carbohydrate and minerals. The investigated genotypes seem to be a good source of minerals for human diet.

Adetuyi *et al.* (2008) carried out a study to determine the antioxidant-phytoconstituents of 6 indigenous okra *Abelmoschus esculentus* (L) Moench varieties in Nigeria and the rate of deterioration of these antioxidants during storage. Okra pods were stored in polypropylene bag for up to 10 days to maintain pod quality parameters. The vitamin C, total phenol, reducing power and iron chelating activity of the Okra were determined on alternate days. The vitamin C content of these okra varieties ranges from 43.42 mg/100 g 'Ikaro' okra to 50.01 mg/100 g 'Okene' okra, during storage there was a significant ($p>0.05$) reduction in the vitamin C content of all the indigenous okra varieties. The total phenolic ranges from 0.106% 'Auchi' okra to 0.095% 'Benin' okra. However, there was no significant difference in the total phenolics of these indigenous okra varieties but in storage; there was a significant difference in the rate of loss of the total phenol contents and reducing power, with 'Lokoja' okra having the lowest percentage loss. Iron chelating activity of all the okra varieties ranges from 86.54% for 'Ikaro' to 77.47% for 'Auchi' okra, during storage there was a significant ($p>0.05$) decrease in the iron chelating activity of all the indigenous okra at the end of the storage period with 'Benin' okra having the lowest percentage loss of activity (19.85%).

Adetuyi *et al.* (2011) evaluated the different local okra varieties (Benin, Auchi, Ikaro, Akure, Okene and Lokoja) sold and consumed in Ifon, Ose Local Government area of Ondo State Nigeria with regards to the nutrients, antinutrients, minerals and zinc bioavailability. The result of the study revealed that the protein content of the varieties ranges between 13.61 – 16.27% with Ikaro variety having the highest protein content. The fiber and fat contents ranges from 10.15 – 11.63% and 9.03 – 10.57% respectively. Okene variety was observed to have the highest content in both fiber and fat contents. The phytate content in the local okra varieties varies from 2.64 – 3.90%. Auchi variety had the highest content of phytate which was not significantly ($P<0.05$) different from the phytate content of Benin variety. The saponin content ranges from 0.470 – 0.612% while the oxalate 0.324 – 0.506%. The viscosity of the local okra varieties ranges between 56.42 – 68.12Cp with Ikaro local okra having the highest viscosity. The mineral content ranges from 1.29-1.37mg/100g (Zinc); 0.87-0.96mg/100g (Iron); 51.08-51.18mg/100g (Magnesium); 58.22-58.31 mg/100g (Calcium) and 62.05-62.17 mg/100g (Phosphorous). There was no significant ($P<0.05$) difference in the magnesium, calcium and phosphorus contents of all the varieties. The calculated [Ca][Phytate]/[Zn] molar ratio was 0.293-0.436mol/kg. Ikaro okra variety recorded the least value in [Ca][Phytate]/[Zn] (0.293) while Auchi variety had the highest value in [Ca][Phytate]/[Zn] (0.436). It could therefore be concluded that the local okra varieties consumed in Ifon are of good nutritional qualities but Ikaro local okra variety had a better nutritional quality considering protein, fiber, ash and viscosity as quality indices. Also the zinc in this variety is more bio-available because it exhibits the least [Ca][Phytate]/[Zn] molar ratio.

Alake *et al.* (2013) conducted an experiment with twenty-five genotypes grown over a period of 4 years in two agroecosystems with the objective to evaluate the effects of agroecosystems and genotype on pod yield and relative contributions of plant characters in West African okra to develop efficient and stable selection criteria for pod yield improvement. Results showed that determination of additional physiological and biochemical subtle but important yield-related characters might provide additional insights into pod yield.

2.4 Insect and disease incidence

Matthew *et al*. (1993) selected six resistant/tolerant okra varieties from various regions of India and were compared with Pusa Sawani. Lowest incidence of okra (bhendi) yellow vein mosaic bigemini virus was recorded in Sel 4 (2.31%) and Arka Anamika (3.02%). Pusa Sawani (54.0%) and AROH1 (22.4%) were the most susceptible.

Similarly, Sharma *et al*. (1993) reported that Punjab Padmini and Punjab-7 were resistant to yellow vein mosaic bigemini virus. A mutant EMS-8 and the high yielding variety Parbhani Kranti were also resistant to the virus. Pusa Sawani and Pusa Makhmali were highly susceptible to the virus and were lower yielding cultivars.

Singh *et al.* (1993) also recorded data for 8 cultivars. The lowest levels of virus infection were recorded for Punjab 7 and Prabhani Kranti. Punjab 7 generally showed least disease severity and pest incidence, and gave the lowest reductions in marketable fruit and seed yields.

Srivastava *et al*. (1995) screened 12 okra varieties for reaction to yellow vein mosaic. Varsha Uphar and HRB55 were free of the disease at Karnal (Haryana) and, with Hy 6, at Mydukur (Andhra Pradesh). Arka Anamika showed moderate resistance at Karnal. The virus was not observed in any variety at Nashik (Maharashtra).

Prasad and Dimri (1998) reported that for control of blister beetle, Mylabris spp. on okra, Decamethrin (0.025%) and Monocrotophos (0.05%) gave good control of this serious pest.

On the other hand, Sannigrahi and Choudhury (1998) evaluated 7 okra cultivars (Arka Abhay, Arka Anamika, BO1, BO2, Parbhani Kranti, Punjab 7 and Pusa Sawani) virus resistance. Arka Anamika and Arka Abhay were the most suitable yellow vein mosaic virus resistant okra cultivars for commercial cultivation in Assam, compared with Pusa Sawani, a popular, but highly YVMV susceptible cultivar. Whereas Shepherd and Winston (1999) evaluated the performance of different okra hybrids (Varsha, Vijaya and Adhunik), including an open-pollinated local cultivar (Prabhani Kranti) as control, to select okra hybrids suitable for cultivation. All the studied hybrids were resistant to yellow vein mosaic virus. A very negligible (less than 1%) infection was recorded by Prabhani Kranti (75-80 days after sowing).

On the other hand, Singh *et al*. (2002) conducted trials in Chhatisgarh to determine the okra cultivar most suitable to the region and resistant to yellow vein mosaic virus (YVMV). Twelve cultivars were evaluated: Arka Anamika, Arka Abhay, Bharat Hari, V-6 06.8, Ambica Local, Parbhani Kranti, Ratna Raj, Chaman-31, Green Gold, V-5 09.5, Ratna Vijay and Chhindwada Local. Arka Abhay showed the lowest average YVMV incidence (1.2%), followed by Ambica Local (7.5%), Ratna Raj (9.6%) and Green Gold (9.7%). These were classified as resistant. Arka Anamika was moderately resistant to YVMV. Disease severity was lowest in Arka Abhay (9.4%). Correlation studies between meteorological parameters (independent variable) and disease incidence progress (dependent variable) showed that the disease incidence progress was positively correlated with minimum temperature and rainfall.

Debnath and Nath (2003) conducted a field experiment in Kalyani, West Bengal, to select the suitable okra cultivars (ParbhaniKranti, Seven Dhari Green, D-1-87-5, Arka Abhay, P-7, Lorm-1, VRO-3, VRO-4, AM-4-5, JNDO-5, KS-410, VRO-5 and VRO-6) in relation to yield and tolerance of yellow vein mosaic virus (YVMV). AM-4-5 showed complete tolerance of YVMV (0%) while Arka Abhay showed mild infection (4.44%) in 1999 and tolerance of YVMV in 2000 (0%).

Singh *et al*. (2003) reported that among 5 okra hybrids (DVR-1, DVR-2, Shree, HIHBO 83 and HIHBO 90), the hybrids HIHBO090, DVR-1 and DVR-2 were free from yellow vein mosaic virus infection.

Patil *et al*. (2005) also carried out a study with 7 new promising genotypes (GK-II-4-1-2, GK-IV-1-2-14, GK-IV-1-3-2, GK-IV-2-4-13, GK-IV-3-3-3, GK-IV-3-4-4 and GK-IV-4-3-7) and 3 open-pollinated cultivars, i.e. Arka Anamika, Parbhani Kranti and Varsha Uphar as the controls. All the genotypes were free from yellow vein mosaic virus, however, a disease incidence of 4.30, 1.50 and 0.72% was observed in Arka Anamika, Parbhani Kranti and Varsha Uphar, respectively.

On the other hand, Singh *et al*. (2008) evaluated thirty four genotypes of okra for various phenotypic characters including yield under the agro-climatic conditions of Varanasi. The genotypes viz. MOS-04-13, VRO-5, MOS-04-07, MOS-04-01 and MOS-04-02 registered resistance to yellow vein mosaic virus.

The experiment was undertaken Drsekender (2007) to study the performance of okra germplasm with special reference to yellow vein mosaic virus among 36 accessions at the Horticulture Farm Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during the period from April 2007 to August 2007. There was a wide range of different parameters. The maximum (169.37 cm) plant height was observed from accession number 14 and the maximum spread of plant was found from accession number 138 (14.62) was recorded from accession number 219 and 114 respectively. At 80 DAS the plant performed the maximum (94.2) number of leaves was obtained from accession number 138. The maximum leaf breath (35.1 cm) was recorded from accession number 148. The minimum (36.39) and the maximum (68.08) days was required for days to first flowering were from accession number 144 and 114 respectively. The minimum (14.27%) plant was infested by virus at 75 DAS in accession number 139 compare to other accessions number. So, accession number 139 was identified as agronomically acceptable resistant line against okra yellow vein mosaic virus.

Tripathy *et al.* (2008) conducted an experiment in West Bengal, India, during the summer and kharif seasons of 2004 to evaluate the relative susceptibility of 8 open-pollinated (OP) okra cultivars to leaf hopper (*Amrascabiguttulabiguttula*), fruit borer (*Eariasvittella*) and Yellow vein mosaic virus (YVMV) as affected by organic fertilizers (cow dung manure at 25 t/ha and neem cake at 2.5 t/ha) with 50% of the recommended NPK rates (90:60:40 kg/ha). Irrespective of the season and manure, ArkaAnamika, Indam 821, UtkalGourav and Pusa A4 were the most resistant to YVMV. However, no significant variation in YVMV incidence in OP okra cultivars was observed under manure application. Pusa A4, Indam 821, UtkalGourav and ArkaAnamika were found suitable for commercial cultivation in West Bengal. Supplementation with neem cake at 2.5 t/ha along with reduced levels of chemical fertilizers is recommended to suppress the pest load, and enhance fruit yield and optimize profit.

Aditi (2010) evaluated en varieties and hybrids of okra *viz*. ArkaAnamika, Harbhajan, P-8, Panchaali, ParbhaniKranti, PusaMakhmali, Shagun, Tulsi, VarshaUphar and PusaSawani for their relative susceptibility to blister beetle (*Mylabris* spp.) at two locations in Kangra valley of Himachal Pradesh during 2005 and 2006. Results revealed that during both the years, VarshaUphar (3.80–3.93 and 4.20–4.80 beetles/10 plants) and Tulsi (4.07–4.60 and 4.93–5.87 beetles/10 plants) were least susceptible to the pest whereas, the most susceptible variety observed was PusaSawani (14.60–17.67 and 17.80–24.13 beetles/10 plants) at Palampur and Kachhiari, respectively. The varieties followed parallel trend for flower damage (%) by the pest.

According to Fajinmi and Fajinmi (2010), okra [*Abelmoschus esculentus* (L.) Moench] is susceptible to at least 19 plant viruses with *Okra mosaic virus* (OkMV) being reported to be the most severe. Alternative host plants have been suspected to harbor OkMV which have contributed in its transmission. A study was carried out to determine the incidence of OkMV in weed species found near cultivated okra. Weed species growing around okra field, and exhibiting virus, or virus-like disease, symptoms were sampled and serologically analyzed to determine whether they harbored OkMV. Healthy okra plants were inoculated with OkMV at 14, 21, and 28 days after emergence and the effect of OkMV on yield components was estimated. Presence of OkMV in some weed samples was confirmed by symptom expression, host range, and serology. The effect of OkMV infection on okra growth and yield varied with time of inoculation. There was a positive correlation between fruit weight and numbers of fruit for all inoculation times. There was reduction in yield components due to infection with OkMV in all time of inoculation.

Magar and Madrap (2010) evaluated forty-one okra genotypes in Kharif, Rabi and summer season against yellow vein mosaic virus. There was no record of disease incidence in summer season that might be due to non-availability of vectors and environmental conditions, prevailed during summer season.

Boopathi *et al.* (2011) conducted field experiments in 2009 to study the pest complex and their succession in okra cv. Green Challenger under subtropical climatic conditions of Mizoram, India. Recommended agricultural practices were followed in raising the crop. No plant protection measure was applied during the cropping season. Observations on the incidence of insect pests were recorded at weekly intervals starting from the initial appearance to the final disappearance or up to the final harvest. Five plants per treatment were selected randomly and tagged for recording observations. The number of insects on each of these selected or tagged plants were recorded to determine the reaction of okra against important insect pests. Observations continued until harvest. Results showed that okra was invaded by 11 insect pests, one mite and 4 natural enemies. *Mylabris pustulata* and *Dysdercus cingulatus* were the major pests. The incidence of these pests were noticed during the reproductive stage and attained peak levels of infestation on first week of July and first week of August.

Oppong-Sekyerre *et al*. (2012) collected twenty-five accessions of okra from different parts of Ghana to evaluate their horticultural characteristics and performance. The results showed that most of the okra displayed symptoms of okra mosaic virus (OMV). Whereas Singh and Jain (2012) carried out a field experiment on fourteen okra hybrid. Hybrid cultivars namely DVR-1, DVR-2, RHROH-1HIHBO-68, and HIHBO-90 were found free from YVMV up to 90 days after seed sowing. The highest infection of YVMV was recorded in HIHBO-90. Similarly, Tiwari *et al*. (2012) reported that out of 5 okra cultivars screened for resistance to infection by YVMV under field conditions, only the VRO-6 cultivar was resistant to OYVMV, while moderate resistance was observed in the VRO-3 and HRB-9-2 cultivars. Pusa Makhamali was moderately susceptible, while Pusa Sawani was highly susceptible. Kumar and Singh (2013) also reported that among seventy-five genotypes of okra, Selection-10, Pant-Selection-1 and AC-317 were reliable source for resistant against yellow vein mosaic virus.

2.5 Genetic Variability

Any crop improvement depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable. The role played by environment in expression of economic characters also needs to be taken into account. The presence of high amount of variability for yield and yield components among the genotypes studied shows that there is of scope for selection for majority of the traits in the progenies. This could be accessed through standardizing the genotypic and phenotypic variance and by obtaining coefficients of variability.

Hazra and Basu (2000) revealed that there was a wide range of variations in okra for plant height, leaves per plant, nodes per plant, days to first flower, fruit weight, fruits per plant, seeds per fruit, fruit yield per plant; moderate variations for number of leaf, primary branches per plant and fruit length, fruits diameter; lesser variations for node at first flower and ridges per fruit. Primary branches per plant, which showed a moderate range of variation, recorded the highest genotypic coefficient of variation (GCV; 35.5%). However, plant height, leaves per plant, fruit weight, fruits per plant, seeds per fruit and fruit yield per plant recorded a moderate GCV.

Bendale *et al*. (2003) showed a wide range of genetic variability for yield and yield-contributing characters *viz.* first flowering node, days to first harvest, pod length, pod weight, plant height, nodes per plant, intermodal length, number of branches per plant, fruiting period, number of pods per plant and yield per plant in okra. The phenotypic variance (PCV) for all the 15 characters was higher than the genotypic variance (GCV). The number of branches per plant, yield per plant and number of pods per plant showed high GCV and PCV estimates. Moderate GCV and PCV was observed for number of fruits per plant, fruit length and fruit weight, whereas fruit circumference exhibited low GCV and PCV.

Verma *et al*. (2004) reported the highly significant differences between okra genotypes for all the characters. Maximum range of mean value was observed for yield per plant and minimum for branches per plant. High degree of variability was observed for branches per plant and yield per plant. Mulge *et al.* (2004) also studied genetic variability among 69 okra cultivars and suggested that GCV and PCV were high for plant height, total yield per plant, yield per plot and number of seeds and moderate for fruits length, branches and fruits diameter. Similarly, Patro and Ravisankar (2004) evaluated 41 genotypes of okra and observed high genotypic co-efficient of variation and phenotypic coefficient of variation for plant height, number of leaf, leaf area index, number of branches per plant, disease incidence (Cercospora leaf spot, powdery mildew, YVMV), yield per plant and fruit weight.

Singh *et al*. (2006) estimated high genotypic coefficient of variation and high phenotypic coefficient of variation for inter nodal length, cumulative leaf area, number of branches per plant, number of fruits per plant, number of seeds per pod and fruit yield per plant in 19 genotypes of okra.

Singh *et al*. (2007) reported high PCV and GCV for number of branches per plant, plant height, number of fruits per plant and total fruit yield. The moderate GCV and PCV estimates were recorded for internodal length, day to fruit setting and fruit length.

Nasit *et al*. (2009) studied variability for different characters in forty eight genotypes of okra and observed high genotypic coefficient of variation and phenotypic coefficient of variation for the characters like plant height, number of branches, fruit yield per plant, fresh fruit crude protein content and plant height.

Jindal *et al.* (2010) studied 12 okra genotypes of okra and observed high GCV and PCV for plant height, number of primary branches indicating maximum variability among the genotypes. Further, Shanthakumar and Salimath (2010) conducted experiment with three double crosses and four single crosses F2 population of okra and reported moderate to high phenotypic and genotypic coefficients of variation for days to 50 per cent flowering, cumulative leaf area, plant height, number of primary branches per plant, fruits length, fruit girth, number of nodes and fruit yield per plant. Yadav *et al*. (2010) also evaluated twenty five germplasm lines of okra and reported that maximum range of variability was recorded for fruit yield per plant followed by plant height, percentage of plants affected by YVMV, percentage of plants affected by mealy bug whereas it was minimum in fruit diameter.

Das *et al*. (2012) studied variability among 18 genotypes of okra and found high PCV and GCV values for fruit yield per plant, numbers of seeds per fruits and plant height at flowering.

Kumar *et al.* (2013) conducted experiment on genetic variability studies in okra and observed a high range of genotypic and phenotypic co-efficient of variation for plant height, branches per plant, nodes per flower, ridges per fruit and fruit yield per plant and low PCV and GCV for duration of flowering and fruit weight was recorded.

Reddy *et al*. (2014) studied sixty four entries of okra consisting of fifty seven inbred lines and seven checks for reaction to yellow vein mosaic virus and reported that high genotypic and phenotypic coefficients of variation were noticed for disease incidence, leaf size, number of nodes per flower,yield per plant and fruit yield per hectare and low GCV and PCV are observed in duration of flowering and leaf areas.

2.6 Heritability and Genetic Advance

Phenotype of an individual is the product of its genotype and the environment in which it grows. Heritability in broad sense or degree of genetic determination is the proportion of hereditary variance to total phenotypic variance.

Heritable variation can be determined with greater accuracy, when heritability is studied along with genetic advance.

Dhall *et al*. (2000) evaluated 48 germplasm lines of okra and reported high heritability and low genetic advance in fruit length, weight of fruits, plant height, and number of fruits per plant and virus incidence. Whereas, Hazra and Basu (2000) reported that plant height, fruit weight, ridges per fruit, dry weight of fruit and seeds per fruit were highly heritable while primary branches per plant, leaves per plant, days to first flower, fruit length, fruits per plant and fruit yield per plant were moderately heritable. Primary branches per plant, seeds per plant, seeds per fruit and fruit weight had high heritability and high genetic advance in 22 okra genotypes.

Bendale *et al*. (2003) reported that all the characters recorded medium to high and high heritability in okra.

Mulge *et al.* (2004) reported that characters *viz*., yield per plant, number of seeds per fruit and number of fruits per plant showed high heritability with high genetic advance, whereas fruit circumference recorded high heritability with low genetic advance in 69 okra cultivars. Patro and Ravishankar (2004) also evaluated 41 genotypes of okra and observed high heritability for number of branches per plant, yield per plant and high genetic advance for fruit yield per plant and plant height. Similarly, Verma *et al*. (2004) reported high estimate of heritability and genetic advance in okra for seeds per fruit and plant height.

Indurani and Veeraragavathatham (2005) conducted experiment with seven okra genotypes and noticed high heritability coupled with high genetic advance for characters such as plant height, first flower bud appearance, number of fruits per plant and yield per plant.

Singh *et al.* (2006) reported that number of branches per plant, fruit yield per plant, yield per plot, number of fruits per plant and plant height exhibited high heritability and high genetic advance in 19 okra genotypes. Similar findings were reported by Vishalkumar *et al*. (2006) who observed high heritability along with high genetic advance over mean for plant height, number of primary branches per plant, number of leaf, internodal length, number of fruits per plant , yield per hectare and fruit yield per plant in okra.

Singh *et al*. (2007) reported high values of heritability for plant height, number of fruits per plant, fruit yield, fruit length, fruit girth, inter nodal length and number of leaf per plant. Sunil *et al.* (2007) also observed high heritability coupled with low genetic advance for day to flowering, number of branches, leaf number, number of nodes in flower, intermodal length, number of fruits per plant and yield per plant in okra. High heritability coupled with low genetic advance was observed for plant height. Low heritability coupled with high genetic advance for fruit width, tapering length of fruit and low heritability with low genetic advance for fruit length.

Saifullah and Rabbani (2009) reported high heritability estimates along with considerable low genetic advance for days to first flowering, plant height, leaf size, number of primary branches per plant, number of internodes per plant, number of ridge per fruits, fruit weight, number of seeds per fruits and fruit yield per plant in 121 okra genotypes.

Akotkar *et al*. (2010) evaluated fifty genotypes of okra and reported high heritability and low genetic advance for number of fruits, leaf area index, number of ridges per fruit, days to fruits setting, diameter of fruits and number of fruiting nodes. Whereas, Jindal *et al.* (2010) reported that high estimates of heritability coupled with high genetic advance were obtained for number of branches per plant and yield per plant indicating presence of additive gene effects thereby effectiveness of selection for these traits. Presence of high heritability coupled with moderate genetic advance for fruit weight, plant height, internodal length, days to maturity, number of fruits per plant and fruit yield revealed that straight selection has limited scope for further improving these traits in okra. Shanthakumar and Salimath (2010) also conducted experiment with three double crosses and four single crosses F2 population of okra and reported heritability and genetic advance were high for plant height, leaf size, number of primary branches per plant, internodal length, days to 50 per cent flowering, fruit length, fruit girth, number of fruits per plant, yield per plot and fruit yield per plant indicating the involvement of additive type of gene action in controlling these characters, hence, selection could be effective. Similarly, Yadav *et al*. (2010) reported high heritability was found for most of the traits *viz*. plant height, days to first flowering, number of ridges per fruit and per cent plants affected by YVMV in the experiment with 25 genotypes of okra.

Nwangburuka *et al*. (2012) evaluated 29 okra genotypes and observed high heritability and genetic advance for plant height, fresh pod length, fresh pod width, and mature pod length, branches per plant and pod weight per plant in 29 okra accessions.

Duggi *et al*. (2013) studied 31 okra genotypes and reported high magnitude of heritability coupled with high genetic advance for the characters *viz*. leaf axil bearing first fruit, plant height, duration, yield per plant, number of fruits per plant, number of primary branches, fruit weight and fruit length. Similarly, Kumar *et al.* (2013) estimated high heritability and genetic advance as per cent mean was observed for plant height, branches per plant, nodes per plant, number of seed per fruits and fruit yield per plant. High heritability with moderate genetic advance and mean was observed for days to 50 per cent flowering, fruit diameter and number of seeds per fruits indicating low variability for this trait in okra.

Reddy *et al.* (2014) reported high heritability coupled with high expected genetic advance in okra revealed that very significant improvement is possible through selection for all the characters studied.

2.7 Correlation coefficient analysis:

Yield is a complex character, controlled by polygenes and highly influenced by environment. Hence, selection based on yield alone is not effective. In breeding efforts to enhance yield, an understanding of the relationships among different characters is inevitable. Knowledge on the direct contribution of different characters to yield is highly useful for formulating a selection programme. Correlation studies provide better understanding of yield components, which helps the plant breeder in making selections (Robinson *et al.,* 1951 and Johnson *et al.,* 1995).

Lerner (1958) stressed the importance of correlation of various characters with yield. He found them useful in the construction of selection indices and predicting correlated response. Genotypic correlation coefficient provides a measure of genotypic association between characters. The genetic basis of such correlation is mainly pleotropic, which refers to manifold effects of a gene (Falconer, 1981). Genotypic correlation provides basic information to breeder in understanding the nature of the species with which they work.

Hazra and Basu (2000) observed fruit yield per plant was significantly and positively associated with plant height, whereas days to first flowering showed negative association with number of fruits per plant among 22 okra genotypes.

Dhankhar and Dhankhar (2002) studied correlation in sixty- two inbred lines of okra and stated that fruit yield was significantly and positively correlated with number of fruits per plant, number of branches per plant and plant height and negatively correlated with days to 50% flowering. Number of leaf per plant also showed significant positive association with Leaf area index, Yield per plant, Size of leave and Weight of fruit.

Gandhi and Yadav (2002) noticed that the dry fruit yield was highly and significantly dependent on the number of nodes per plant, inter nodal length, number of fruits per plant and yield per plant.

Nimbalkar et al. (2002) observed that the dry fruit yield exhibited positive and significant correlation with number of days to maturity, plant height, seed yield per plant and number of fruits per plant, seed yield recording the highest correlation (r=0.667) with dry fruit yield. Regression studies showed that seed yield per plant contributed 62.8% genetic variability to the total 71.1% variability of the cultivars examined.

Kamal *et al.* (2003) estimated that yield per plant was positively and highly significantly correlated with number of nodes per plant, width of fruit and number of fruits per plant.

Niranjan and Mishra (2003) observed that fruit yield was positively and significantly correlated with edibility period of fruits, number of fruits per plant, number of seeds per fruit, fruit weight, plant height and number of branches per plant at both genotypic and phenotypic levels.

Bendale et al. (2003) reported that the pod length, pod weight, plant height, nodes per plant and number of pods per plant were positively correlated with the yield.

Duzyaman et al. (2003) investigated that pod weight and diameter were positively correlated with total yield. Early flowering was negatively correlated with total yield. Pod weight and pod number per plant were highly associated with flowering behavior and pod composition on the first year. Pod weight per plant was associated with average pod weight, pod width and flesh thickness, whereas pod number per plant was correlated with dry matter content only. Significant correlation was observed among pod weight, pod width and flesh thickness.

Jaiprakashnarayan and Ravindra Mulge (2004) evaluated 69 okra genotypes and reported inverse relationship between growth and earliness, but strong association between growth and yield characters. Total yield per plant was positively and significantly correlated with number of fruits per plant, average fruit weight, number of nodes on main stem, fruit length, plant height at 60 and 100 DAS and number of leaves at 45 and 100 DAS, but negatively and significantly correlated with number of nodes at first flowering and first fruiting.

Correlation studies among 41 genotypes of okra revealed that fruit yield per plant had significant and positive correlation with number of branches per plant, number of ridges per fruit, fruit length, fruit weight and ascorbic acid content. Significant negative correlation of fruit yield per plant was recorded with plant height, number of days taken for first pod setting, fruit volume, shape index, longevity of tenderness (Patro and Ravishankar, 2004).

Jaiprakashnarayan and Mulge (2004) reported that total yield per plant was positively and significantly correlated with number of fruits per plant, average fruit weight, number of nodes on main stem, fruit length, plant height (at 60 & 100 DAS) and number of leaves (at 45 & 100 DAS), but negatively and significantly correlated with number of locules per fruit, number of nodes at first flowering and first fruiting.

Sureshbabu et al. (2004) noted that the significant phenotypic and genotypic correlation with yield was shown by fruit length and fruits per plant.

Subrata et al. (2004) reported in his studies that, in 25 genotypes of okra fruit yield had significant positive correlation with number of fruits per plant and fruit weight.

The correlation studies among 30 lines of okra indicated that the yield was closely and positively correlated with its component characters like plant height, fruit length, node number and number of fruits per plant both at phenotypic and genotypic levels (Khan *et al.,* 2005).

Bhalekar et al. (2005) observed that fruit length, inter-nodal length, number of fruits per plant and number of branches per plant had positive and strong correlation with fruit yield.

Ghosh (2005) reported that fruit yield per plant was recorded significantly positively correlated with fruiting span, inter-nodal length, number of seeds per fruit, plant height at maturity and weight of fruit.

Pawar (2005) found that the yield per plant was significantly positively correlated with number of fruits per plant, fruit weight, fruit length and fruit girth.

Choudhary (2006) noted that the yield per plant showed positively significant association with number of fruits per plant, fruit weight, length of fruit, number of seeds per fruit, plant height, fruiting span, fruit girth and number of branches per plant.

Akinyele and Oseikita (2006) observed that the seed yield per plant showed significant positive correlation with number of pods per plant, height mat flowering, pod width and weight of hundred seeds.

Mehta *et al*. (2006) observed that fruit yield was significantly and positively correlated with fruit length and average fruit weight among 22 genotypes of okra.

Singh *et al.* (2006) studied 19 genotypes of okra and revealed that fruit yield per plant was positively and significantly correlated with fruit length, fruit diameter, fruit weight and number of fruits per plant.

Correlation studies of Adeniji and Aremu (2007) evaluated 18 F2 generations of okra and revealed that pod and seed yield were positively correlated with number of pods per plant, height at maturity, seed weight, and ridges per pod.

Mohapatra *et al*. (2007) evaluated 23 genotype of okra for different yield traits as well as yellow vein mosaic virus and estimated that total fresh yield per plant had a positive and significant phenotypic and genotypic correlation with number of fruits per plant, fruit girth, fruit diameter, inter nodal distance and fruit weight.

Fruit yield had significant positive genotypic and phenotypic correlations with number of fruits per plant, fruit length, ridges per fruits and plant height. Number of fruits per plant also showed significant positive genotypic and phenotypic associations with fruits weight, plant height, number of leaf and fruit length. Similarly, fruit girth exhibited positive and significant genotypic and phenotypic correlations with number of branches per plant, internodal length and fruit length (Singh *et al.*, 2007).

Ali et al. (2008) reported that the Correlation coefficients were estimated among parents, F1 hybrids and F2 population separately at genotypic and phenotypic correlation coefficients. The correlation coefficients were consistently significant and positive in all the three population between fruit yield per plant and number of fruits per plant at both genotypic and phenotypic levels. The consistency was also observed in F1 and F2 generations between fruit yield per plant and plant height at both genotypic and phenotypic levels. Fruit yield per plant showed significant and positive correlation between length of fruit and width of fruit at genotypic level in both F1 and F2 generations.

Correlation co-efficient between yield and growth contributing parameters indicated that yield of green pod had highly significant positive association with size of leaf and number of ridges per fruits among 50 okra accessions (Alam and Hossain, 2008).

Kumar *et al*. (2009) evaluated twenty genotypes of okra and revealed that number of flowers per plant was positively and significantly correlated with number of leaves per plant, diameter of stem and number of days to flower at genotypic and phenotypic levels and also stated that number of fruits per branch, number of fruits per plant and number of days to flower was positively and significantly correlated at genotypic and phenotypic levels.

Ramya and Senthilkumar (2009) evaluated 35 genotypes of okra and reported that pod yield per plant had significant positive relationship with number of pods per plant at phenotypic, genotypic and environmental levels. It also showed positive significant association with plant height at genotypic level.

Chaukhande *et al*. (2011) evaluated 75 diverse okra genotypes and revealed that yield per plant exhibited positive and significant correlation with plant height, number of flowering nodes on main stem, number of fruits per plant, average weight of fruit.

Nagre et al. (2011) investigated that the yield per plant was closely associated positively and significantly with number of nodes per plant, number of fruits per plant, length of fruit, weight of fruit, leaf area, chlorophyll content of leaves plant height and number of primary branches per plant. The characters like number of leaves per plant, number of lobes per leaf, inter nodal length, node at which first fruit appears and ascorbic acid content of fruits exhibited positive, however non-significant correlation with yield per plant. The characters diameter of fruit was negatively and significantly correlated with yield per plant. Number of ridges per fruit also showed negative but non-significant correlation with yield per plant.

Somashekhar *et al.* (2011) evaluated three populations of the okra and reported significant positive correlation of yield per plant with fruit weight, number of fruits per plant, 100 seed weight and number of branches per plant.

Nwangburuka *et al*. (2012) observed positive and significant phenotypic and genotypic correlation between plant height at maturity, fresh pod width, seeds per pod and pods per plant, branches per plant with fruits weight per plant and pod weight per plant among 29 okra accessions.

Jagan *et al.* (2013) conducted experiments comprising 60 hybrids obtained by crossing 19 parents and reported that fruit yield per plant showed highly significant positive association with number of branches per plant and number of fruits per plant at phenotypic and genotypic levels in F1s and positive correlation between day to first flowering and first flowering.

Reddy *et al.* (2013) studied correlation in 100 germplasm lines of okra and reported that total yield per plant was positively and significantly correlated with plant height, fruit length, fruit width, fruit weight, total number of fruits per plant, number of marketable fruits per plant, while number of branches per plant, internodal length, days to 50% flowering, first flowering node and first fruiting node had significant negative correlation with marketable yield per plant.

Chand *et al.* (2014) evaluated 27 genotypes of okra for fruit yield and its component traits and reported that yield per plant had highly significant positive genotypic and phenotypic correlation with plant height, length of pod, average weight of edible pod and number of seeds per pod. Non-significant correlation was observed for number of pods per plant and weight of 100 seeds with yield per plant. Correlation studies indicated that close relationship between genotypic and phenotypic correlation coefficients and magnitude of genotypic correlation were higher than their corresponding phenotypic correlation for most of the characters.

Yonas *et al*. (2014) evaluated 25 okra genotypes and observed fruit yield was positively correlated with fruit length, average fruit weight, fruit diameter and number of pods per plant.

Mihretu et al. (2014) found that Correlation study between various quantitative characters highlighted significant association among characters. Fruit yield was positive and highly significant genotypic correlation with fruit length, fruit weight, fruit diameter, seed per pod , hundred seed weight and number of ridges per fruit.

Saryam et al. (2015) reported that Yield plant-1 had highly significant positive phenotypic correlation with viz., number of fruits per plant (0.803), fruit diameter (0.376), fruit length (0.349), number of seeds fruit-1 (0.316), days to maturity (0.301), fruit weight (0.274) leaf area (0.219),100 seed weight (0.219), flower diameter (0.154), fruiting span (0.152), petiole length (0.151), and stem diameter (0.150). Highly negative non-significant association was observed with incidence of YVMV (-0.389), days to 50 per cent flowering (-0.319) and node at first flower appears (-0.307) this correlation study indicated that close interrelationship between genotypic and phenotypic correlation co-efficient and magnitude of genotypic correlation were higher than their corresponding phenotypic correlation for most of the traits.

Mishra et al. (2015) observed that wide variability was found for different traits in Okra. Invariably, higher values were observed for phenotypic coefficient of variation with respect to corresponding genotypic coefficient of variation indicating the impact of environmental factors towards trait expression. The presence of moderate to high heritability coupled with moderate genetic advance for fruit weight, days to 50% flowering, fruits per plant as well as fruit yield per plant indicated their possibility of improvement with simple selection procedure in okra. Similarly, highly significant and positive correlation of fruit yield per plant with plant height, nodes per plant and fruits per plant was observed.

Ahamed et al. (2015) revealed that the highest range of variation was recorded in average fruit weight (18.25- 25.41g), followed by yield per plant (98.90 – 1650.00g). The highest GCV (46.70 %) and PCV (47.72 %) were recorded for fruit yield per plant while both were lowest for days to maturity (8.07 % and 8.25 %)

Sreenivas et al. (2015) found that fruit length had significant positive correlation with fruit girth, fruit weight, number of fruits per plant and duration. Fruit girth had significant positive correlation with fruit length, fruit weight and number of fruits per plant. Fruit weight had significant positive correlation with fruit length, fruit girth, number of fruits per plant and duration. Number of fruits per plant had significant positive correlation with all characters.

CHAPTER III

MATERIALS

AND

METHODS

MATERIALS AND METHODS

The present investigation entitled, “Performance of various okra genotypes for growth, yield and quality attributes under foothill condition of Nagaland” was carried out in the experimental farm of School of Agricultural Sciences and Rural Development (SASRD) Medziphema campus, Nagaland University during 2013 and 2014. The details of materials used and procedures followed during the period of investigation are as follows:

3.1 GENERAL INFORMATION

3.1.1 Location

The experimental site is located in the Horticultural Farm, School of Agricultural Sciences and Rural Development, Medziphemaat an altitude of 310 meters above mean sea level, with geographical location of 25˚45’43’’N latitude and 93˚53’04’’E longitude.

3.1.2 Climate

The site of the experimental farm has sub-tropical climate, predominantly humid with moderate temperature and medium to heavy rainfall. The summer temperature ranges from 21˚C to 32˚C, the average annual precipitation varies from 200 cm to250 cm which is spread over 6 months *i.e.* April to September while the remaining period from October to March is comparatively dry. Details of the climatic condition during the period of investigation are presented in Table 3.1 and graphically shown in figure 3.1.

3.1.3 Soil

The soil of the experimental plot was sandy loam and well drained with a pH of 4.5.The composite soil samples were collected randomly at 15 cm depth from the experimental plot with the help of soil augur. After various manual operations like mixing, drying, grinding and sieving, representative samples of soil were analyzed. The results of the soil sample analysis are presented in Table 3.2.

Table 3.1 Meteorological data during the period of investigation

(April-August 2013 and 2014)

Month	Max. Temp. (˚C)		Min. Temp. (˚C)		Relative humidity (%)		Total rainfall (cm)	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
April	33.50	32.83	15.60	19.04	60.50	31.43	86.80	44.10
May	32.80	31.55	17.60	21.55	59.50	51.93	310.20	133.20
June	35.40	31.84	21.80	23.36	63.00	57.77	181.50	118.30
July	32.90	30.75	22.60	23.18	83.00	56.33	245.50	283.50
August	33.10	29.96	22.10	22.72	75.50	57.10	415.60	201.20

Source : Central Institute of Horticulture (CIH), Medziphema, Nagaland

Table 3.2: Soil fertility status of the experimental plot

Parameters	Value	Status	Method employed
pH	4.5	Acidic	Digital pH meter scale (Single electrode meter)
Organic carbon (%)	1.65	High	Walkey and Black method (Piper, 1966)
Available N (kg ha^{-1})	245.22	Medium	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	18.11	Medium	Bray and Kurtz method (1954)
Available K_2O (kg ha^{-1})	222.14	Medium	Flame Photometer (Hanway and Heidal, 1952)

3.2. Experimental details

3.2.1 Technical Programme

Experimental design	: Randomised Block Design
Replication	: 3
Number of treatments (genotypes)	: 28
Plot size	: 1.8m x 1.8m
Spacing	: 45cm x 30cm
Total number of plots	: 84
Total number of plants per plot	: 24

Treatments

The genotypes used along with treatment symbols are listed below:

Sl. No.	Genotypes	Symbols
1.	IIVRO-7	T_1
2.	IIVRO-608-8-1	T_2
3.	IIVRO-SKY/DR/RS-107	T_3
4.	IC-042484-B	T_4
5.	IC-140880	T_5
6.	IIVRO-212-10-1	T_6
7.	IIVRO-599-8-1	T_7
8.	IC-69257	T_8
9.	IIVRO-770	T_9
10.	IIVRO-SC-108	T_{10}
11.	IIVRO-307-10-1 II	T_{11}
12.	IIVRO-SKY/DR/RS-66	T_{12}
13.	Kashi Kranti	T_{13}
14.	IIVRO-3	T_{14}
15.	IIVRO-419-01-1	T_{15}
16.	IIVRO-325-10-1	T_{16}
17.	IIVRO-130-10-1	T_{17}
18.	IIVRO-1773	T_{18}
19.	IIVRO-49	T_{19}
20.	IIVRO-363	T_{20}
21.	IC-218844	T_{21}
22.	IC-45831	T_{22}
23.	IIVRO-137-10-1,2	T_{23}

24.	IIVRO-814-K	T_{24}
25.	IC-039140	T_{25}
26.	IC-117319	T_{26}
27.	Arka Anamika	T_{27}
28.	Prabhani Kranti	T_{28}

3.2.2 Layout of the experiment

The experiment was laid out in Randomized Block Design with 28 treatments (genotypes) and 3 replications. The detailed layout of the experiment is given in figure 3.2

3.2.3 Source of planting materials

The 28 genotypes of okra were collected from Indian Institute of Vegetable Research (IIVR), Varanasi, Uttar Pradesh.

3.2 Agronomic practices

3.3.1 Field preparation

The experimental field was ploughed twice by a tractor drawn spike tooth harrow and leveled properly. The soil of the experimental plot was well pulverized. Stubbles and plant debris were removed thoroughly by manual labour. Plots were measured with measuring tape. Beds were raised 15 cm above the

R_1T_6	R_2T_{18}	R_3T_8
R_1T_4	R_2T_2	R_3T_9
R_1T_{10}	R_2T_{19}	R_3T_{13}
R_1T_{15}	R_2T_3	R_3T_{17}
R_1T_{20}	R_2T_7	R_3T_1
R_1T_8	R_2T_{16}	R_3T_{14}
R_1T_{23}	R_2T_{21}	R_3T_{22}
R_1T_{12}	R_2T_5	R_3T_{27}
R_1T_{26}	R_2T_{28}	R_3T_{25}
R_1T_{11}	R_2T_{14}	R_3T_3
R_1T_{27}	R_2T_{24}	R_3T_{26}
R_1T_{17}	R_2T_{10}	R_3T_4
R_1T_5	R_2T_{22}	R_3T_{15}
R_1T_2	R_2T_8	R_3T_{12}
R_1T_{16}	R_2T_6	R_3T_{18}
R_1T_7	R_2T_{23}	R_3T_{19}
R_1T_{28}	R_2T_{25}	R_3T_{11}
R_1T_9	R_2T_{13}	R_3T_{20}
R_1T_{21}	R_2T_{26}	R_3T_{28}
R_1T_3	R_2T_1	R_3T_{10}
R_1T_{25}	R_2T_{27}	R_3T_{24}
R_1T_{14}	R_2T_{12}	R_3T_{16}
R_1T_{24}	R_2T_{15}	R_3T_{23}
R_1T_{22}	R_2T_{17}	R_3T_7
R_1T_{19}	R_2T_{11}	R_3T_6
R_1T_{18}	R_2T_9	R_3T_5
R_1T_1	R_2T_{20}	R_3T_{21}
R_1T_{13}	R_2T_4	R_3T_2

Fig 3.2: Farm layout of the experimental plot in Randomized Block Design

Plate 1: General view of the experimental plot.

ground to avoid water logging condition. The bed size was kept 1.8m x 1.8m. Eighty-four plots were prepared with a distance of 30 cm between individual plots and block to block distance of 1 m. Soil application of Carbofuran @ 1 kg a.i./ha was done at the time of sowing.

3.3.2 Application of manures and fertilizers

Well decomposed FYM @20 t/ha was uniformly incorporated in the soil during the final land preparation. NPK @ 80:40:40 kg ha^{-1} were applied in the experimental plots. N, P and K were given through Urea, SSP and MOP respectively. Full dose of P and K and half dose of N were applied just before planting and the remaining dose of N was applied 30 days after sowing the crop.

3.3.3 Sowing of seeds

Before sowing, the seeds were soaked in a solution of Bavistin (0.2%) for 6 hours. The seeds were then dried in shade. Seeds were sown in the 14^{th} of April in both the years at a spacing of 45 cm row to row and 30 cm plant to plant accommodating 24 plants in each plot.

3.3.4 Interculture operation

A light irrigation was given soon after seed sowing to ensure good germination. Subsequent irrigations were given as per the requirement depending on the rainfall and soil conditions. The plots were weeded manually throughout the crop growth. Earthing up, staking of the plants and plant protection measures were also carried out as and when required.

3.3.5 Harvesting

The fruits were harvested at tender stage before they attained full maturity. The pods were handpicked and sharp knives were used to cut them from the stalks to avoid fruit damage.

3.4 Sampling and observations recorded

Five plants were randomly selected in respect of each treatment under every replication as sample plants and duly tagged for recording the observations from the selected plants.

3.4.1 Growth characters

3.4.1.1 Days to first flowering

Number of days taken for initiation of flowering from the date of sowing was recorded from five tagged plants in each plot and the average value was expressed in days.

3.4.1.2 Number of nodes for first flower

The observation of this character was done by counting the number of nodes from the ground level on which the first flower appeared in each sample plant and mean value was calculated.

3.4.1.3 Duration of flowering

Duration of flowering was recorded as the difference between the lifespan and number of days to flowering. The difference thus was obtained in terms of number of days. Observations were taken from five tagged plants in each plot and the average value was worked out.

3.4.1.4 Days to fruit setting

Number of days taken from sowing to the date of shedding of first flower resulting in fruit formation was recorded from five tagged plants in each plot and the average value was calculated.

3.4.1.5 Days to marketable maturity

Number of days taken from sowing to the date of first fruit harvesting was recorded from five tagged plants in each plot and the average value was calculated.

3.4.1.6 Days from fruit set to harvesting

Number of days taken from fruit set to harvesting was recorded from five tagged plants in each plot and the average value was calculated.

3.4.1.7 Plant height

Plant height was measured during the entire growth period at 30, 60, 90 and 105 days with the help of a scale from the ground level to the tip of the top most part of the plant. Observations were taken from five tagged plants in each plot and the average value was represented in centimeters.

3.4.1.8 Number of branches per plant

The number of branches per plant was counted in each sample plant in each plot and the average value was calculated. The observation was recorded at final harvest of the crop.

3.4.1.9 Number of leaves per plant

The number of leaves per plant was counted in each sample plant in each plot and the average value was calculated. The observation was recorded during the entire growth period at 30, 60, 90 and 105 days.

3.4.1.10 Size of leaf

Three leaves were selected from each sampling plant representing all possible sizes and their area was recorded using a leaf area metre. The average leaf area was calculated and represented in terms of square centimetre.

3.4.1.11Cumulative leaf area

The cumulative leaf area was determined by multiplying the number of leaves of each plant with the mean leaf area and represented in terms of square metre.

3.4.1.12 Leaf area index

The leaf area index was estimated using the given formula below (Konyeha and Alatise, 2013). LAI depicts the leafiness in relation to land area at a time.

$$LAI = \frac{Area\ of\ leaf\ per\ plant}{Area\ under\ cultivation}$$

3.4.1.13 Number of ridges

Numbers of ridges in five randomly selected fruits from the sample plants were recorded and their average was taken.

3.4.1.14 Colour of fruits

The colour of fruits from the sample plants were visually observed and recorded at marketable stage in the following categories *viz.* dark green, green and light green.

3.4.2 Yield attributes

3.4.2.1 Length of fruit

Length of five randomly selected fruits harvested from the sample plants representing all possible sizes were recorded with the help of a vernier caliper and their average was expressed in centimetres.

3.4.2.2 Width of fruit

Width of five randomly selected fruits harvested from the sample plants representing all possible sizes were recorded with the help of a vernier caliper and their average was expressed in centimetres.

3.4.2.3 Weight of fruit

Weight of five randomly selected fruits harvested from the sample plants representing all possible sizes were recorded with the help of an electronic balance and their average was expressed in grams.

3.4.2.4 Number of seeds per fruit

Numbers of seeds from five randomly selected fruits harvested from the sample plants were counted and their average was taken.

3.4.2.5 Number of fruits per plant

Number of fruits per plant from five randomly selected plants were recorded throughout the harvest period and their average was worked out.

3.4.2.6Yield per plant

Yield per plant was worked out by multiplying the average weight of the pod with total number of pods per plant. The data was represented in grams.

3.4.2.7 Yield per plot

Yield per plot was worked out by multiplying the average yield per plant with total number of plants per plot. The data was represented in grams.

3.4.2.8 Projected yield per hectare

Projected yield from the experimental plot was calculated on the basis of actual yield per plot recorded under each treatment by using the formula.

$$Y = \frac{Yield\ per\ plot \times 10{,}000}{Area\ of\ the\ plot}$$

Where Y denotes yield per hectare

The data thus obtained was expressed in terms of tonnes per hectare.

3.4.3 Quality characters

3.4.3.1 Protein content

Protein content per cent (%) in the fruits was determined after estimating the value of nitrogen content in the fruits. Nitrogen was determined by macro-Kjedahl method described by AOAC and the percentage nitrogen was converted to crude protein by multiplying with a constant value of 6.25.

Protein content = % Nitrogen content x 6.25

3.4.3.2 Vitamin C content

Vitamin C content of the fruit was determined by using 2,6-Dichlorophenol indophenol visual titration method as given by A.O.A.C. (1984) and expressed in mg/100 g of fruit.

3.4.3.3 Crude fibre content

Crude fibre content of the fruit was determined by using the method as given by A.O.A.C. (1984) and expressed in percentage. This method gives the crude fibrecontent of the sample after it has been digested in sulphuric acid and sodium hydroxide solutions and the residue calcined. The difference in weight after calcinations indicates the quantity of fibre present.

$$\%\ \text{Crude Fibre in ground sample} = \frac{\text{Loss in weight in ignition x } 100}{\text{Weight of the sample (gm)}}$$

3.4.3.4 Dry matter content (%)

Dry matter content (%)of the fruit was determined by using the method as given by A.O.A.C. (1984) and expressed in percentage. Approximately 5g of samples weredried in an oven at 105˚C for at least 12 hours. After removing the samples from the oven, they were allowed to cool in a dessicator and weighed again.

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight of sample (gm) x 100}}{\text{Fresh weight of sample (gm)}}$$

3.4.4 Insect and disease incidence

3.4.4.1 Incidence of blister beetle

Observations on the population of blister beetle in the respective plots were made at forthnightly interval during the entire cropping period and the percentage of infestation was worked out in each genotype.

$$\text{\% blister beetle infestation} = \frac{\text{Number of infested plants X 100}}{\text{Total number of plants}}$$

3.4.4.2 Incidence of Yellow Vein Mosaic Virus

Observations on Yellow Vein Mosaic disease were made in the respective plots at forthnightly interval during the entire cropping period and the percentage of incidence was worked out in each genotype.

$$\% \text{ YVMV incidence} = \frac{\text{Number of infected plants X 100}}{\text{Total number of plants}}$$

3.5 Biometrical analysis:

3.5.1 The mean, range of variation, standard error of mean and critical difference for each quantitative characters recorded during the period of investigation were worked out by the method of analysis of variance using Randomized Block Design (Panse and Sukhatme, 1989) and the treatment variance was tested against error variance by applying Fischer Shedecore 'F' test of probability at 0.05 per cent level.

3.5.2 The observations under study were recorded and were analyzed statistically for various genetical parameters. The statistical methods used are described as follows

- Genotypic and phenotypic variance (Burton and De Vane, 1953)
- Phenotypic and genotypic coefficient of variation (Burton, 1952)
- Heritability (Allard, 1960)
- Genetic advance (Lush,1949 and Johnson *et al*.,1955)
-

3.5.2.1 Estimates of genotypic and phenotypic variance

The phenotypic, genotypic and environmental variation were calculated following the method given by Burton and De Vane (1953).

3.5.2.1.1 Genotypic variance (σ^2g)

$$\sigma^2 g = \frac{MSg - MSe}{r}$$

Where, MSg : mean sum of square due to genotype

MSe : mean sum of square due to error

r : number of replication.

3.5.2.1.2 Phenotypic variance (σ^2p)

$\sigma^2 p$=$\sigma^2 g$+ σ^2e

Where, $\sigma^2 g$= genotypic variance

σ^2e = environmental variance

3.5.2.2 Coefficient of variation (CV)

3.5.2.3

The phenotypic and genotypiccoefficient of variation were calculated following the method given by Burton (1952).

3.5.2.3.1 Genotypic coefficient of variation (GCV%)

$$GCV = \frac{\sqrt{\sigma^2 g}}{\bar{x}} \times 100$$

3.5.2.2.2 Phenotypic coefficient of variation (PCV%)

$$PCV = \frac{\sqrt{\sigma^2 p}}{\bar{x}} \times 100$$

Where, σ^2g = Genotypic variation

σ^2p = Phenotypic variation

$\bar{x}$ = Mean value

3.5.2.4 Heritability (%)

Heritability in broad sense (h^2_{bs}) was calculated according to the formula suggested by Allard (1960). It was computed as the ratio of genotypic variance (σ^2g) to the phenotypic variance (σ^2p) and expressed in percentage.

$$h^2_{bs} = \frac{\sigma^2 g}{\sigma^2 p} \text{ X } 100$$

$where,$ σ^2g = Genotypic variation

σ^2p = Phenotypic variation

3.5.2.4 Genetic advance (GA)

The expected genetic advance was calculated using the formula suggested by Johnson *et al* (1955)

$$GA = K\sigma p h^2_{bs}$$

Where, K = Selection differential at 5% intensity, the value is 2.06

σp = Phenotypic standard deviation

h^2_{bs}= heritability in broad sense

The genetic advance was expressed as percentage of the mean to facilitate the comparison between different characters under study.

3.5.2.5 Correlation studies

The correlation coefficient at phenotypic and genotypic levels was determined according to the formula given by Searle (1961).

3.5.6.1 Genotypic correlation coefficient between x and y.

$$rg_{xy} = \frac{Cov.xy\ (g)}{\sqrt{Varx(g)Vary\ (g)}}$$

3.5.6.2 Phenotypic correlation coefficient between x and y.

$$rp_{xy} = \frac{Cov.xy\ (p)}{\sqrt{Varx(p)Vary\ (p)}}$$

Where,

- $Cov.xy\ (g)$,$Cov.xy(p), Cov.xy(e)$ denotes genotypic, phenotypic and environmental co-variance for the characters x and y respectively.
- $Varxg, Varx(p), Varx(e)$ denotes genotypic, phenotypic and environmental variance for the characters x.
- $Varyg, Vary(p), Vary(e)$ denotes genotypic, phenotypic and environmental variance for the characters y.

The calculated genotypic and phenotypic correlations were tested for

$t = \frac{r\sqrt{n-2}}{\sqrt{(1-r)}}$ at (n-2) degree of freedom.

Where, n = Number of genotypes

The calculated "t" value was compared with "t" value at 5% or 1% probability level with (n-2) degree of freedom for its significance.

CHAPTER IV

RESULTS

AND

DISCUSSION

RESULTS AND DISCUSSION

The results and discussion of the present investigation, "**Performance of various okra genotypes for growth, yield and quality attributes under foothill condition of Nagaland**" are presented in this chapter. In order to make the findings more comprehensive, the results obtained from the present studies have been duly supported by respective tables and figures.

4.1 Growth attributes

Performance of growth and growth attributes of various okra genotypes.

4.1.1 Plant height

The plant height of twenty-eight okra genotypes was recorded during the entire growth period at every 15 days interval. The results obtained on plant height in different genotypes have been presented in Table 4.1 and Fig 4.1. Plant height varied significantly among the genotypes. Plant height obtained from genotypes at at 105 DAS ranged from 97.47 to 176.23 cm. There was an appreciable increase with the advancement of days in the height of the plant. Genotype IIVRO-SKY/DR/RS-66 recorded maximum plant height of 176.23 cm followed by Arka Anamika which recorded a height of 167.60 cm. The minimum plant height was recorded from genotype IC-140880 at 97.47 cm.

Under the present study, growth behavior of all the twenty-eight genotypes varied considerably. In regard to plant height, the genotype IIVRO-SKY/DR/RS-66 exhibited the maximum height under all stages of growth which was followed by Arka Anamika. These genotypes were categorized as fast growers as compared to genotype IC-140880 which exhibited the minimum height. The plant height varied from 97.47 cm to 176.23 cm under the present investigation. Similar observation was recorded by Pandey *et al.* (2017) with significant variation in plant height at final harvest ranging from 102.20 cm to 178.33 cm. They reported that the maximum plant height may be because of longer internodal length. The wide variation among various genotypes in respect of plant height may be due to the fact that the growth of the plants are determined by the genetic make-up of the different genotypes, since all the genotypes were grown under the same climatic condition. This was supported by Biswas *et al.* (2016) who reported that plant height varies significantly at 25 DAS, 40 DAS, 55 DAS and 70 DAS among genotypes which might be due to the inherent characteristics of the genotype. The finding is consistent with the work of Sajjan *et al*. (2002) who reported that differential growth of crops is normally attributed to their genetic make-up. Khan *et al*. (2002) also reported that the differences in plant height may be due to its varietal nature. Similar findings were reported by Alam and Hossain (2008) who reported significant variations among 50 okra accessions. Similar results were reported by a number of researchers including Chaudhary *et al*. (2006); Hussain *et al*. (2006); Desai *et al*. (2007); Katung, (2007); Ojo *et al.* (2012); Okocha and Chinatu (2008); Rahman *et al*. (2012); Saha *et al*. (2016) who also found significant differences among different okra cultivars for plant height. Okonmah (2011) reported that there were increases in plant height with plant age for each cultivar.

Table 4.1: Growth attributes of various okra genotypes on plant height.

Genotypes	Plant height (cm) at											
	30 DAS			60 DAS			90 DAS			105 DAS		
	2013	**2014**	**Pooled**	**2013**	**2014**	**Pooled**	**2013**	**2014**	**Pooled**	**2013**	**2014**	**Pooled**
IIVRO-7	61.96	56.33	59.15	120.05	112.16	116.10	151.32	144.62	147.97	162.20	154.72	158.46
IIVRO-608-8-1	38.67	35.00	36.84	85.16	79.50	82.33	129.40	122.72	126.06	137.32	130.84	134.08
IIVRO-SKY/DR/RS-107	38.04	34.10	36.07	76.71	68.71	72.71	97.78	91.12	94.45	108.50	100.36	104.43
IC-042484-B	47.99	42.50	45.24	111.33	102.86	107.10	141.25	134.26	137.76	150.47	142.25	146.36
IC-140880	33.75	30.25	32.00	69.11	65.93	67.52	90.62	85.92	88.27	100.62	94.32	97.47
IIVRO-212-10-1	46.70	42.15	44.42	106.60	100.33	103.47	132.45	126.64	129.55	140.55	132.68	136.62
IIVRO-599-8-1	52.00	49.47	50.74	115.27	109.60	112.44	145.20	138.56	141.88	155.00	148.82	151.91
IC-69257	42.96	41.48	42.22	100.69	93.70	97.19	128.12	121.12	124.62	135.44	129.35	132.39
IIVRO-770	43.14	38.75	40.95	101.15	95.87	98.51	130.82	124.45	127.64	140.50	134.62	137.56
IIVRO-SC-108	62.70	58.20	60.45	123.50	117.50	120.50	152.00	145.10	148.55	168.65	160.30	164.47
IIVRO-307-10-1 II	47.87	44.73	46.30	111.11	105.20	108.15	136.95	128.42	132.69	145.60	138.22	141.91
IIVRO-SKY/DR/RS-66	69.54	63.42	66.48	143.20	138.00	140.60	170.56	165.24	167.90	180.00	172.45	176.23
Kashi Kranti	38.75	36.25	37.50	87.75	81.25	84.50	107.85	100.45	104.15	116.20	110.62	113.41
IIVRO-3	49.46	43.85	46.65	114.05	107.24	110.65	146.20	138.52	142.36	156.35	150.74	153.54
IIVRO-419-01-1	44.84	41.00	42.92	106.00	97.85	101.93	130.75	124.28	127.52	140.50	135.00	137.75
IIVRO-325-10-1	48.32	43.67	45.99	113.70	107.25	110.48	132.35	125.46	128.90	142.42	137.76	140.09
IIVRO-130-10-1	45.95	41.98	43.97	106.44	98.22	102.33	135.00	129.65	132.33	144.84	138.82	141.83
IIVRO-1773	44.06	39.67	41.86	105.47	98.62	102.04	129.22	120.78	125.00	139.22	132.26	135.74
IIVRO-49	56.98	51.38	54.18	119.87	111.67	115.77	147.56	140.02	143.79	156.65	150.58	153.61
IIVRO-363	42.03	41.89	41.96	95.60	88.35	91.98	122.95	115.30	119.13	130.12	125.32	127.72
IC-218844	54.10	50.20	52.15	117.03	108.86	112.94	145.72	139.56	142.64	155.30	150.45	152.88
IC-45831	40.57	36.58	38.58	93.08	87.54	90.31	115.00	108.80	111.90	124.92	120.72	122.82
IIVRO-137-10-1,2	39.00	35.77	37.38	87.75	78.50	83.13	112.68	105.32	109.00	120.16	114.86	117.51
IIVRO-814-K	49.47	46.20	47.83	114.25	108.25	111.25	145.95	138.78	142.37	155.25	150.48	152.87
IC-039140	40.29	36.02	38.15	91.52	84.32	87.92	112.80	107.20	110.00	120.52	114.92	117.72
IC-117319	42.04	38.50	40.27	98.36	92.58	95.47	124.12	116.12	120.12	132.44	124.50	128.47
Arka Anamika	69.00	64.85	66.92	142.25	136.29	139.27	162.26	154.62	158.44	170.65	164.55	167.60
Prabhani Kranti	64.28	59.69	61.99	136.50	130.75	133.63	155.40	148.16	151.78	165.20	160.62	162.91
SEm±	1.64	1.51	1.11	3.55	3.40	2.46	4.77	4.20	3.18	5.62	5.00	3.76
CD at 5%	4.64	4.27	3.12	10.07	9.64	6.89	13.52	11.90	8.90	15.94	14.19	10.55

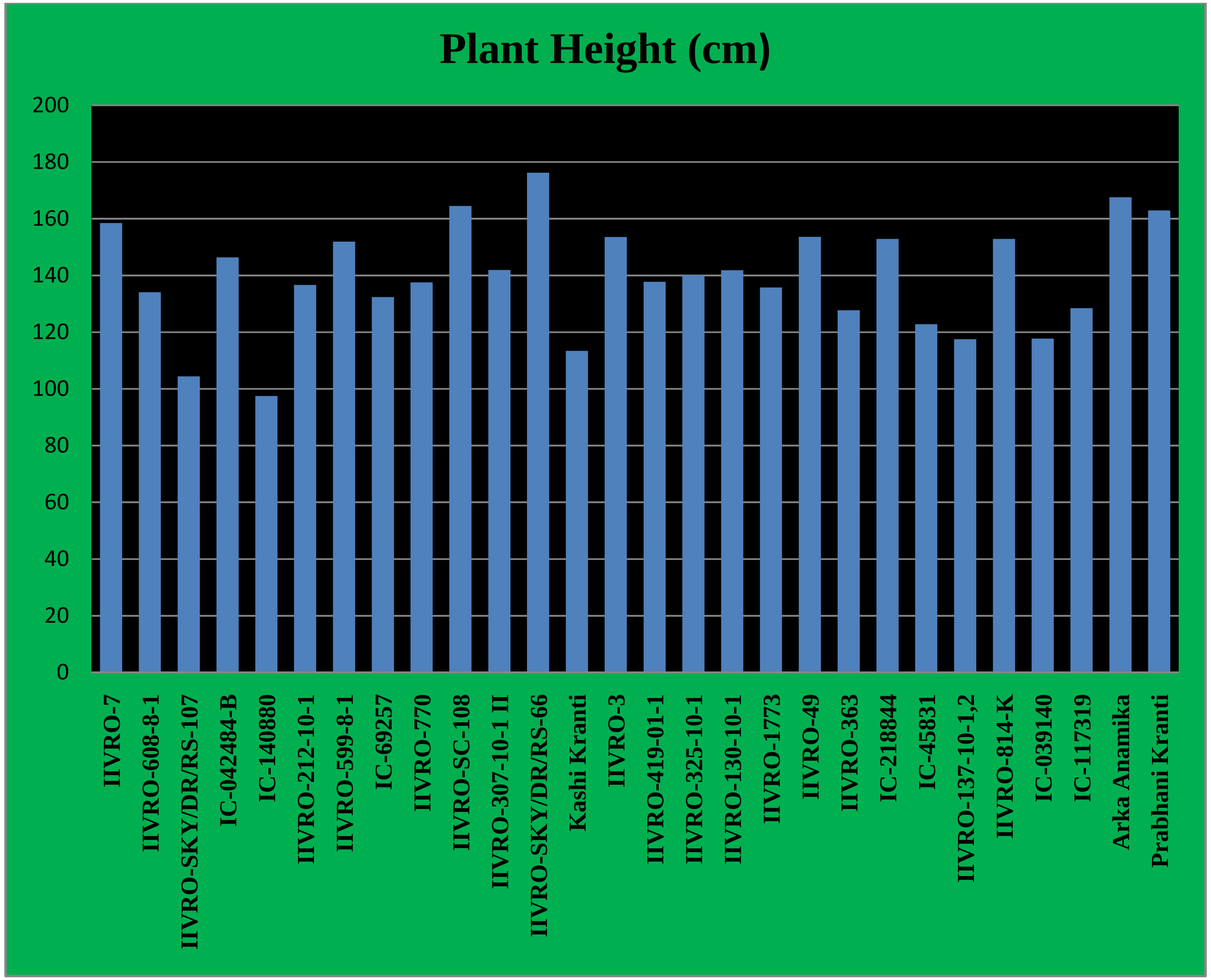

Figure 4.1: Growth attributes of various okra genotypes on plant height.

4.1.2 Number of leaves per plant

The data on the number of leaves per plant of different genotypes are shown in table 4.2 and Fig 4.2. Different genotypes show variable behavior on the number of leaves per plant. The maximum number of leaves recorded (44.06) was from genotype IIVRO-608-8-1 which was followed by genotype IIVRO-770 *i.e.* 41.57. The minimum number of leaves per plant recorded was 13.01 from genotype IC-140880.

The attainment of the highest number of leaves by genotype IIVRO-608-8-1 and least number of leaves by genotype IC-140880 may be due to the genetic make-up of the genotype which influences the performance of a crop. Alam and Hossain, (2008) reported significant variation in respect of number of leaves per plant and are in conformity with the findings of Gondane and Bahatia (1995); Martin and Rhodes, (1983); Okocha and Chinatu (2008); Biswas *et al.* (2016); Saha *et al*. (2016) who found significant varietal differences for the number of leaves per plant in okra. Khan (2003) reported that the number of leaves increased with the age of plants though the differences in the number of leaves between the cultivars depend upon the inherent characters of the respective cultivars. Sajjan *et al.* (2002) also reported that growth parameters such as number of leaves was enhanced by genetic factors.

4.1.3 Size of leaf

The data on the size of leaves per plant of different genotypes are shown in Table 4.3 and fig 4.3. Different genotypes show variable behavior on the size of leaves per plant. The maximum size of leaves recorded was 680.17 cm^2 from genotype IIVRO-608-8-1 which was followed by genotype IIVRO-770 *i.e.* 601.33

Table 4.2: Growth attributes of various okra genotypes on number of leaves.

Genotypes	Number of leaves plant^{-1} at											
	30 DAS			60 DAS			90 DAS			105 DAS		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
IIVRO-7	9.00	8.33	8.67	16.20	15.00	15.60	29.00	27.00	28.00	33.66	31.83	32.74
IIVRO-608-8-1	13.35	12.00	12.68	28.00	24.00	26.00	39.00	35.50	37.25	46.23	41.90	44.06
IIVRO-SKY/DR/RS-107	8.80	8.00	8.40	19.00	17.20	18.10	28.00	26.00	27.00	30.27	29.10	29.69
IC-042484-B	8.00	6.50	7.25	12.10	11.30	11.70	16.00	15.60	15.80	16.95	15.21	16.08
IC-140880	7.00	6.00	6.50	10.00	9.50	9.75	12.10	11.60	11.85	13.50	12.52	13.01
IIVRO-212-10-1	8.50	8.33	8.42	16.25	15.50	15.88	23.50	20.00	21.75	25.37	23.21	24.29
IIVRO-599-8-1	8.50	7.66	8.08	14.00	13.66	13.83	19.55	18.00	18.78	22.13	20.91	21.52
IC-69257	7.20	6.00	6.60	11.00	10.50	10.75	14.50	11.80	13.15	15.19	12.22	13.71
IIVRO-770	12.00	11.33	11.67	24.00	21.00	22.50	37.00	33.00	35.00	42.73	40.40	41.57
IIVRO-SC-108	9.00	8.50	8.75	26.00	21.00	23.50	33.00	30.00	31.50	35.68	35.61	35.65
IIVRO-307-10-1 II	7.30	6.50	6.90	13.50	12.80	13.15	17.25	15.80	16.53	18.44	16.76	17.60
IIVRO-SKY/DR/RS-66	8.50	8.00	8.25	17.00	16.50	16.75	21.50	20.70	21.10	23.25	21.20	22.23
Kashi Kranti	8.25	7.66	7.96	15.00	12.66	13.83	19.00	18.20	18.60	21.99	20.00	21.00
IIVRO-3	8.70	7.66	8.18	17.00	15.66	16.33	23.00	20.45	21.73	24.72	21.93	23.33
IIVRO-419-01-1	7.95	7.20	7.58	15.50	13.00	14.25	19.00	17.80	18.40	20.58	19.16	19.87
IIVRO-325-10-1	7.80	7.00	7.40	11.50	10.66	11.08	15.95	14.00	14.98	17.22	15.55	16.39
IIVRO-130-10-1	8.20	7.42	7.81	16.00	15.25	15.63	21.00	19.15	20.08	24.54	21.86	23.20
IIVRO-1773	7.65	6.80	7.23	12.00	11.40	11.70	14.90	14.00	14.45	15.46	14.52	14.99
IIVRO-49	7.80	6.00	6.90	11.20	10.50	10.85	15.00	11.50	13.25	15.37	12.90	14.14
IIVRO-363	9.50	8.66	9.08	17.50	16.33	16.92	25.00	22.00	23.50	28.30	25.91	27.11
IC-218844	12.00	10.50	11.25	19.00	17.77	18.38	27.00	25.00	26.00	29.66	28.18	28.92
IC-45831	8.00	6.50	7.25	17.00	15.33	16.17	23.00	19.50	21.25	26.57	21.81	24.19
IIVRO-137-10-1,2	8.60	8.00	8.30	17.00	15.75	16.38	22.00	19.50	20.75	24.27	20.89	22.58
IIVRO-814-K	7.50	6.80	7.15	15.50	14.00	14.75	21.00	19.00	20.00	23.31	22.00	22.66
IC-039140	7.33	6.50	6.92	14.00	13.50	13.75	18.00	17.55	17.78	20.36	19.01	19.69
IC-117319	8.70	7.00	7.85	19.50	17.00	18.25	27.00	24.00	25.50	30.48	28.28	29.38
Arka Anamika	13.00	10.60	11.80	25.50	22.00	23.75	34.50	31.00	32.75	37.29	35.10	36.20
Prabhani Kranti	8.00	7.50	7.75	20.50	19.00	19.75	28.00	26.00	27.00	31.36	28.29	29.82
SEm±	1.02	0.89	0.68	2.04	2.03	1.44	2.38	2.35	1.67	1.38	1.34	0.96
CD at 5%	2.90	2.53	1.90	5.78	5.74	4.03	6.74	6.65	4.68	3.92	3.80	2.70

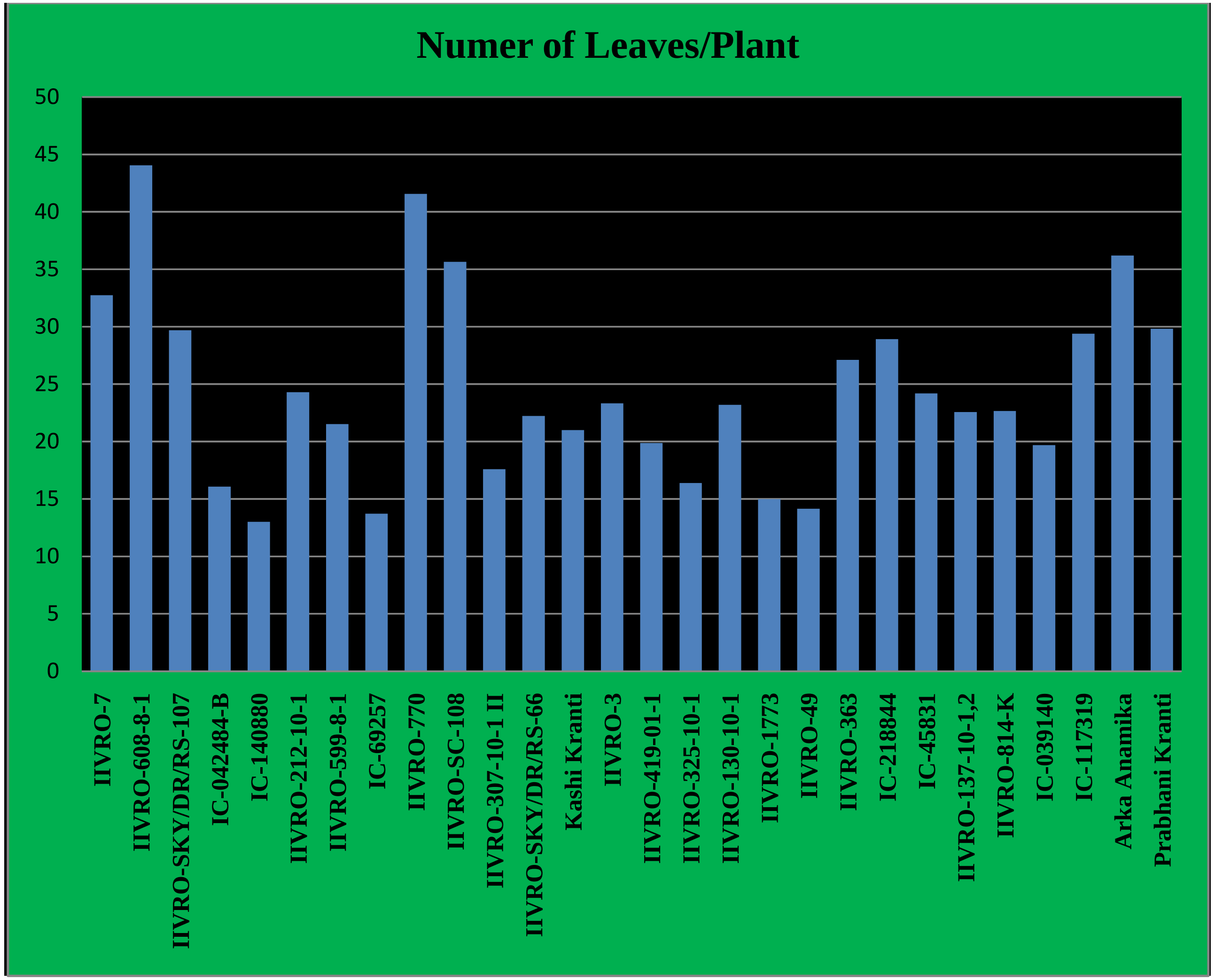

Figure 4.2: Growth attributes of various okra genotypes on number of leaves.

Table 4.3: Growth attributes of various okra genotypes on size of leaf.

Genotypes	Size of leaf (cm)		
	2013	2014	Pooled
IIVRO-7	319.51	302.84	311.17
IIVRO-608-8-1	698.50	661.83	680.17
IIVRO-SKY/DR/RS-107	365.87	349.20	357.54
IC-042484-B	316.45	303.45	309.95
IC-140880	227.07	209.74	218.40
IIVRO-212-10-1	364.61	327.94	346.28
IIVRO-599-8-1	540.25	513.58	526.92
IC-69257	260.28	240.28	250.28
IIVRO-770	609.66	592.99	601.33
IIVRO-SC-108	501.53	488.20	494.86
IIVRO-307-10-1 II	345.55	322.22	333.88
IIVRO-SKY/DR/RS-66	488.41	447.74	468.07
Kashi Kranti	348.77	315.44	332.10
IIVRO-3	284.32	270.99	277.65
IIVRO-419-01-1	476.91	430.24	453.58
IIVRO-325-10-1	419.65	402.98	411.32
IIVRO-130-10-1	307.04	293.70	300.37
IIVRO-1773	435.43	405.43	420.43
IIVRO-49	266.49	236.49	251.49
IIVRO-363	404.08	390.75	397.41
IC-218844	320.30	306.97	313.63
IC-45831	311.20	294.53	302.87
IIVRO-137-10-1,2	414.88	394.88	404.88
IIVRO-814-K	276.54	253.21	264.87
IC-039140	402.12	397.79	399.95
IC-117319	362.50	335.83	349.17
Arka Anamika	554.63	524.63	539.63
Prabhani Kranti	443.44	393.44	418.44
SEm±	21.94	14.57	13.17
CD at 5%	62.22	41.31	36.92

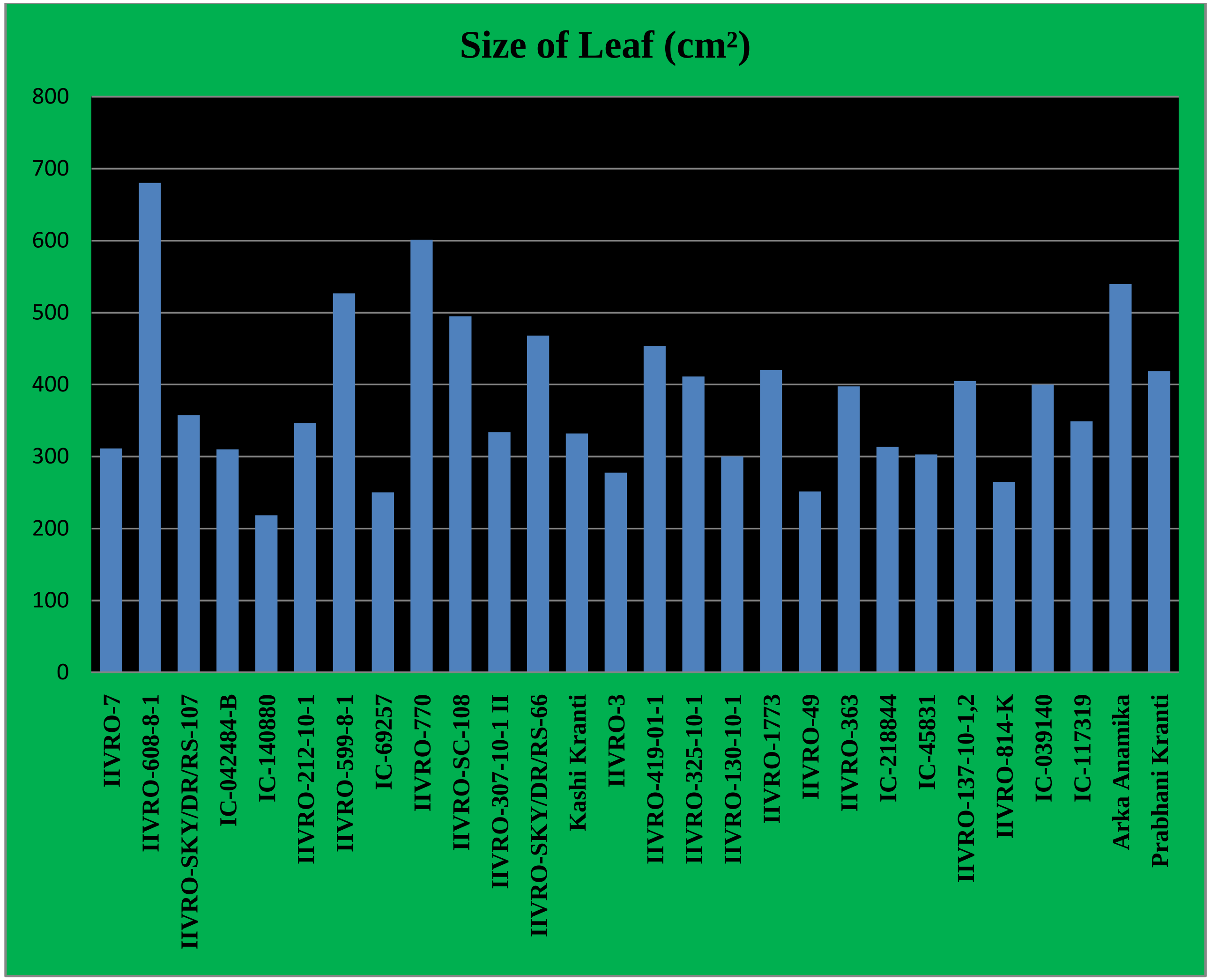

Figure 4.3: Growth attributes of various okra genotypes on size of leaf.

cm^2. The minimum size of leaves recorded was 218.40 cm^2 from genotype IC-140880.

The attainment of the maximum size of leaves by genotype IIVRO-608-8-1 and minimum size of leaves by genotype IC-140880 may be due to the genetic make-up of the genotype which influences the performance of a crop. In regard to breadth of leaf, Alam and Hossain (2008) reported that the breadth of the leaf varied significantly among 50 okra accessions. These results agreed with the findings of Martin and Rhodes (1983). With regard to the length of the leaf, Alam and Hossain, (2008) and Gondane and Bahatia (1995) observed that it varied significantly in different okra varieties.

4.1.4 Cumulative leaf area

The data on the cumulative leaf area of different genotypes are shown in Table 4.4 and fig 4.4. Different genotypes show variable behavior on the cumulative leaf area. The maximum cumulative leaf area recorded was 3.00 m^2 from genotype IIVRO-608-8-1 which was followed by genotype IIVRO-770 *i.e.* 2.50. The minimum cumulative leaf area recorded was 0.29 m^2 from genotype IC-140880.

The attainment of the maximum cumulative leaf area by genotype IIVRO-608-8-1 and minimum cumulative leaf area by genotype IC-140880 may be due to the genetic make-up of the genotype which influences the performance of a crop. Singh et al. (2006) reported reported that maximum variability among the okra genotypes exist for cumulative leaf area.

Table 4.4: Growth attributes of various okra genotypes on cumulative leaf area.

Genotypes	**Cumulative leaf area (m^2)**		
	2013	**2014**	**Pooled**
IIVRO-7	1.08	0.96	1.02
IIVRO-608-8-1	3.23	2.78	3.00
IIVRO-SKY/DR/RS-107	1.10	1.01	1.06
IC-042484-B	0.54	0.45	0.50
IC-140880	0.31	0.26	0.29
IIVRO-212-10-1	0.93	0.76	0.84
IIVRO-599-8-1	1.19	1.07	1.13
IC-69257	0.41	0.29	0.35
IIVRO-770	2.61	2.40	2.50
IIVRO-SC-108	1.79	1.74	1.77
IIVRO-307-10-1 II	0.64	0.54	0.59
IIVRO-SKY/DR/RS-66	1.14	0.93	1.03
Kashi Kranti	0.77	0.63	0.70
IIVRO-3	0.70	0.59	0.65
IIVRO-419-01-1	0.98	0.82	0.90
IIVRO-325-10-1	0.72	0.62	0.67
IIVRO-130-10-1	0.75	0.65	0.70
IIVRO-1773	0.67	0.59	0.63
IIVRO-49	0.40	0.31	0.36
IIVRO-363	1.14	1.02	1.08
IC-218844	0.95	0.87	0.91
IC-45831	0.83	0.64	0.74
IIVRO-137-10-1,2	1.01	0.83	0.92
IIVRO-814-K	0.64	0.56	0.60
IC-039140	0.82	0.75	0.79
IC-117319	1.10	0.95	1.03
Arka Anamika	2.07	1.84	1.96
Prabhani Kranti	1.40	1.11	1.26
SEm±	0.10	0.07	0.06
CD at 5%	0.27	0.19	0.17

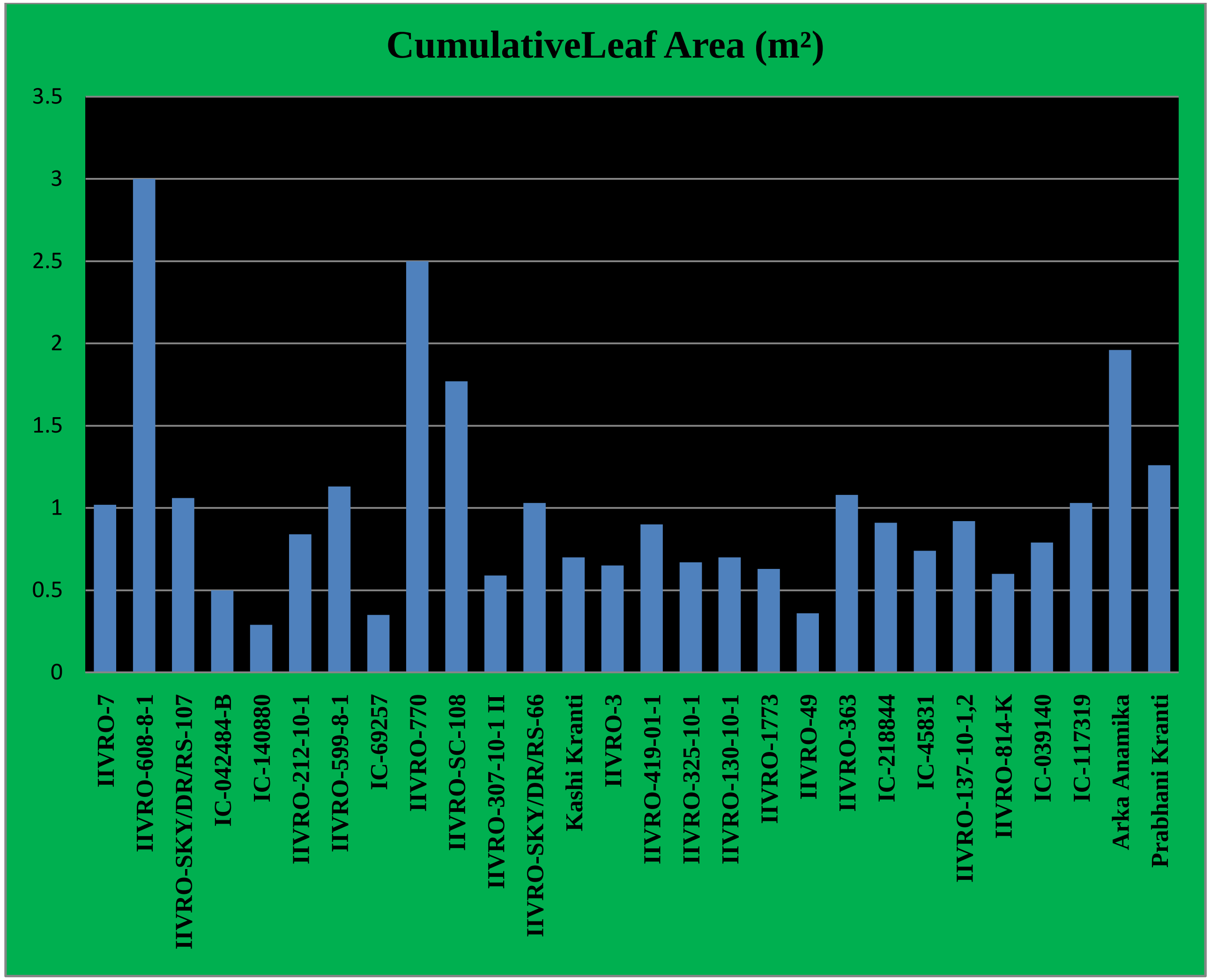

Figure 4.4: Growth attributes of various okra genotypes on cumulative leaf area.

4.1.5 Leaf area index

The data on the leaf area index of different genotypes are shown in Table 4.5 and fig 4.5. Different genotypes show variable behavior on the leaf area index. The maximum leaf area index recorded was 22.25 from genotype IIVRO-608-8-1 which was followed by genotype IIVRO-770 *i.e.* 18.54. The minimum leaf area index recorded was 2.12 from genotype IC-140880.

The attainment of the maximum leaf area index by genotype IIVRO-608-8-1 and minimum leaf area index by genotype IC-140880 may be due to the genetic make-up of the genotype which influences the performance of a crop. Patro and Ravisankar (2004) reported that maximum variability among the okra genotypes exist for leaf area index.

4.1.6 Number of branches per plant

The data taken for number of branches per plant are given in Table 4.6 and fig 4.6. The number of branches per plant recorded at the time of final harvest showed significant difference among genotypes. Among the genotypes, the genotype IIVRO-SKY/DR/RS-107 was found to be significantly superior over other genotypes which recorded the maximum number of branches per plant (2.45). The minimum number of branches per plant was recorded from genotype IC-45831 (0.74).

Number of branches per plant was greatly influenced by different genotypes. Highest number of branches per plant was recorded from the genotype IIVRO-SKY/DR/RS-107 and the lowest number of branches per plant was recorded from the genotype IC-45831. The character like number of

Table 4.5: Growth attributes of various okra genotypes on leaf area index.

Genotypes	Leaf area index		
	2013	2014	Pooled
IIVRO-7	7.98	7.13	7.55
IIVRO-608-8-1	23.93	20.57	22.25
IIVRO-SKY/DR/RS-107	8.18	7.51	7.84
IC-042484-B	3.99	3.36	3.67
IC-140880	2.29	1.95	2.12
IIVRO-212-10-1	6.87	5.62	6.25
IIVRO-599-8-1	8.82	7.95	8.39
IC-69257	3.01	2.15	2.58
IIVRO-770	19.33	17.74	18.54
IIVRO-SC-108	13.28	12.88	13.08
IIVRO-307-10-1 II	4.74	4.00	4.37
IIVRO-SKY/DR/RS-66	8.42	6.88	7.65
Kashi Kranti	5.68	4.67	5.17
IIVRO-3	5.19	4.40	4.80
IIVRO-419-01-1	7.25	6.07	6.66
IIVRO-325-10-1	5.36	4.62	4.99
IIVRO-130-10-1	5.58	4.79	5.18
IIVRO-1773	4.96	4.36	4.66
IIVRO-49	2.96	2.30	2.63
IIVRO-363	8.43	7.54	7.99
IC-218844	7.05	6.42	6.74
IC-45831	6.14	4.77	5.46
IIVRO-137-10-1,2	7.48	6.14	6.81
IIVRO-814-K	4.76	4.16	4.46
IC-039140	6.04	5.59	5.82
IC-117319	8.18	7.02	7.60
Arka Anamika	15.36	13.65	14.50
Prabhani Kranti	10.39	8.24	9.32
SEm±	0.72	0.50	0.44
CD at 5%	2.03	1.43	1.23

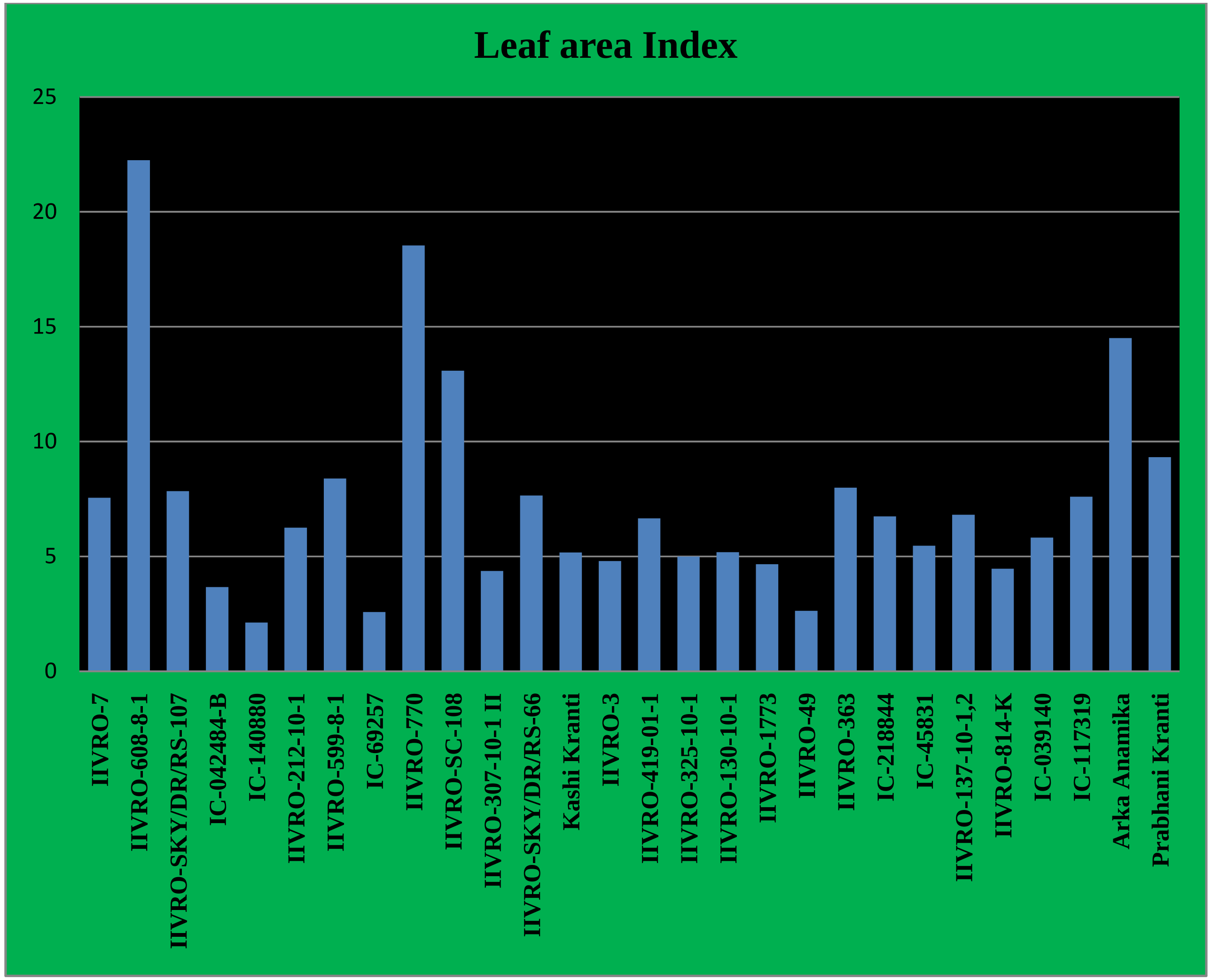

Figure 4.5: Growth attributes of various okra genotypes on leaf area index.

Table 4.6: Growth attributes of various okra genotypes on number of branches per plant

Genotypes	Number of branches plant^{-1}		
	2013	2014	Pooled
IIVRO-7	2.26	2.22	2.24
IIVRO-608-8-1	2.01	1.98	2.00
IIVRO-SKY/DR/RS-107	2.47	2.43	2.45
IC-042484-B	0.91	0.89	0.90
IC-140880	2.11	1.90	2.01
IIVRO-212-10-1	1.45	1.43	1.44
IIVRO-599-8-1	1.43	1.36	1.40
IC-69257	1.30	1.27	1.29
IIVRO-770	2.00	1.98	1.99
IIVRO-SC-108	2.00	1.98	1.99
IIVRO-307-10-1 II	1.25	1.25	1.25
IIVRO-SKY/DR/RS-66	1.85	1.79	1.82
Kashi Kranti	2.10	1.90	2.00
IIVRO-3	1.83	1.81	1.82
IIVRO-419-01-1	2.40	2.38	2.39
IIVRO-325-10-1	1.25	1.24	1.24
IIVRO-130-10-1	1.80	1.77	1.79
IIVRO-1773	1.25	1.22	1.24
IIVRO-49	1.65	1.63	1.64
IIVRO-363	1.02	1.00	1.01
IC-218844	1.41	1.40	1.41
IC-45831	0.75	0.73	0.74
IIVRO-137-10-1,2	2.15	2.14	2.15
IIVRO-814-K	1.63	1.57	1.60
IC-039140	0.82	0.78	0.80
IC-117319	1.00	1.00	1.00
Arka Anamika	1.75	1.72	1.74
Prabhani Kranti	1.66	1.65	1.66
SEm±	0.12	0.12	0.09
CD at 5%	0.33	0.35	0.24

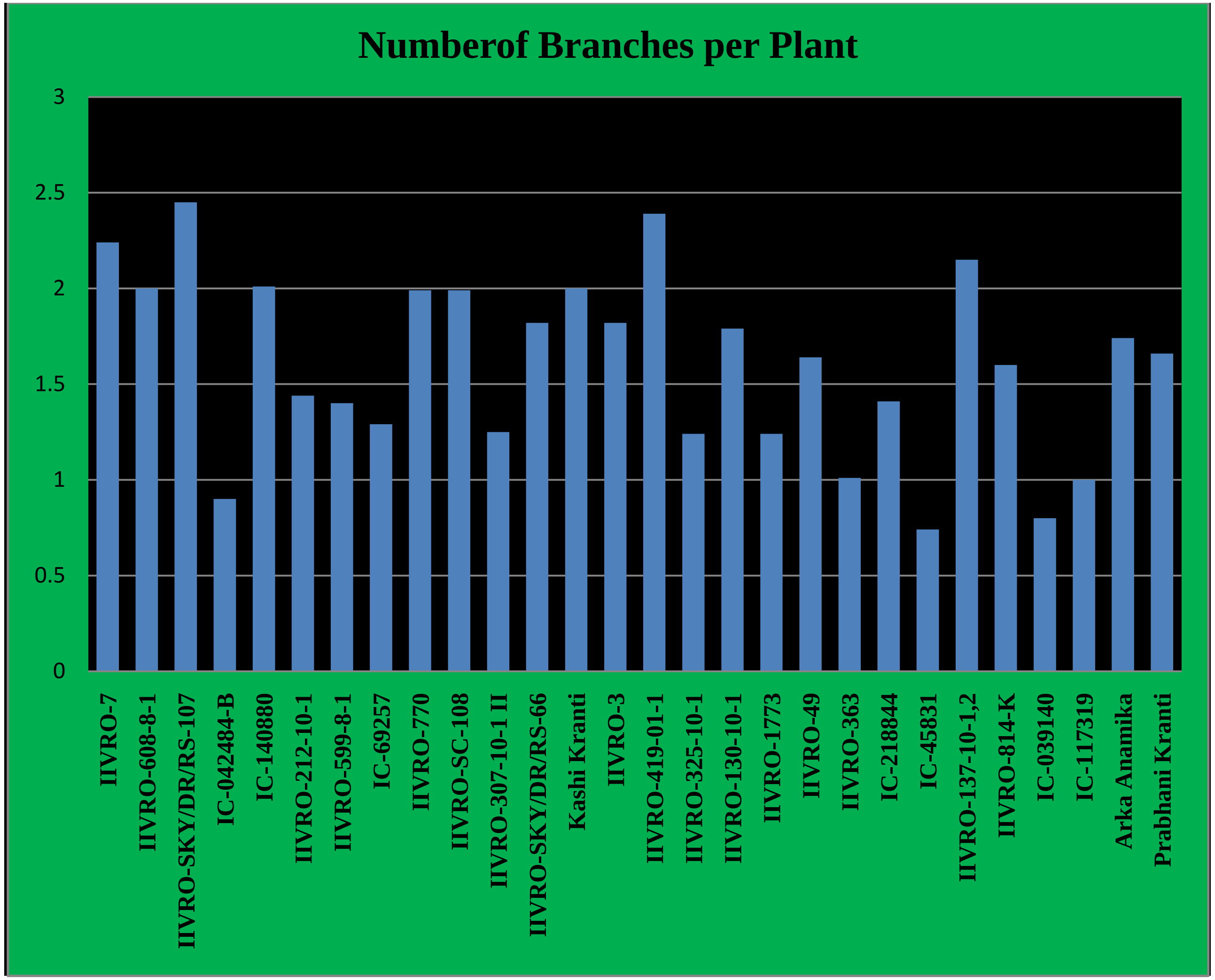

Figure 4.6: Growth attributes of various okra genotypes on number of branches per plant

branches per plant depends on the genetic make-up of the genotype. Pandey *et al.* (2017) also revealed significant differences among genotypes with a range of 1.38 to 2.30 and reported that the differences may be the result of variation in its genetic makeup and environmental conditions prevailing during the growth period. These findings are in conformity with Alam and Hossain (2008) who observed significant variation for number of primary branches per plant among 50 okra accessions. Similarly, Dash and Misra (1995) observed significant number of primary branches per plant among 27 okra cultivars. Similar results were reported by a number of researchers including Kunwar *et al.* (2001); Halim (2008); Islam *et al*. (2000); Saha *et al*. (2016); Shivaramegowda *et al.* (2016); Biswas *et al.* (2016) who observed cultivar variations in respect to the number of branches per plant.

4.1.7 Days to first flowering

Table 4.7 and fig 4.7 depicted data on duration of flowering. Data showed that the genotypes differ significantly in the days taken for first flowering. Maximum (53.68 days) duration of flowering was observed in genotype IC-039140 and minimum (42.52 days) days taken for first flowering was observed in genotype IIVRO-770.

Days taken to first flowering was significantly affected by genotypes. It was noted that number of days taken to first flowering ranged from 42.52 days (IIVRO-770) to 53.68 days (IC-039140). The wide variation among genotypes with respect to number of days taken for first flowering may be due to the genetic make-up of the crop or due to the environmental condition. These results are in accordance to the findings of Amjad *et al.* (2001) who reported that

Table 4.7: Growth attributes of various okra genotypes on days to first flowering.

Genotypes	Days to first flowering (Days)		
	2013	2014	Pooled
IIVRO-7	46.83	47.53	47.18
IIVRO-608-8-1	46.87	48.17	47.52
IIVRO-SKY/DR/RS-107	46.90	48.87	47.88
IC-042484-B	46.67	47.13	46.90
IC-140880	45.00	47.43	46.22
IIVRO-212-10-1	45.63	46.37	46.00
IIVRO-599-8-1	47.20	47.67	47.43
IC-69257	48.20	48.60	48.40
IIVRO-770	42.83	42.20	42.52
IIVRO-SC-108	43.57	45.43	44.50
IIVRO-307-10-1 II	46.80	48.73	47.77
IIVRO-SKY/DR/RS-66	46.73	47.13	46.93
Kashi Kranti	52.90	54.27	53.58
IIVRO-3	45.26	47.20	46.23
IIVRO-419-01-1	46.33	47.13	46.73
IIVRO-325-10-1	45.30	44.93	45.12
IIVRO-130-10-1	48.37	48.80	48.58
IIVRO-1773	43.83	44.33	44.08
IIVRO-49	47.17	47.73	47.45
IIVRO-363	45.03	45.33	45.18
IC-218844	48.20	48.73	48.47
IC-45831	50.47	51.60	51.03
IIVRO-137-10-1,2	48.03	48.83	48.43
IIVRO-814-K	44.73	45.00	44.87
IC-039140	53.23	54.13	53.68
IC-117319	47.07	44.93	46.00
Arka Anamika	49.60	48.07	48.83
Prabhani Kranti	47.97	48.03	48.00
SEm±	1.74	1.48	1.14
CD at 5%	4.93	4.20	3.20

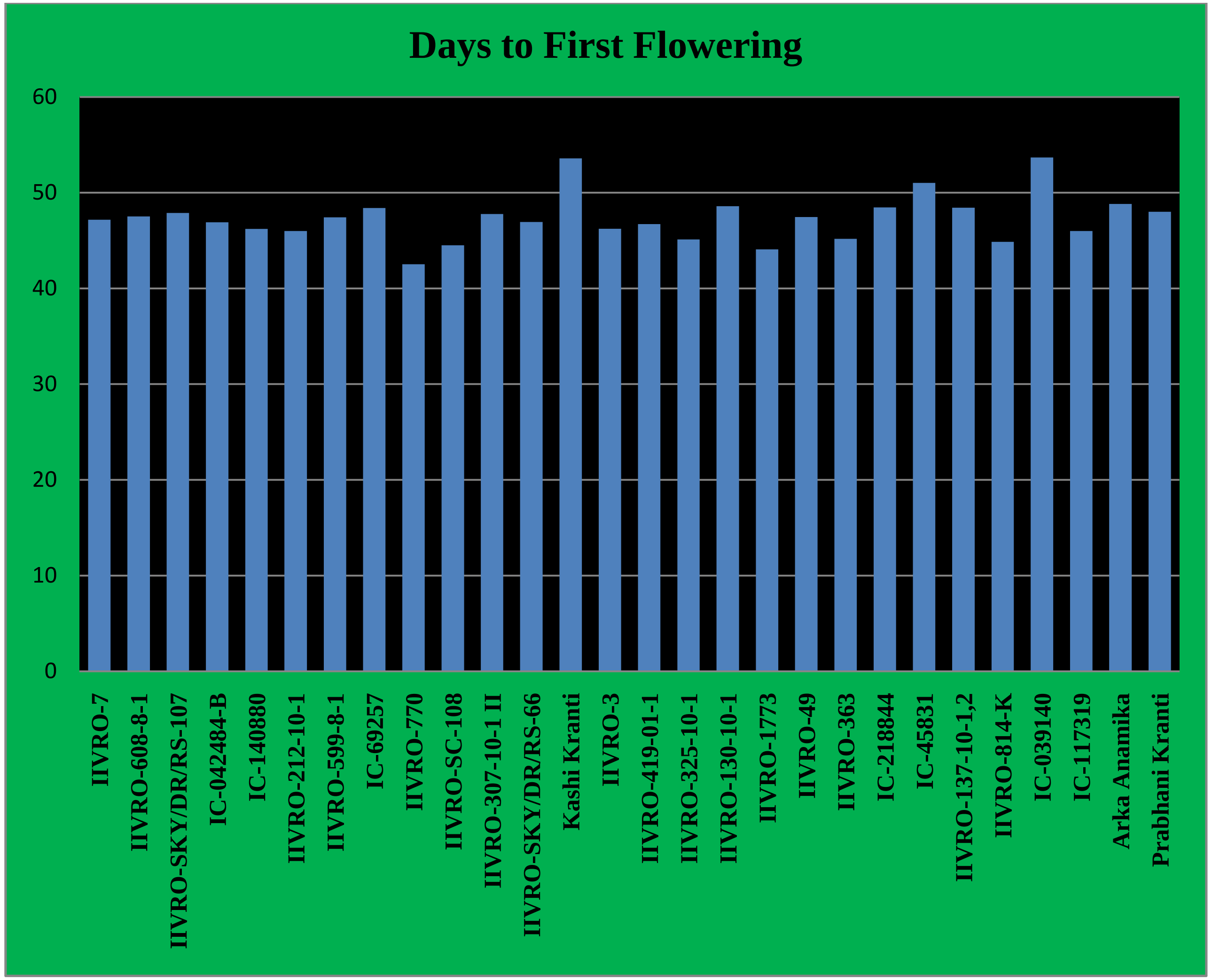

Figure 4.7: Growth attributes of various okra genotypes on days to first flowering.

the difference in the number of days to flowering might be due to genetic variation among the cultivars because all the cultural practices were kept uniform for all the cultivars. The early flowering may be attributed to genetic makeup of the cultivars. These findings are also in close proximity with Ali (1999) who reported that it requires 47 days to initiate flowering. Similarly, Jamala *et al.* (2011) observed varietal differences in days of flowering and concluded that the prevailing climatic and environmental conditions may allow for better expression of genetic potentials of the varieties thereby enticing their differential performance. Also the most important factor for production, solar radiation might have been utilized differently by the varieties. Salau and Makinde (2015) also opined that the number of days to flowering was affected by cultivar. Rahman *et al*. (2012) observed that Arka-Anamika took significantly the least days to flowering (45.67) which shows that Anamika matures earlier and stands a better chance of earlier returns than the other cultivars. He reported that this may be due to the fact that the soil, prevailing climatic and environmental conditions may have been more conducive to allow for better expression of the genetic potentials of the varieties thereby eliciting their differential performance. These results coincide with the previous findings of Dash and Misra (1995); Shri-Dhar and Dhar (1995); Ashraful and Hossain (2006); Katung (2007); Ojo *et al*. (2012) who also found similar behavior amongst the different okra cultivars for days to flowering.

4.1.8 Number of nodes for first flower

Table 4.8 and fig 4.8 depicted data on days taken for number of nodes on which the first flower appears on the plants. Data showed that the genotypes differ significantly in the number of nodes for first flower. The genotype Kashi Kranti

Table 4.8: Growth attributes of various okra genotypes on number of nodes for first flower.

Genotypes	**Number of nodes for first flower**		
	2013	**2014**	**Pooled**
IIVRO-7	5.40	5.60	5.50
IIVRO-608-8-1	6.70	6.80	6.75
IIVRO-SKY/DR/RS-107	6.20	6.40	6.30
IC-042484-B	5.20	5.40	5.30
IC-140880	6.50	6.80	6.65
IIVRO-212-10-1	6.30	6.40	6.35
IIVRO-599-8-1	5.90	6.00	5.95
IC-69257	6.30	6.40	6.35
IIVRO-770	4.90	5.00	4.95
IIVRO-SC-108	5.20	5.40	5.30
IIVRO-307-10-1 II	6.00	6.00	6.00
IIVRO-SKY/DR/RS-66	6.40	6.60	6.50
Kashi Kranti	7.20	7.40	7.30
IIVRO-3	6.80	7.00	6.90
IIVRO-419-01-1	5.50	5.60	5.55
IIVRO-325-10-1	6.10	6.33	6.22
IIVRO-130-10-1	6.50	6.60	6.55
IIVRO-1773	6.20	6.40	6.30
IIVRO-49	6.30	6.40	6.35
IIVRO-363	6.20	6.40	6.30
IC-218844	4.90	5.00	4.95
IC-45831	5.50	5.60	5.55
IIVRO-137-10-1,2	6.50	6.80	6.65
IIVRO-814-K	5.60	5.80	5.70
IC-039140	6.60	6.80	6.70
IC-117319	6.50	6.80	6.65
Arka Anamika	6.40	6.60	6.50
Prabhani Kranti	6.10	6.20	6.15
SEm±	0.19	0.31	0.18
CD at 5%	0.55	0.89	0.52

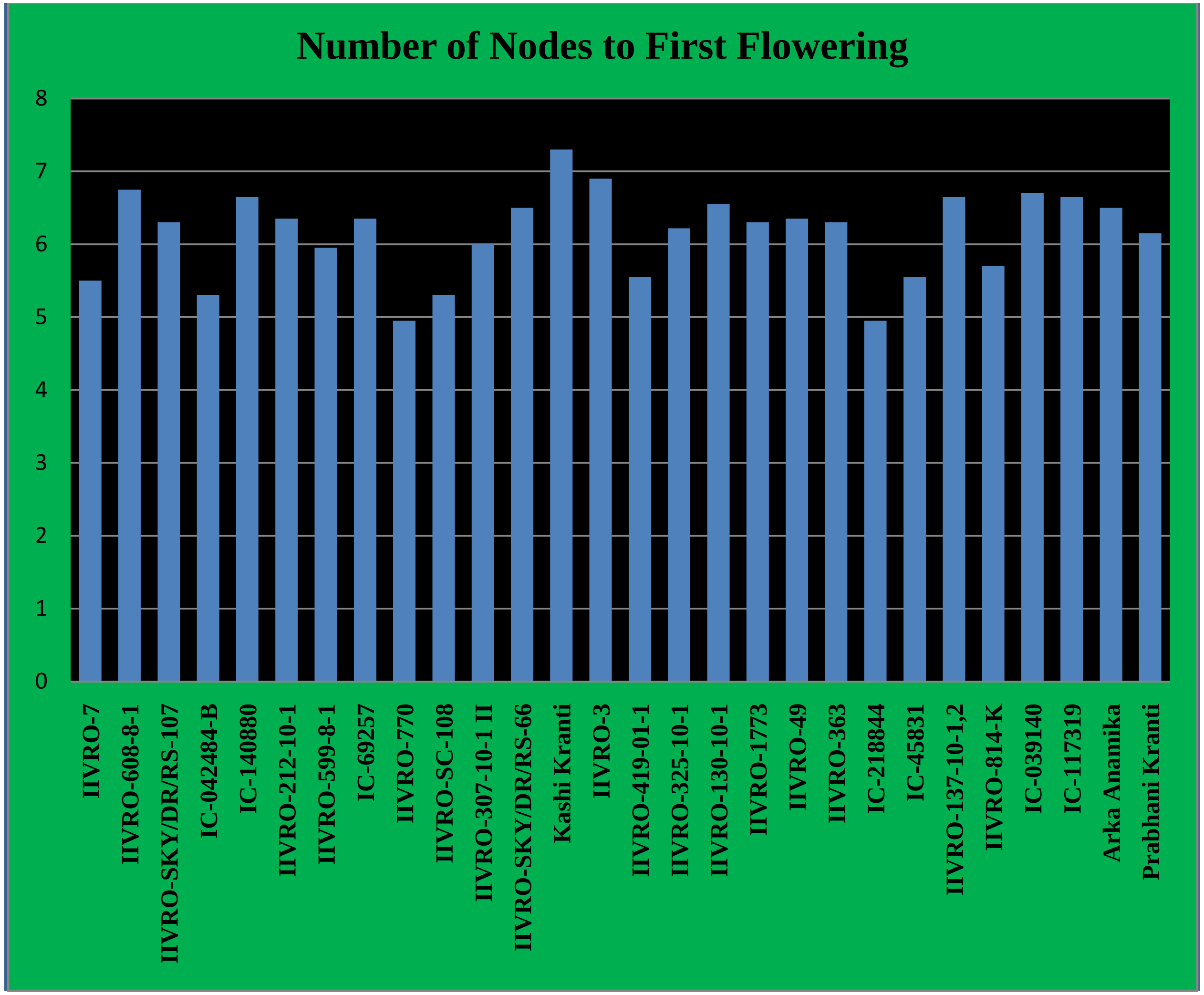

Figure 4.8: Growth attributes of various okra genotypes on number of nodes for first flower.

showed maximum number of nodes for the first flower to appear on the plants at 7.30 node from ground level. Minimum number of nodes for the first flower to appear on the plants was observed in genotypes IIVRO-770 and IC-218844 at 4.95 node from ground level.

Numbers of nodes for first flower were greatly influenced by different genotypes. The number of nodes for first flower ranged from 4.95 to 7.30 with an overall average of 6.12. Das *et al.* (2012) reported that number of nodes for first flower ranged from 4.60 to 5.92 whereas Karri and Acharyya (2012) reported that number of nodes for first flower ranged from 4.10 to 4.63. The present result is within the range of reported results. The wide variation among genotypes with respect to number of nodes on which the first flower appear on the plants may be due to the genetic make-up of the crop or due to the environmental condition. This is in conformity with Pandey *et al.* (2017) who reported that early flowering may be due to the better adaptability and genetic performance of the genotypes. Similar results were also found by Mohapatra *et al.* (2007).

4.1.9 Duration of flowering

Table 4.9 and fig 4.9 depicted data on duration of flowering. Data showed that the genotypes differ significantly in the duration of flowering. Maximum (62.48 days) duration of flowering was observed in genotype IIVRO-770 and minimum (51.32 days) duration of flowering was observed in genotype IC-039140.

Table 4.9: Growth attributes of various okra genotypes on duration of flowering

Genotypes	Duration of flowering (Days)		
	2013	2014	Pooled
IIVRO-7	58.17	57.47	57.82
IIVRO-608-8-1	58.13	56.83	57.48
IIVRO-SKY/DR/RS-107	58.10	56.13	57.12
IC-042484-B	58.33	57.87	58.10
IC-140880	60.00	57.57	58.78
IIVRO-212-10-1	59.37	58.63	59.00
IIVRO-599-8-1	57.80	57.33	57.57
IC-69257	56.80	56.40	56.60
IIVRO-770	62.17	62.80	62.48
IIVRO-SC-108	61.43	59.57	60.50
IIVRO-307-10-1 II	58.20	56.27	57.23
IIVRO-SKY/DR/RS-66	58.27	57.87	58.07
Kashi Kranti	52.10	50.73	51.42
IIVRO-3	59.74	57.80	58.77
IIVRO-419-01-1	58.67	57.87	58.27
IIVRO-325-10-1	59.70	60.07	59.88
IIVRO-130-10-1	56.63	56.20	56.42
IIVRO-1773	61.17	60.67	60.92
IIVRO-49	57.83	57.27	57.55
IIVRO-363	59.97	59.67	59.82
IC-218844	56.80	56.27	56.53
IC-45831	54.53	53.40	53.97
IIVRO-137-10-1,2	56.97	56.17	56.57
IIVRO-814-K	60.27	60.00	60.13
IC-039140	51.77	50.87	51.32
IC-117319	57.93	60.07	59.00
Arka Anamika	55.40	56.93	56.17
Prabhani Kranti	57.03	56.97	57.00
SEm±	1.74	1.48	1.14
CD at 5%	4.93	4.20	3.20

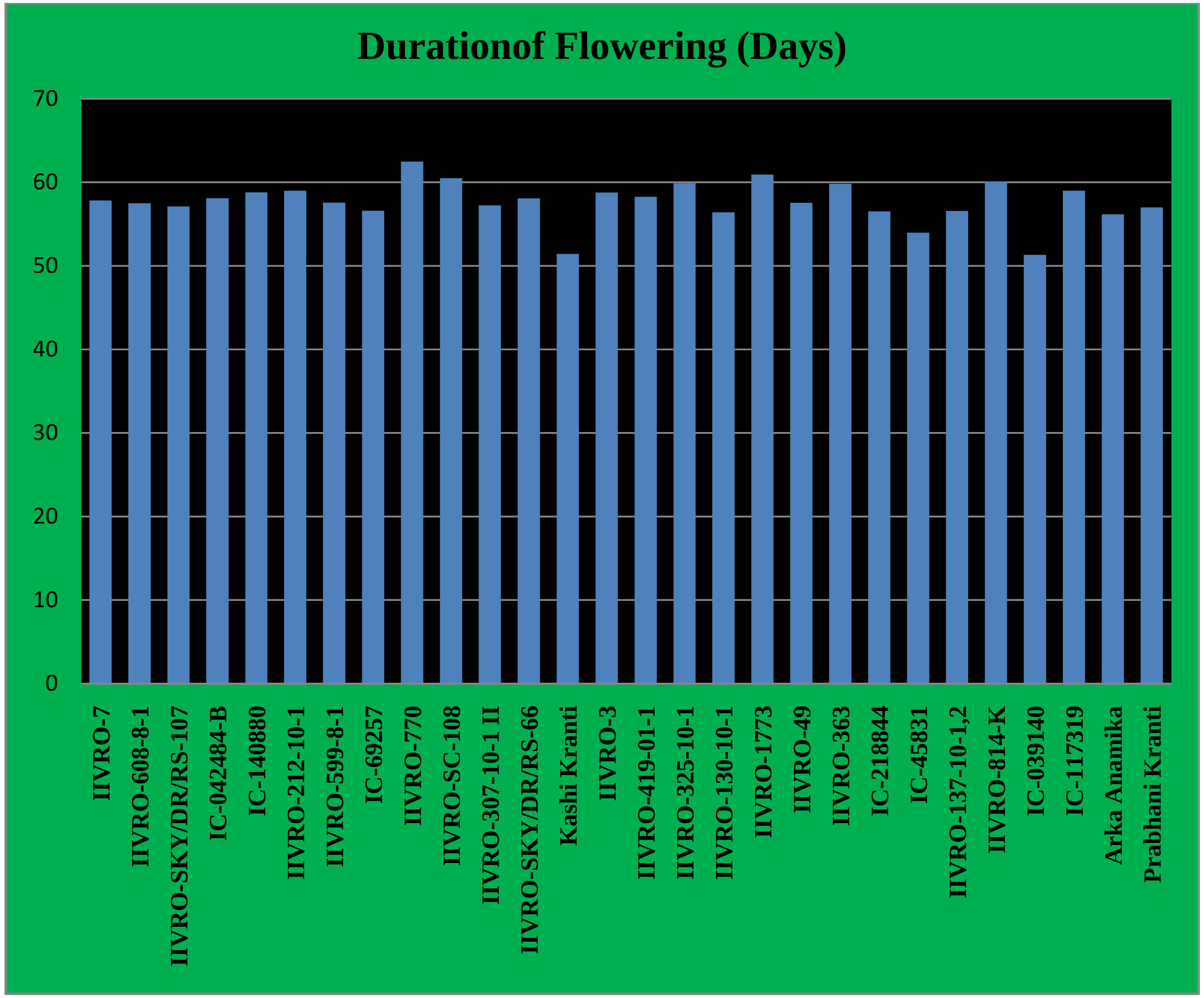

Figure 4.9: Growth attributes of various okra genotypes on duration of flowering

Duration of flowering was greatly influenced by different genotypes. It was noted that the duration of flowering ranged from 51.32 days (IC-039140) to 62.48 days (IIVRO-770). The wide variation among genotypes with respect to duration of flowering may be the resultant of the inherent genetic influence. These results are in conformity with the findings of Binalfew and Alemu (2016) who observed wide range of flowering periods among okra accessions which implies varying maturity periods even on the same plant making it difficult for harvesting and practically unfeasible for mechanization. He reported that these types of cultivars are appropriate for home gardening for continuous harvest.

4.1.10 Days to fruit setting

The data on the days taken for fruit setting are presented in table 4.10 and Fig 4.10. A perusal of the data revealed that the number of days taken to fruit setting among the genotypes differed significantly. The maximum number of days (54.68 days) was taken by the genotype IC-039140 while the minimum number of days to fruit setting (43.55 days) was observed in genotype IIVRO-770.

The variation in the number of days to fruit setting among the genotypes was significant. The number of days taken for fruit setting ranged from 43.55 days (IIVRO-770) to 54.68 days (IC-039140). The minimum days taken by the genotype IC-039140 may be due to early flowering exhibited by it that led to early fruit setting. These results are in conformity with the previous findings of Rahman *et al.* (2012) who reported that Arka Anamika took the least days to flowering and subsequently recorded the minimum number of days to fruit setting and concluded that the okra variety which matures earlier stands a better chance of earlier returns than the other cultivars. It was also reported that this may be due to

Table 4.10: Growth attributes of various okra genotypes on days to fruit setting.

Genotypes	Days to fruit setting (Days)		
	2013	2014	Pooled
IIVRO-7	47.77	48.63	48.20
IIVRO-608-8-1	47.90	49.27	48.58
IIVRO-SKY/DR/RS-107	47.90	49.93	48.92
IC-042484-B	47.77	48.07	47.92
IC-140880	46.17	48.47	47.32
IIVRO-212-10-1	46.73	47.43	47.08
IIVRO-599-8-1	48.10	48.90	48.50
IC-69257	49.27	49.67	49.47
IIVRO-770	43.87	43.23	43.55
IIVRO-SC-108	44.87	46.50	45.68
IIVRO-307-10-1 II	47.87	49.53	48.70
IIVRO-SKY/DR/RS-66	47.77	48.43	48.10
Kashi Kranti	53.83	54.93	54.38
IIVRO-3	46.23	48.17	47.20
IIVRO-419-01-1	47.43	47.13	47.28
IIVRO-325-10-1	46.27	45.80	46.03
IIVRO-130-10-1	48.37	49.67	49.02
IIVRO-1773	44.97	45.37	45.17
IIVRO-49	48.07	48.57	48.32
IIVRO-363	46.10	46.50	46.30
IC-218844	49.13	49.73	49.43
IC-45831	51.50	52.73	52.12
IIVRO-137-10-1,2	49.07	48.33	48.70
IIVRO-814-K	45.73	46.17	45.95
IC-039140	54.20	55.17	54.68
IC-117319	48.10	45.27	46.68
Arka Anamika	50.73	49.17	49.95
Prabhani Kranti	49.13	49.13	49.13
SEm±	1.71	1.47	1.13
CD at 5%	4.85	4.15	3.16

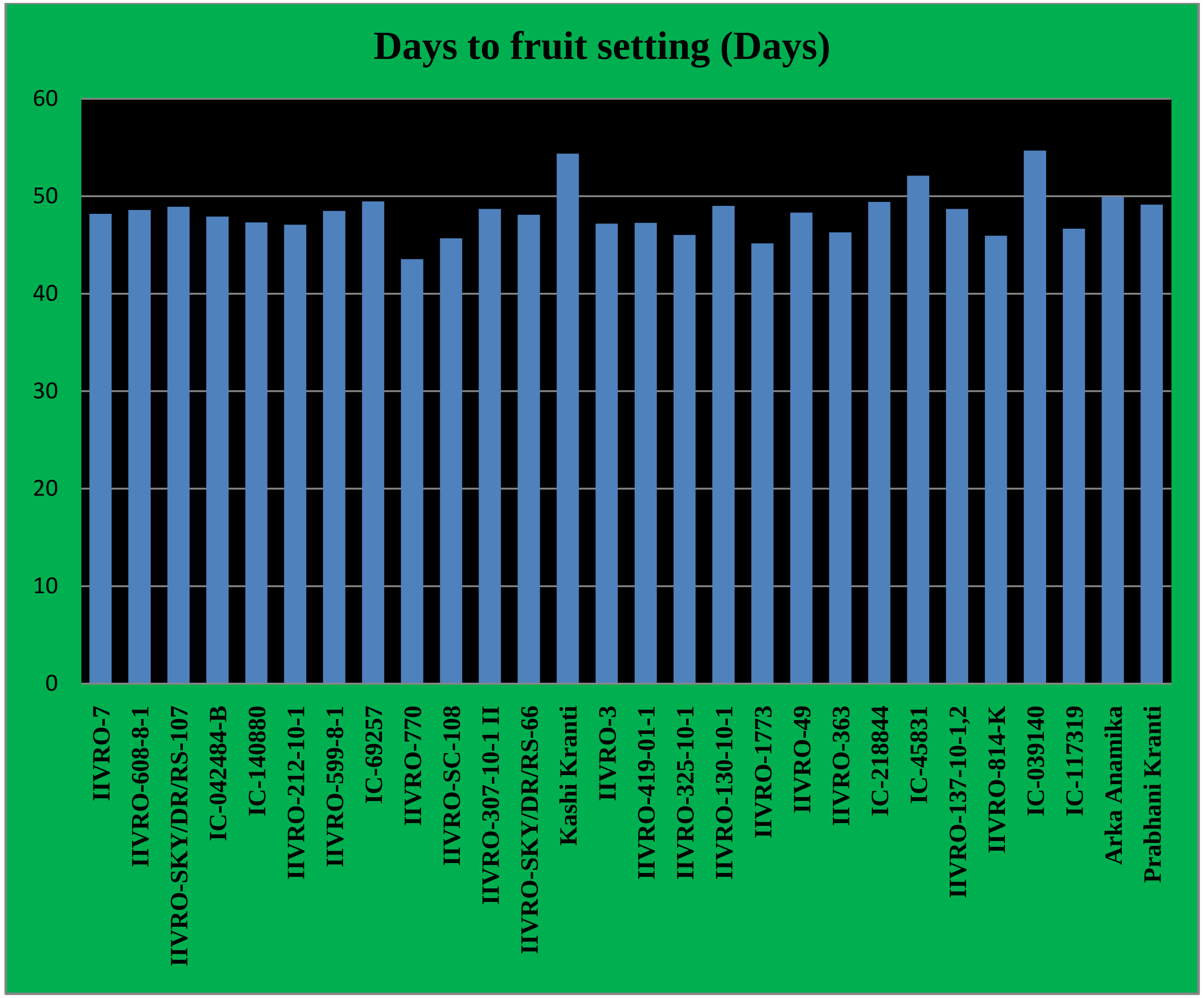

Figure 4.10: Growth attributes of various okra genotypes on days to fruit setting.

the fact that the soil, prevailing climate and environmental conditions may have been more conducive to allow for better expression of the genetic potentials of the varieties thereby eliciting their differential performance.

4.1.11 Days to marketable maturity

The data on the days to marketable maturity are presented in table 4.11 and Fig 4.11. A perusal of the data revealed that the number of days taken to marketable maturity varied significantly among the genotypes. The maximum number of days to marketable maturity (64.75 days) was taken by the genotype IC-45831 while the minimum number of days to marketable maturity (50.95 days) was observed in genotype IIVRO-770.

The variation in the number of days to marketable maturity among the genotypes was significant. The number of days taken for fruit setting ranged from 50.95 days (IIVRO-770) to 64.75 days (IC-45831). The minimum days taken by the genotype IIVRO-770 may be due to early flowering exhibited by it that led to early fruit setting and its maturity. These results are in conformity with the findings of Olczyk *et al.* (2002) who observed that first harvest of hybrid varieties occurred approximately 54 days after germination.

4.1.12 Days from fruit set to harvesting

Table 4.12 and Fig 4.12 depicted data on days taken from fruit set to harvesting. Data showed that the genotypes differ significantly in the days taken from fruit set to harvesting. Maximum (12.63 days) days taken from fruit set to harvesting was observed in genotype genotype IC-45831 and minimum

Table 4.11. Growth attributes of various okra genotypes on days to marketable maturity.

Genotypes	Days to marketable maturity (Days)		
	2013	2014	Pooled
IIVRO-7	54.13	55.13	54.63
IIVRO-608-8-1	57.50	57.40	57.45
IIVRO-SKY/DR/RS-107	57.60	58.03	57.82
IC-042484-B	54.10	54.17	54.13
IC-140880	59.20	59.27	59.23
IIVRO-212-10-1	55.77	56.73	56.25
IIVRO-599-8-1	59.90	60.20	60.05
IC-69257	57.67	58.17	57.92
IIVRO-770	50.80	51.10	50.95
IIVRO-SC-108	54.17	54.00	54.08
IIVRO-307-10-1 II	57.87	57.73	57.80
IIVRO-SKY/DR/RS-66	53.10	54.13	53.62
Kashi Kranti	60.93	61.67	61.30
IIVRO-3	53.17	53.97	53.57
IIVRO-419-01-1	53.60	54.03	53.82
IIVRO-325-10-1	52.00	53.00	52.50
IIVRO-130-10-1	59.00	58.47	58.73
IIVRO-1773	53.37	53.67	53.52
IIVRO-49	57.07	57.67	57.37
IIVRO-363	53.70	53.70	53.70
IC-218844	58.87	58.93	58.90
IC-45831	64.90	64.60	64.75
IIVRO-137-10-1,2	57.87	57.07	57.47
IIVRO-814-K	54.17	54.57	54.37
IC-039140	61.17	65.27	63.22
IC-117319	51.93	52.13	52.03
Arka Anamika	56.17	57.00	56.58
Prabhani Kranti	56.47	56.77	56.62
SEm±	1.71	1.70	1.20
CD at 5%	4.84	4.82	3.38

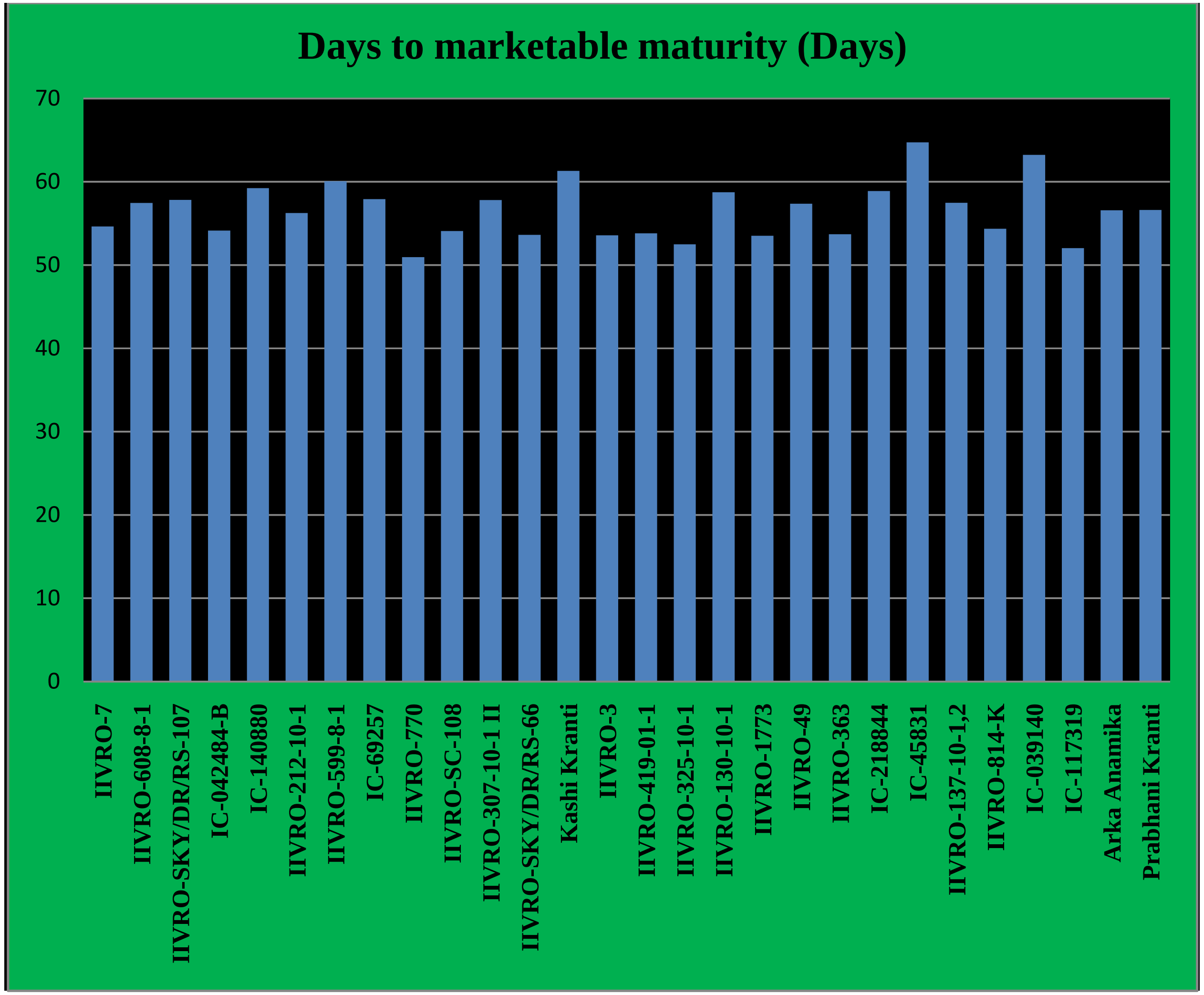

Figure 4.11. Growth attributes of various okra genotypes on days to markeFigure maturity.

Table 4.12: Growth attributes of various okra genotypes on days from fruit setting to harvesting.

Genotypes	Days from fruit setting to harvesting (Days)		
	2013	2014	Pooled
IIVRO-7	6.37	6.50	6.43
IIVRO-608-8-1	9.60	8.13	8.87
IIVRO-SKY/DR/RS-107	9.70	8.10	8.90
IC-042484-B	6.33	6.10	6.22
IC-140880	13.03	10.80	11.92
IIVRO-212-10-1	9.03	9.30	9.17
IIVRO-599-8-1	11.80	11.30	11.55
IC-69257	8.40	8.50	8.45
IIVRO-770	6.93	7.87	7.40
IIVRO-SC-108	9.30	7.50	8.40
IIVRO-307-10-1 II	10.00	8.20	9.10
IIVRO-SKY/DR/RS-66	5.33	5.70	5.52
Kashi Kranti	7.10	6.73	6.92
IIVRO-3	6.93	5.80	6.37
IIVRO-419-01-1	6.17	6.90	6.53
IIVRO-325-10-1	5.73	7.20	6.47
IIVRO-130-10-1	10.63	8.80	9.72
IIVRO-1773	8.40	8.30	8.35
IIVRO-49	9.00	9.10	9.05
IIVRO-363	7.60	7.20	7.40
IC-218844	9.73	9.20	9.47
IC-45831	13.40	11.87	12.63
IIVRO-137-10-1,2	8.80	8.73	8.77
IIVRO-814-K	8.43	8.40	8.42
IC-039140	6.97	10.10	8.53
IC-117319	3.83	6.87	5.35
Arka Anamika	5.43	7.83	6.63
Prabhani Kranti	7.33	7.63	7.48
SEm±	1.03	0.57	0.59
CD at 5%	2.93	1.60	1.65

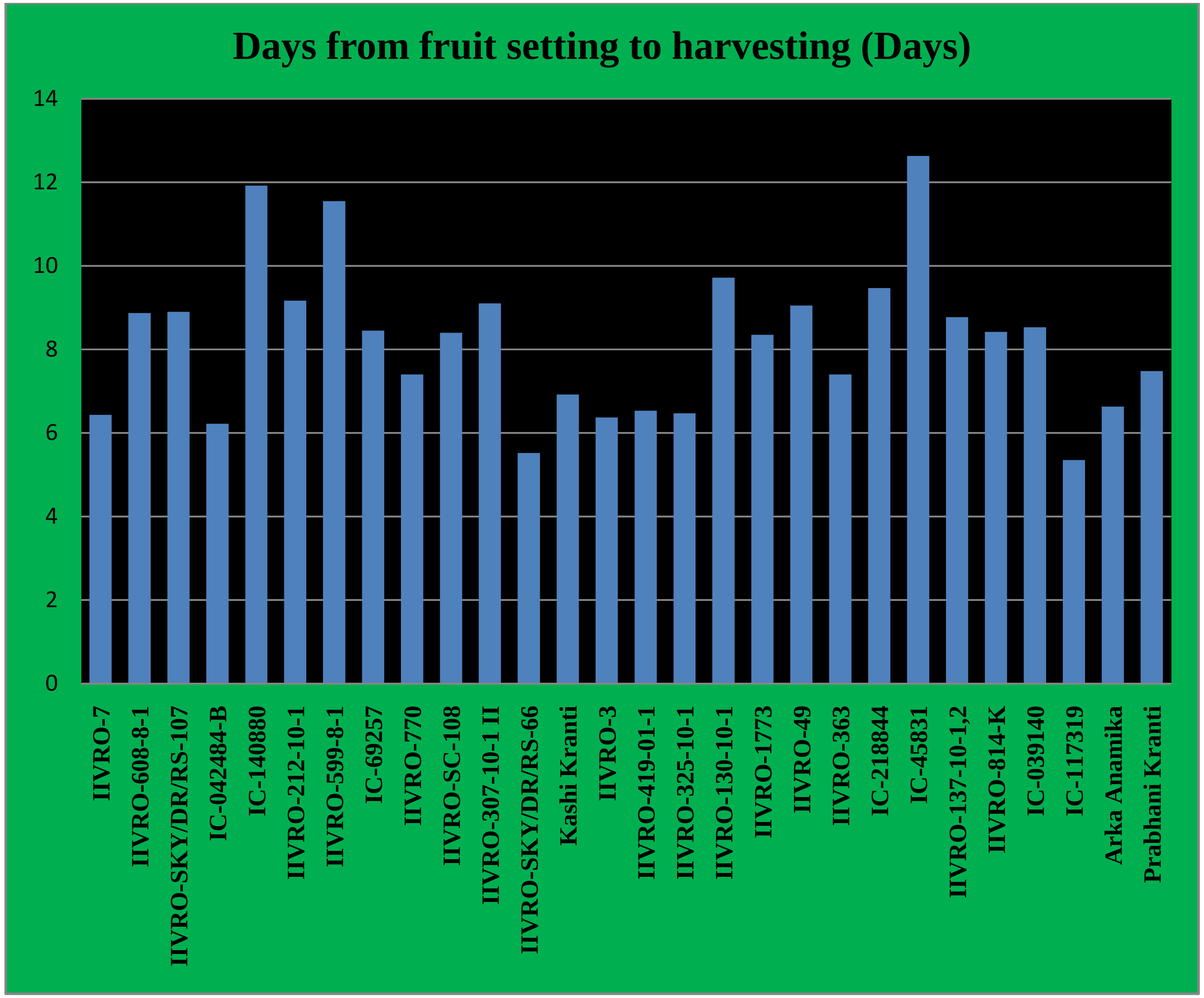

Figure 4.12: Growth attributes of various okra genotypes on days from fruit setting to harvesting.

(5.35 days) days taken from fruit set to harvesting was observed in IC-117319.

Days taken from fruit set to harvesting were greatly influenced by different genotypes. It was noted that the days taken from fruit set to harvesting ranged from 5.35 days (IC-117319) to 12.63 days (IC-45831). Similarly, Saleem *et al*. (2018) reported that the number of days from flowering to produce marketable sized fruit ranged between 6.2 to 9.2 days. The wide variation among genotypes with respect to number of days taken from fruit set to harvesting may be the resultant of the inherent genetic influence. This was supported by Hidayatullah *et al*. (2008) who reported that highly significant differences among genotypes for all attributes measured is an indication of significant genetic variability and diversity among genotypes.

4.1.13 Number of ridges

The results obtained on number of ridges in different genotypes have been presented in table 4.13 and Fig 4.13. There was significant difference in number of ridges among various genotypes. Genotype IIVRO-770 recorded maximum number of ridges (7.13) followed by IC-039140 which recorded 7.10 number of ridges. The minimum number of ridges was equally recorded from genotypes IIVRO-363, IIVRO-49 and IC-117319 *i.e.* 5.03.

Under the present study, number of ridges all the twenty-eight genotypes varied considerably. The number of ridges per fruit ranged from 5.03 to 7.13 with a mean of 6.08. Das *et al.* (2012) reported that number of ridges per pod ranged from 5 to 6.26 with a mean of 5.135 whereas Karri and Acharyya (2012) reported that that number of ridges per pod ranged from 4.90 to 6.87 with a mean of 5.16.

Table 4.13: Growth attributes of various okra genotypes on number of ridges per fruit

Genotypes	Number of ridges fruit^{-1}		
	2013	2014	Pooled
IIVRO-7	5.07	5.07	5.07
IIVRO-608-8-1	7.00	7.00	7.00
IIVRO-SKY/DR/RS-107	5.08	5.00	5.04
IC-042484-B	5.10	5.07	5.08
IC-140880	5.13	5.10	5.12
IIVRO-212-10-1	5.13	5.13	5.13
IIVRO-599-8-1	5.13	5.07	5.10
IC-69257	5.07	5.07	5.07
IIVRO-770	7.13	7.13	7.13
IIVRO-SC-108	6.07	6.00	6.03
IIVRO-307-10-1 II	5.13	5.13	5.13
IIVRO-SKY/DR/RS-66	5.13	5.00	5.07
Kashi Kranti	5.13	5.07	5.10
IIVRO-3	5.13	5.08	5.11
IIVRO-419-01-1	7.00	6.93	6.97
IIVRO-325-10-1	5.10	5.07	5.08
IIVRO-130-10-1	5.10	5.07	5.08
IIVRO-1773	5.13	5.07	5.10
IIVRO-49	5.07	5.00	5.03
IIVRO-363	5.07	5.00	5.03
IC-218844	5.20	5.13	5.17
IC-45831	5.20	5.08	5.14
IIVRO-137-10-1,2	5.13	5.13	5.13
IIVRO-814-K	5.13	5.07	5.10
IC-039140	7.13	7.07	7.10
IC-117319	5.07	5.00	5.03
Arka Anamika	5.13	5.08	5.11
Prabhani Kranti	5.20	5.15	5.18
SEm±	0.08	0.07	0.05
CD at 5%	0.23	0.19	0.15

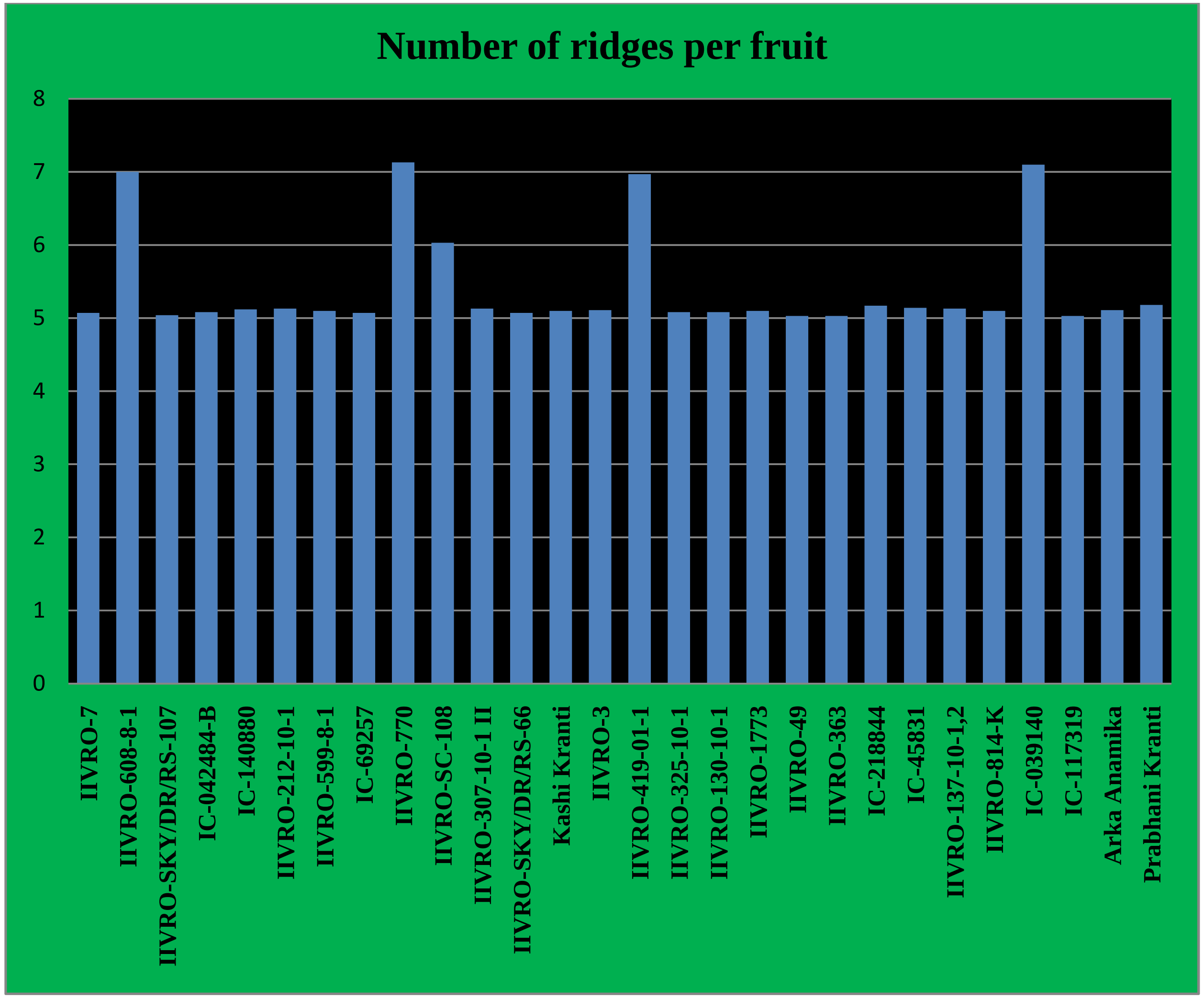

Figure 4.13: Growth attributes of various okra genotypes on number of ridges per fruit.

The present result is within the range of reported results. The wide variation among various genotypes in respect of number of ridges may be due to the genetic make-up of the genotype which influences the performance of a crop.

4.1.14 Colour of fruits

The results obtained by visual observation on the colour of fruits in different genotypes have been presented in table 4.14. The colour of fruits varied among the genotypes. Among the twenty eight genotypes, eight genotypes were dark green, twelve genotypes were green and seven genotypes were light green in colour while one genotype (IIVRO-814-K) showed reddish green fruit colour. The differences among the genotypes in regard to the colour of fruits may be due to the genetic constitution of the genotypes. These results are in conformity with the findings of Asare *et al.* (2016) who reported differences in fruit colour of 21 okra genotypes. Similarly, Martin *et al.* (1981) demonstrated genetic variation of okra fruit colour in diverse genetic population. The results of the previous work done by Diaz-Franco *et al.* (1998) indicated that an association existed between okra genotypes and fruit greenness. He reported that the intensity of greenness is determined by the chlorophyll content and is very important in marketing. He further observed that although the highest yield was obtained by cultivars that showed medium and light-green fruit colour, the processing companies more easily accept the very dark or dark-green genotypes. It has been found that the chlorophyll content in spinach leaves (*Spinacea oleracea* L.) leaves determines its quality and is indicative of nutrimental and health status (Santos, 1992).

Table 4.14: Growth attributes of various okra genotypes on colour of fruit

Genotypes	Colour of fruit
IIVR0-7	Light Green
IIVRO-608-8-1	Dark Green
IIVRO-SKY/DR/RS-107	Green
IC-042484-B	Dark Green
IC-140880	Green
IIVRO-212-10-1	Dark Green
IIVRO-599-8-1	Green
IC-69257	Light Green
IIVRO-770	Green
IIVRO-SC-108	Light Green
IIVRO-307-10-1 II	Dark Green
IIVRO-SKY/DR/RS-66	Light Green
Kashi Kranti	Dark Green
IIVRO-3	Light Green
IIVRO-419-01-1	Green
IIVRO-325-10-1	Dark Green
IIVRO-130-10-1	Dark Green
IIVRO-1773	Light Green
IIVRO-49	Green
IIVRO-363	Light Green
IC-218844	Green
IC-45831	Green
IIVRO-137-10-1,2	Green
IIVRO-814-K	Reddish Green
IC-039140	Green
IC-117319	Green
Arka Anamika	Green
Prabhani Kranti	Dark Green

4.2 Yield attributes

Performance of yield and yield attributes of various okra genotypes.

4.2.1 Number of fruits per plant

The data pertaining to the number of seeds per fruit are presented in table 4.15 and Fig 4.14. Significant differences were observed among the genotypes with respect to the number of fruits per plant. The maximum number of fruits per plant (18.42) was recorded from genotype IIVRO-608-8-1. The minimum number of fruits per plant recorded was 6.15 from genotype IC-69257.

It was observed that the number of fruits per plant is one of the most important yield attributing character of okra. Significant differences were observed among the genotypes with respect to the number of fruits per plant. Rahman *et al.* (2012) also observed significant differences amongst okra cultivars for number of pods per plant and reported that this might be due to their genetic characteristics and adaptability of these cultivars to the environmental conditions of the area. These findings are in resemblance with the results obtained by Khan *et al.* (2002) who stated that low number of pods per plant by genotypes might be due to their natural characteristics or it might be due to non-adaptation with the climatic and soil conditions of the area. The results of the present study are also in good conformity with Jordan-Molero (1986); Gondane and Bahatia, (1995); Shri-Dhar and Dhar (1995); Diaz-Franco *et al.* (1998) and Amjad *et al*. (2001) who in separate experiments have already reported variation in number of fruits per plant among several okra genotypes/cultivars. Sajjan *et al.* (2002) also reported that

Table 4.15: Yield attributes of various okra genotypes on number of fruits per plant.

Genotypes	Number of fruits plant^{-1}		
	2013	**2014**	**Pooled**
IIVRO-7	13.25	12.77	13.01
IIVRO-608-8-1	18.45	18.40	18.42
IIVRO-SKY/DR/RS-107	11.28	10.96	11.12
IC-042484-B	12.60	11.59	12.10
IC-140880	8.22	8.11	8.17
IIVRO-212-10-1	9.89	9.25	9.57
IIVRO-599-8-1	12.02	11.81	11.92
IC-69257	6.15	6.15	6.15
IIVRO-770	18.32	18.15	18.24
IIVRO-SC-108	13.62	12.95	13.29
IIVRO-307-10-1 II	15.20	14.66	14.93
IIVRO-SKY/DR/RS-66	14.80	14.67	14.74
Kashi Kranti	12.62	12.05	12.34
IIVRO-3	12.00	11.20	11.60
IIVRO-419-01-1	9.84	9.25	9.55
IIVRO-325-10-1	12.26	11.76	12.01
IIVRO-130-10-1	9.07	8.93	9.00
IIVRO-1773	11.02	10.58	10.80
IIVRO-49	10.26	10.00	10.13
IIVRO-363	13.23	12.55	12.89
IC-218844	11.42	11.04	11.23
IC-45831	10.20	9.95	10.08
IIVRO-137-10-1,2	14.65	13.33	13.99
IIVRO-814-K	11.22	10.98	11.10
IC-039140	12.05	11.23	11.64
IC-117319	15.23	14.82	15.03
Arka Anamika	17.05	17.02	17.04
Prabhani Kranti	16.25	16.00	16.13
SEm±	1.35	1.13	0.88
CD at 5%	3.83	3.20	2.47

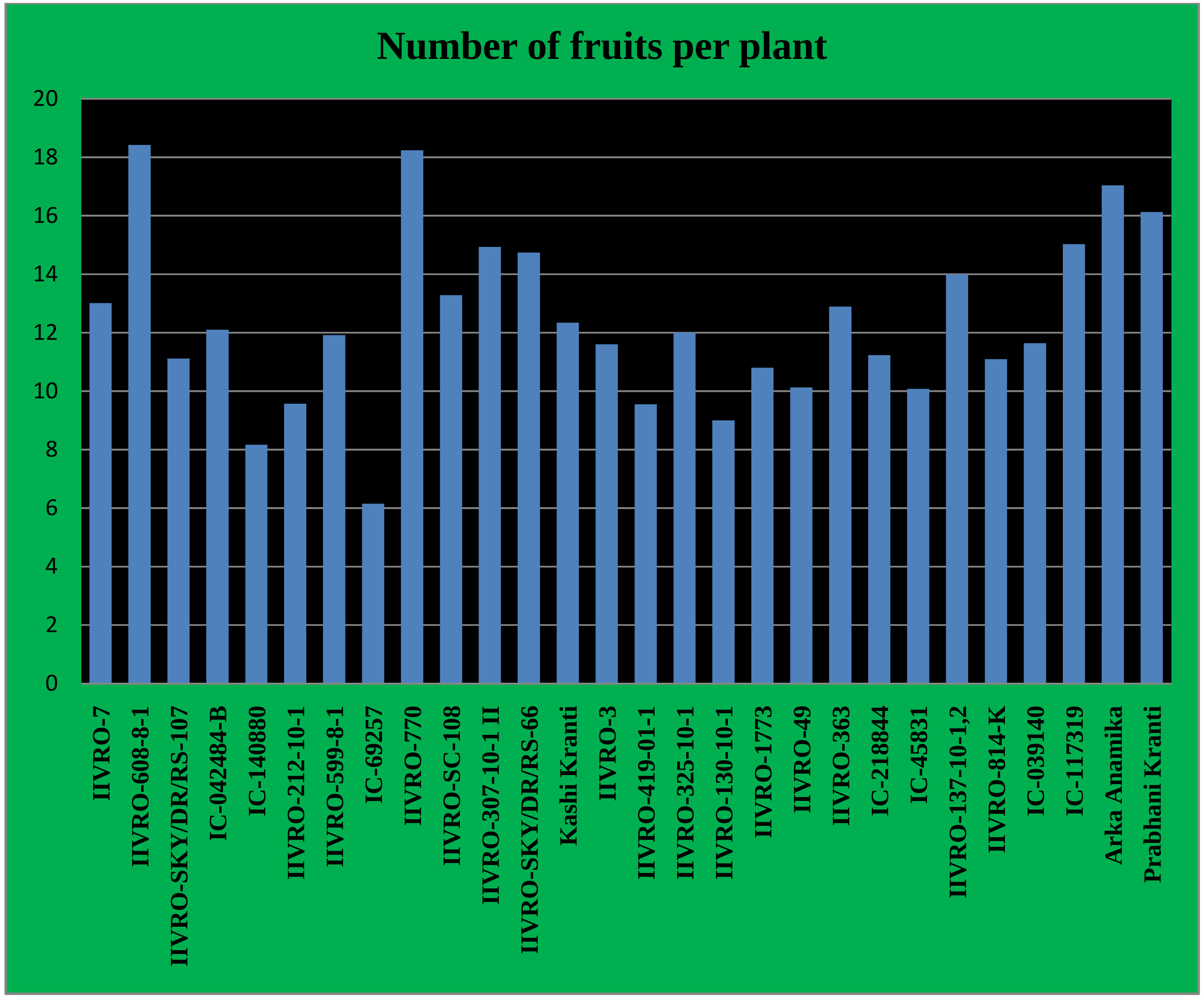

Figure 4.14: Yield attributes of various okra genotypes on number of fruits per plant.

growth parameter such as number of fruits was enhanced by genetic factors. Similarly, a number of research workers Islam *et al.* (2000); Bello *et al.* (2006); Chaudhary *et al.* (2006); Hussain *et al.* (2006); Sachan (2006); Okocha and Chinatu (2008); Saifullah and Rabbani (2009); Ojo *et al.* (2012) and Saha *et al.* (2016) also found significant variety effect for pods per plant indicating that the okra varieties evaluated are genetically diverse.

4.2.2 Length of fruit

The data on length of the fruit are presented in table 4.16 and Fig 4.15. All the genotypes showed significant difference in fruit length. From the table 8, it is clear that the longest fruit (16.89 cm) was recorded in genotype IIVRO-1773 followed by genotype Kashi Kranti having 14.82 cm while the shortest length of fruit (10.08 cm) was recorded from genotype IC-140880.

Statistical analysis of the data revealed significant differences in length of fruit among the various okra genotypes. The differences in length of fruit might be due to differences in genetic make-up of the okra genotypes and their response to the prevailing environmental conditions. These results are also supported by the previous findings of Amjad *et al.* (2001) who opined that the difference in pod length might be due to the differences in genetic makeup of the cultivars and their response to the prevailing environmental conditions. These results are also supported by the previous findings of Diaz-Franco *et al.* (1998) reported significant variation in fruit diameter among okra genotypes. Similar pattern have been reported by Rahman *et al.* (2012) who stated that the longer pods of okra might be due to the prevailiung environmental conditions of the area. Similarly, a number of research workers Islam *et al.* (2000); Khan *et al.* (2002); Prakash *et*

Table 4.16: Yield attributes of various okra genotypes on number of length of fruit

Genotypes	Length of fruit (cm)		
	2013	2014	Pooled
IIVRO-7	12.40	12.32	12.36
IIVRO-608-8-1	14.80	14.66	14.73
IIVRO-SKY/DR/RS-107	10.78	10.63	10.71
IC-042484-B	13.70	13.50	13.60
IC-140880	10.15	10.00	10.08
IIVRO-212-10-1	11.85	11.70	11.78
IIVRO-599-8-1	12.45	12.30	12.38
IC-69257	12.03	11.98	12.01
IIVRO-770	14.70	14.42	14.56
IIVRO-SC-108	13.40	13.24	13.32
IIVRO-307-10-1 II	12.49	12.40	12.45
IIVRO-SKY/DR/RS-66	13.48	13.30	13.39
Kashi Kranti	14.93	14.70	14.82
IIVRO-3	13.87	13.70	13.79
IIVRO-419-01-1	12.65	12.51	12.58
IIVRO-325-10-1	12.99	11.00	12.00
IIVRO-130-10-1	11.75	11.61	11.68
IIVRO-1773	16.95	16.82	16.89
IIVRO-49	12.75	12.60	12.68
IIVRO-363	13.02	12.87	12.95
IC-218844	10.95	10.80	10.88
IC-45831	13.53	13.32	13.43
IIVRO-137-10-1,2	13.36	13.20	13.28
IIVRO-814-K	12.72	12.60	12.66
IC-039140	13.65	13.45	13.55
IC-117319	12.72	12.55	12.64
Arka Anamika	14.60	14.44	14.52
Prabhani Kranti	12.85	12.68	12.77
SEm±	0.82	0.66	0.53
CD at 5%	2.32	1.88	1.48

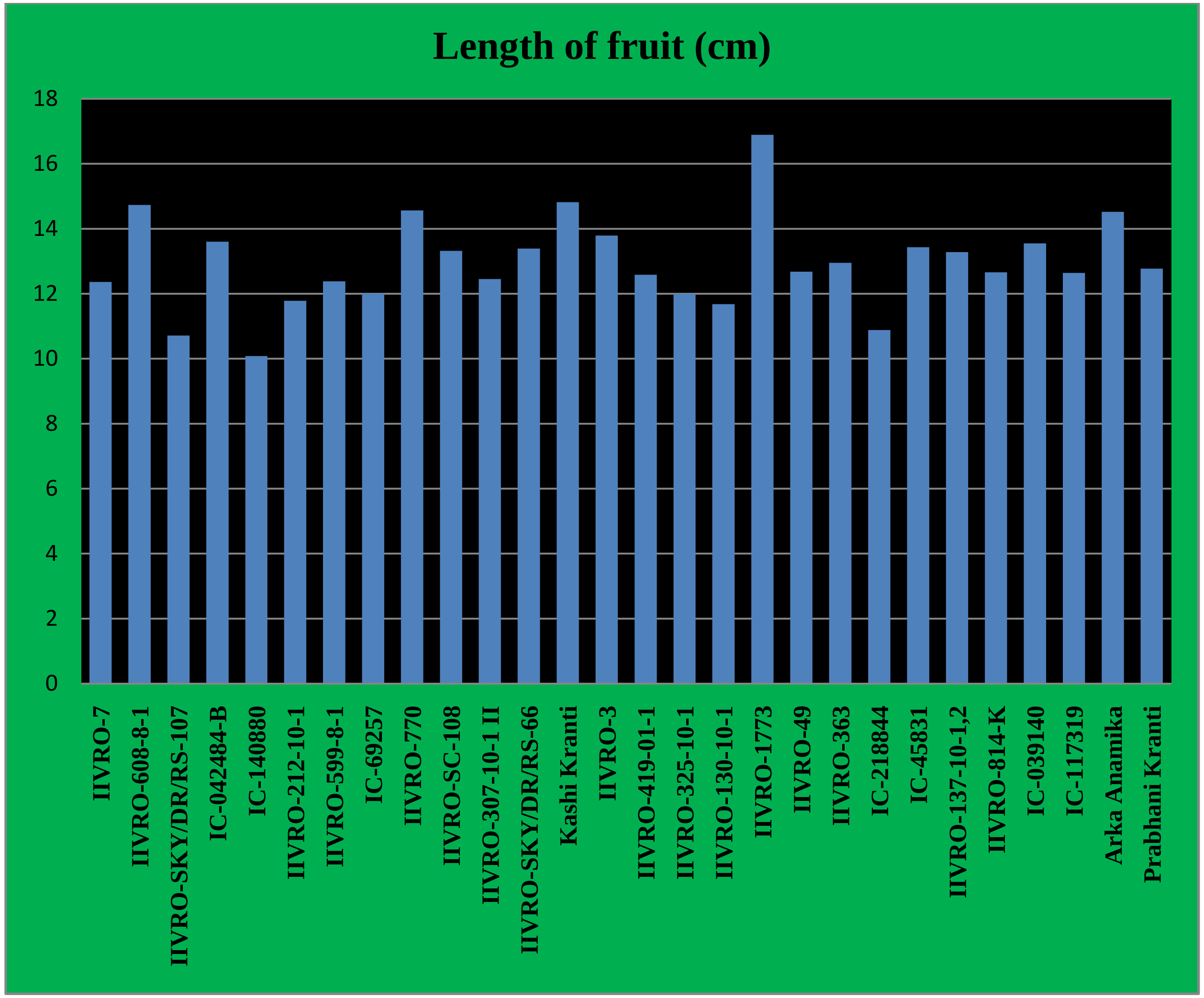

Figure 4.15: Yield attributes of various okra genotypes on number of length of fruit

al.(2001); Ashraful and Hossain (2006); Bello *et al.* (2006); Halim (2008); Ojo *et al.* (2012) and Saha *et al.* (2016) also found significant variety effect for length of fruit indicating that the okra varieties evaluated are genetically diverse.

4.2.3 Diameter of fruit

As evident from the data presented in table 4.17 and Fig 4.16, diameter of fruit differed significantly among the genotypes. The maximum diameter of fruit (2.06 cm) was found in genotype IIVRO-770 which was at par with genotype IIVRO-608-8-1. The minimum diameter of fruit (1.58 cm) was recorded in genotype IIVRO-1773.

Statistical analysis of the data revealed significant differences in diameter of fruit among the various okra genotypes. The differences in diameter of fruit might be due to differences in genetic make-up of the okra genotypes and their response to the prevailing environmental conditions. These results are also supported by the previous findings of Diaz-Franco *et al.* (1998) reported significant variation in fruit diameter among okra genotypes. He also observed that hybrids tend to produce longer fruits with small diameters. Similarly, a number of research workers Islam *et al.* (2000); Saifullah and Rabbani (2009); Saha *et al.* (2016) and Ojo *et al.* (2012) also found significant variety effect for diameter of fruit indicating that the okra varieties evaluated are genetically diverse.

Plate 2(a): Fruits of various okra genotypes.

Plate 2(b): Fruits of various okra genotypes.

Plate 2(c): Fruits of various okra genotypes

Plate 2(d): Fruits of various okra genotypes.

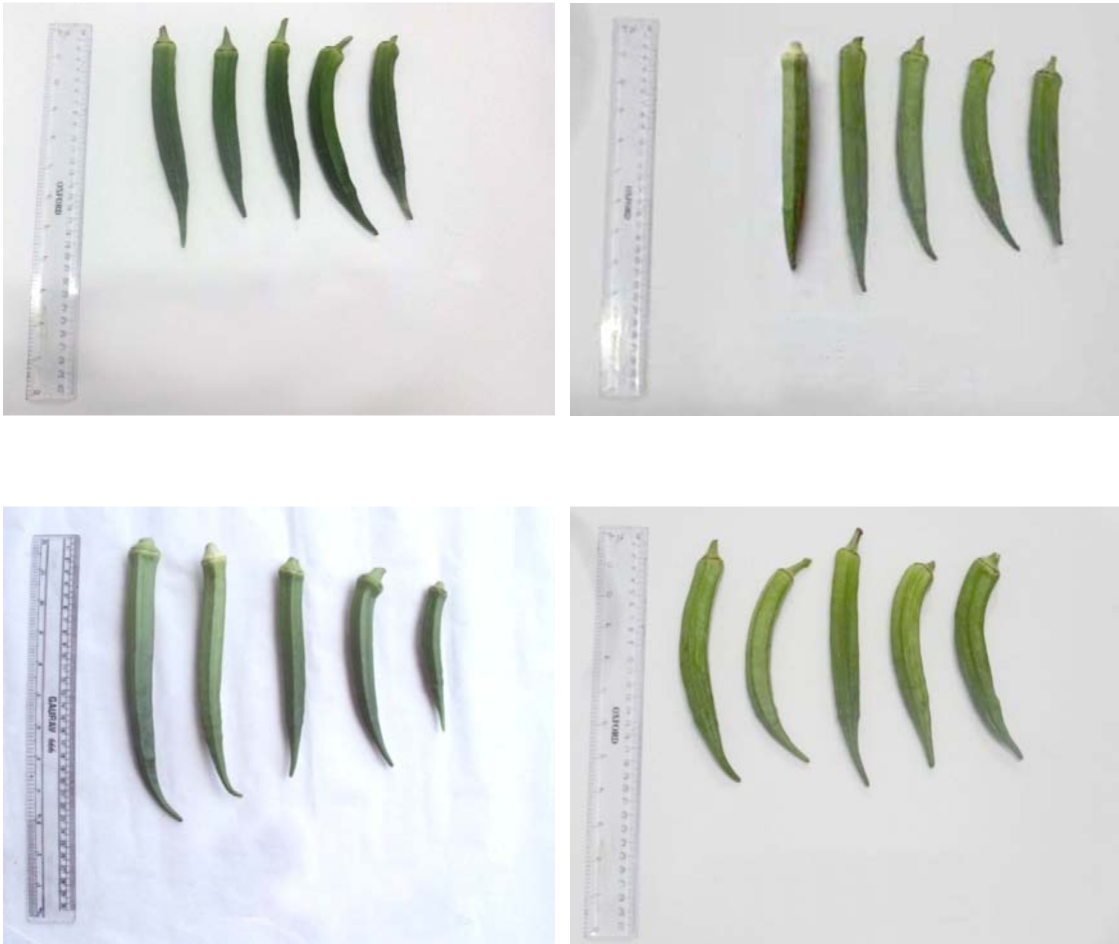

Plate 2(e): Fruits of various okra genotypes

Table 4.17: Yield attributes of various okra genotypes on diameter of fruit.

Genotypes	Diameter of fruit (cm)		
	2013	**2014**	**Pooled**
IIVRO-7	1.70	1.66	1.68
IIVRO-608-8-1	2.07	2.05	2.06
IIVRO-SKY/DR/RS-107	1.79	1.75	1.77
IC-042484-B	1.83	1.79	1.81
IC-140880	1.72	1.70	1.71
IIVRO-212-10-1	1.65	1.63	1.64
IIVRO-599-8-1	1.79	1.77	1.78
IC-69257	1.90	1.89	1.90
IIVRO-770	2.06	2.05	2.06
IIVRO-SC-108	1.90	1.90	1.90
IIVRO-307-10-1 II	2.05	2.03	2.04
IIVRO-SKY/DR/RS-66	1.97	1.95	1.96
Kashi Kranti	1.98	1.97	1.97
IIVRO-3	1.96	1.95	1.96
IIVRO-419-01-1	1.96	1.94	1.95
IIVRO-325-10-1	1.87	1.86	1.87
IIVRO-130-10-1	1.95	1.95	1.95
IIVRO-1773	1.59	1.57	1.58
IIVRO-49	1.71	1.70	1.71
IIVRO-363	1.72	1.71	1.72
IC-218844	1.78	1.76	1.77
IC-45831	1.71	1.70	1.71
IIVRO-137-10-1,2	2.00	1.97	1.99
IIVRO-814-K	1.67	1.66	1.67
IC-039140	1.65	1.65	1.65
IC-117319	1.82	1.81	1.82
Arka Anamika	1.76	1.75	1.76
Prabhani Kranti	1.80	1.78	1.79
SEm±	0.07	0.07	0.05
CD at 5%	0.20	0.19	0.14

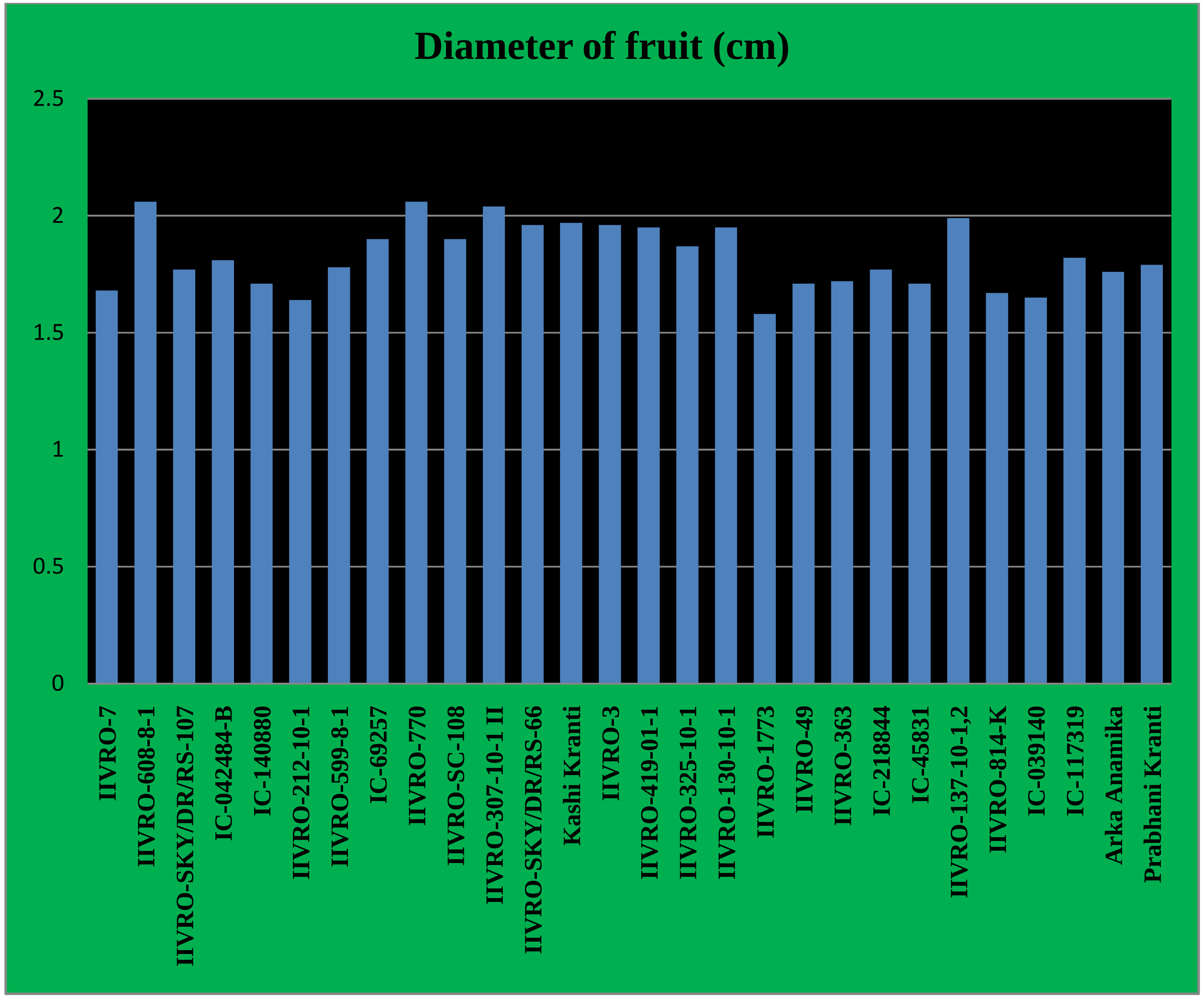

Figure 4.16: Yield attributes of various okra genotypes on diameter of fruit.

. **4.2.4 Weight of fruit**

The data on the weight of fruit of different genotypes are shown in table 4.18 and Fig 4.17. Different genotypes show variable behavior on the weight of fruit. The maximum weight of fruit recorded was 25.95 g from genotype IIVRO-608-8-1 which was followed by genotype IIVR0-770 *i.e.* 24.91g. The minimum weight of fruit recorded was 11.96 g from genotype IC-140880.

Statistical analysis of the data revealed significant differences in fruit weight among the various okra genotypes. The differences in weight of fruit might be due to differences in genetic make-up of the okra genotypes and their response to the prevailing environmental conditions. These results are also supported by the previous findings of Rahman *et al.* (2012) who also reported highly significant results among the different okra cultivars for average weight of single pod. These differences might be due to variation in their genetic makeup. Previous workers who have also reported differences in the pod weight among different okra genotypes include Sadiq *et al*. (1988); Shri-Dhar and Dhar (1995); Amjad *et al*. (2001). Katung (2007) and Rahman *et al.* (2012) reported that changes in the environmental conditions influences the growth and performance of okra. These results were supported by the previous observations of various researchers including Ashraful and Hossain (2006); Sachan (2006) and Saha *et al* (2016).

4.2.5 Number of seeds per fruit

The data pertaining to the number of seeds per fruit are presented in table 4.19 and Fig 4.18. It was evident from the data that there was a significant difference among the genotypes in terms of the number of seeds per fruit.

Table 4.18: Yield attributes of various okra genotypes on weight of fruit

Genotypes	Weight of fruit (g)		
	2013	**2014**	**Pooled**
IIVRO-7	18.21	17.59	17.90
IIVRO-608-8-1	26.05	25.85	25.95
IIVRO-SKY/DR/RS-107	15.18	14.95	15.07
IC-042484-B	18.00	17.66	17.83
IC-140880	12.06	11.85	11.96
IIVRO-212-10-1	15.05	14.95	15.00
IIVRO-599-8-1	20.20	19.44	19.82
IC-69257	16.38	16.02	16.20
IIVRO-770	25.00	24.82	24.91
IIVRO-SC-108	20.57	20.06	20.32
IIVRO-307-10-1 II	20.25	19.99	20.12
IIVRO-SKY/DR/RS-66	19.60	19.55	19.58
Kashi Kranti	21.02	20.20	20.61
IIVRO-3	20.00	19.05	19.53
IIVRO-419-01-1	21.90	21.20	21.55
IIVRO-325-10-1	19.40	18.50	18.95
IIVRO-130-10-1	20.08	19.63	19.86
IIVRO-1773	16.00	15.96	15.98
IIVRO-49	14.88	14.85	14.87
IIVRO-363	17.24	16.78	17.01
IC-218844	18.08	17.97	18.03
IC-45831	18.44	18.20	18.32
IIVRO-137-10-1,2	24.67	23.67	24.17
IIVRO-814-K	18.00	17.75	17.88
IC-039140	16.28	15.95	16.12
IC-117319	15.80	14.33	15.07
Arka Anamika	21.53	20.50	21.02
Prabhani Kranti	16.85	16.78	16.82
SEm±	1.68	1.60	1.16
CD at 5%	4.77	4.53	3.25

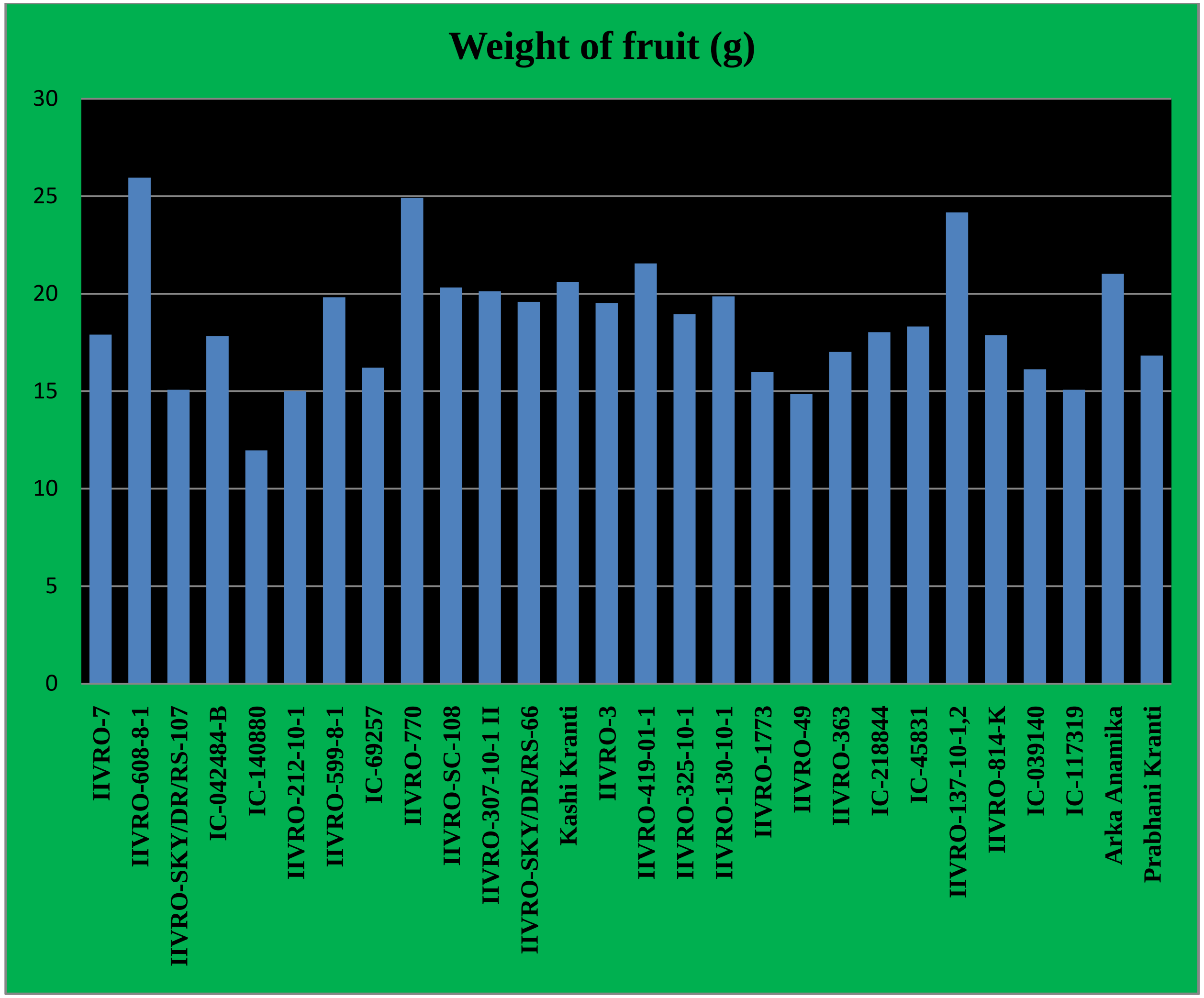

Figure 4.17: Yield attributes of various okra genotypes on weight of fruit.

Table 4.19: Yield attributes of various okra genotypes on number of seeds per fruit

Genotypes	Number of seeds fruit^{-1}		
	2013	**2014**	**Pooled**
IIVRO-7	36.40	33.90	35.15
IIVRO-608-8-1	56.20	51.98	54.09
IIVRO-SKY/DR/RS-107	49.30	45.76	47.53
IC-042484-B	37.59	32.76	35.18
IC-140880	33.07	30.51	31.79
IIVRO-212-10-1	45.37	40.95	43.16
IIVRO-599-8-1	54.36	50.28	52.32
IC-69257	42.30	35.25	38.77
IIVRO-770	44.39	38.39	41.39
IIVRO-SC-108	48.13	43.98	46.06
IIVRO-307-10-1 II	44.83	40.14	42.49
IIVRO-SKY/DR/RS-66	41.65	36.87	39.26
Kashi Kranti	43.40	36.95	40.18
IIVRO-3	50.70	43.70	47.20
IIVRO-419-01-1	54.20	49.58	51.89
IIVRO-325-10-1	33.29	31.88	32.59
IIVRO-130-10-1	32.95	28.95	30.95
IIVRO-1773	44.89	39.75	42.32
IIVRO-49	39.80	32.40	36.10
IIVRO-363	46.20	40.18	43.19
IC-218844	45.80	39.70	42.75
IC-45831	45.81	45.57	45.69
IIVRO-137-10-1,2	44.60	42.55	43.58
IIVRO-814-K	36.58	32.55	34.57
IC-039140	41.40	37.00	39.20
IC-117319	35.49	31.35	33.42
Arka Anamika	51.62	45.60	48.61
Prabhani Kranti	48.18	45.12	46.65
SEm±	3.75	3.93	2.71
CD at 5%	10.62	11.14	7.61

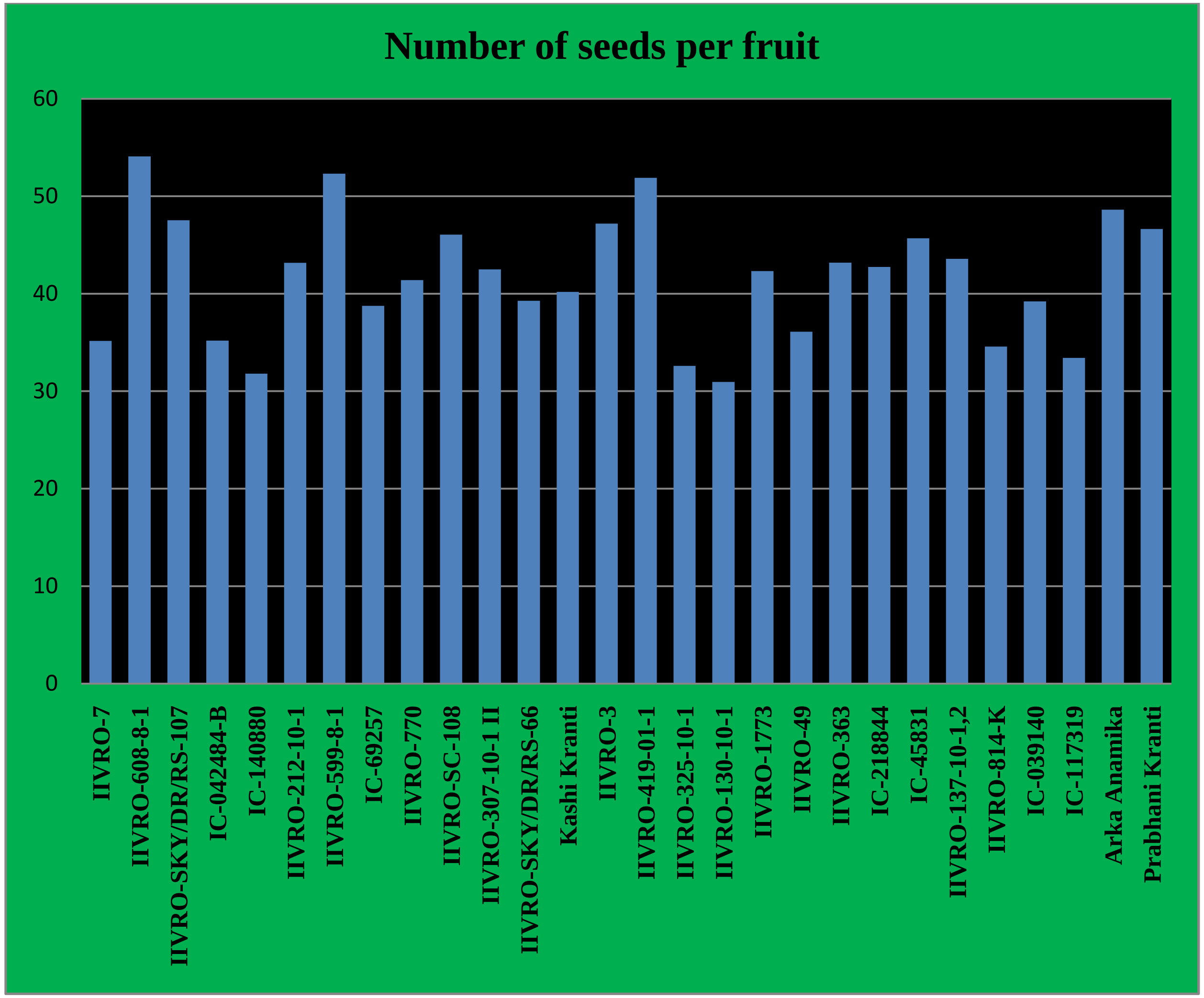

Figure 4.18: Yield attributes of various okra genotypes on number of seeds per fruit.

Genotype IIVRO-608-8-1 recorded maximum number of seeds per fruit (54.09) followed by genotype IIVRO-419-01-1 (51.89). The minimum number of seeds per fruit was recorded from genotype IIVRO -130-10-1 *i.e.*30.95. .

Statistical analysis of the data revealed significant differences in number of seeds per fruit among the various okra genotypes. The differences in number of seeds per fruit might be due to differences in genetic make-up of the okra genotypes and their response to the prevailing environmental conditions. These results are also supported by the previous findings of Jordan-Molero (1986) who has already reported variation in pod number among six okra cultivars. Amjad *et al.* (2001) also reported that different okra genotypes differ significantly for traits like number of seeds per pod.

4.2.6 Yield per plant

The data on the yield per plant are presented in table 4.20 and Fig 4.19. It was evident from the data that there was a significant difference among the genotypes in terms of yield per plant. Genotype IIVRO-608-8-1 recorded maximum yield per plant (477.66 g) followed by genotype IIVRO-770 (448.23 g). The minimum yield per plant was found in genotype IVRO-IC-140880 (97.19 g).

The data revealed that the number of fruits per plant has a direct effect on yield *i.e.* more number of fruits per plant higher the yield per plant. This finding was supported by Saha *et al.* (2016) who reported that yield is the result of complex interaction of the parameters like number of fruits and individual fruit weight. Similar revelation was made by Karri and Acharyya (2012) who asserted that for selecting high yielding okra types, stress should be laid on more number

Table 4.20: Yield attributes of various okra genotypes on yield per plant.

Genotypes	Yield plant^{-1} (g)		
	2013	**2014**	**Pooled**
IIVRO-7	240.37	214.01	227.19
IIVRO-608-8-1	478.77	476.55	477.66
IIVRO-SKY/DR/RS-107	177.31	166.85	172.08
IC-042484-B	224.21	201.19	212.70
IC-140880	100.93	93.45	97.19
IIVRO-212-10-1	147.94	139.61	143.78
IIVRO-599-8-1	244.40	232.49	238.45
IC-69257	100.33	97.23	98.78
IIVRO-770	451.72	444.74	448.23
IIVRO-SC-108	277.30	265.19	271.24
IIVRO-307-10-1 II	308.46	295.29	301.88
IIVRO-SKY/DR/RS-66	286.88	284.19	285.54
Kashi Kranti	261.38	244.32	252.85
IIVRO-3	235.97	212.70	224.33
IIVRO-419-01-1	215.78	197.74	206.76
IIVRO-325-10-1	241.09	218.46	229.77
IIVRO-130-10-1	180.85	176.77	178.81
IIVRO-1773	178.83	169.54	174.18
IIVRO-49	150.22	151.31	150.76
IIVRO-363	226.87	208.22	217.54
IC-218844	207.83	195.81	201.82
IC-45831	188.98	181.65	185.31
IIVRO-137-10-1,2	359.08	323.98	341.53
IIVRO-814-K	201.44	198.64	200.04
IC-039140	200.82	177.71	189.27
IC-117319	235.03	208.71	221.87
Arka Anamika	369.70	344.30	357.00
Prabhani Kranti	270.43	267.86	269.14
SEm±	31.87	29.67	21.77
CD at 5%	90.36	84.14	61.03

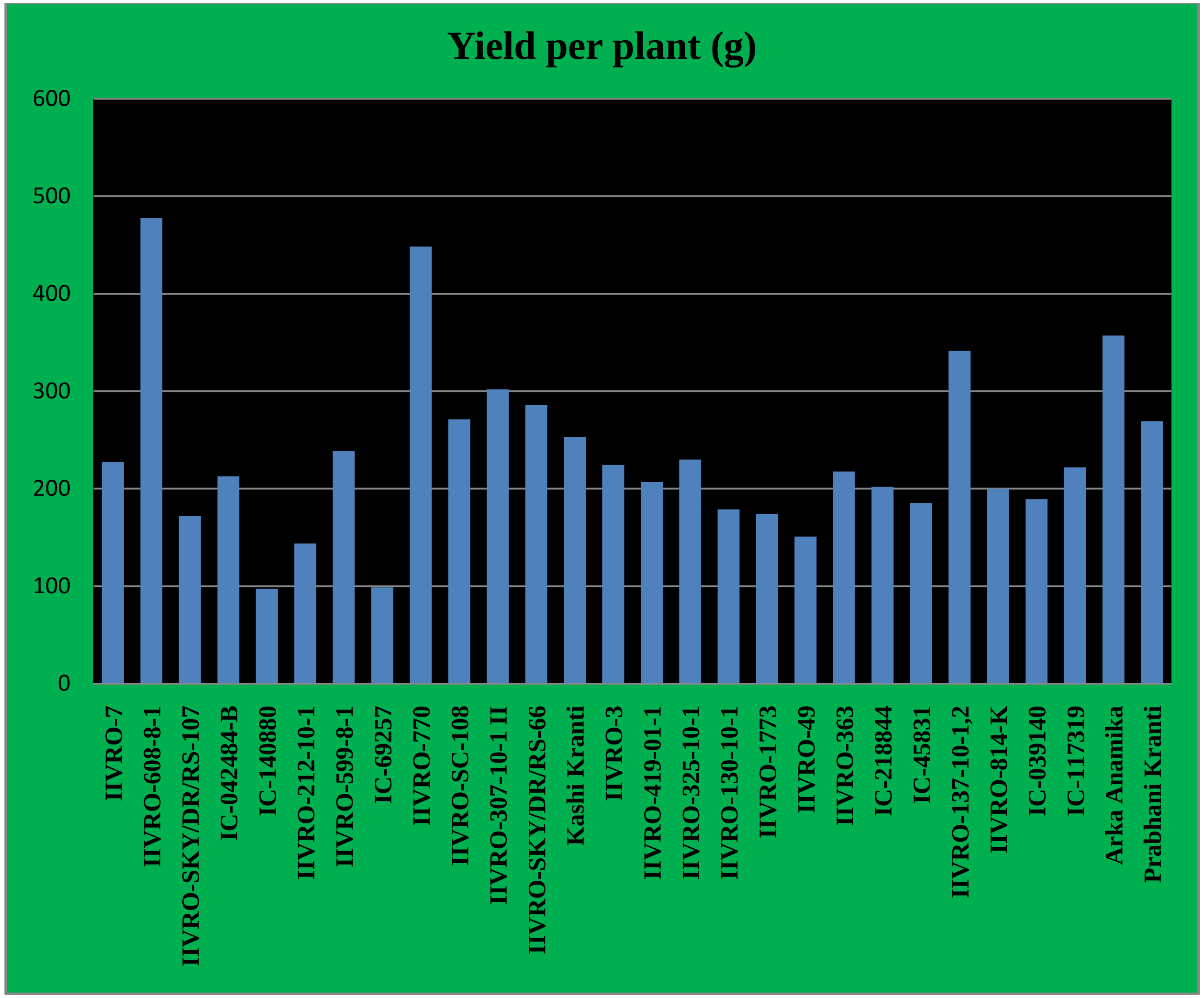

Figure 4.19: Yield attributes of various okra genotypes on yield per plant.

previous findings of Ashraful and Hossain (2006) who also reported significant results amongst the 50 cultivars of okra. In separate studies, similar results have of fruits per plant and average fruit weight. Gondane and Bahatia (1995) evaluated fifty genotypes and already reported significant and marked variation in yield components among the cultivars. Rahman *et al.* (2012) also found significant differences among various okra cultivars and reported that the differences in weight of pods per plant might be due to the genetic makeup of the genotypes and their response to environmental conditions. These results are also supported by the been reported by Martin and Rhodes (1983); Sadiq *et al*. (1988); Hussein *et al.* (1994); Dash and Misra (1995); Jordan-Molero, (1986); Amjad *et al*. (2001); Satish and Kanwar (2005); Choudhary *et al.* (2006); Alam and Hossain (2008) and Ojo *et al.* (2012).

4.2.7 Yield per plot

The data on the yield per plot are presented in table 4.20 and Fig 4.19. It was evident from the data that there was a significant difference among the genotypes in terms of yield per plot. Genotype IIVRO-608-8-1 recorded maximum yield per plot (11.47 kg) followed by genotype IIVRO-770 (10.76 g). The minimum yield per plot was found in genotype IVRO-IC-140880 (2.33 kg).

It was revealed that genotype IIVRO-608-8-1 showed its superiority over all the other genotypes for its yield per plot as it produced maximum number of fruits per plant. Similar trend of results was obtained for yield per plot as was observed in number of pods per plant and yield per plant. These results got support from previous work done by Rahman *et al.* (2012) who also observed variations in yield of different okra cultivars reported that the reason might be due

Table 4.21: Yield attributes of various okra genotypes on yield per plot.

Genotypes	Yield plot^{-1} (kg)		
	2013	**2014**	**Pooled**
IIVRO-7	5.77	5.14	5.45
IIVRO-608-8-1	11.49	11.44	11.47
IIVRO-SKY/DR/RS-107	4.26	4.00	4.13
IC-042484-B	5.38	4.83	5.11
IC-140880	2.42	2.24	2.33
IIVRO-212-10-1	3.55	3.35	3.45
IIVRO-599-8-1	5.87	5.58	5.72
IC-69257	2.41	2.33	2.37
IIVRO-770	10.84	10.67	10.76
IIVRO-SC-108	6.65	6.36	6.51
IIVRO-307-10-1 II	7.41	7.09	7.25
IIVRO-SKY/DR/RS-66	6.88	6.82	6.85
Kashi Kranti	6.27	5.86	6.07
IIVRO-3	5.66	5.10	5.38
IIVRO-419-01-1	5.18	4.75	4.96
IIVRO-325-10-1	5.79	5.24	5.52
IIVRO-130-10-1	4.34	4.24	4.29
IIVRO-1773	4.29	4.07	4.18
IIVRO-49	3.61	3.63	3.62
IIVRO-363	5.44	4.99	5.22
IC-218844	4.99	4.70	4.84
IC-45831	4.54	4.36	4.45
IIVRO-137-10-1,2	8.62	7.78	8.20
IIVRO-814-K	4.84	4.77	4.80
IC-039140	4.82	4.27	4.55
IC-117319	5.64	5.01	5.33
Arka Anamika	8.87	8.26	8.57
Prabhani Kranti	6.49	6.43	6.46
SEm±	0.76	0.71	0.52
CD at 5%	2.17	2.02	1.46

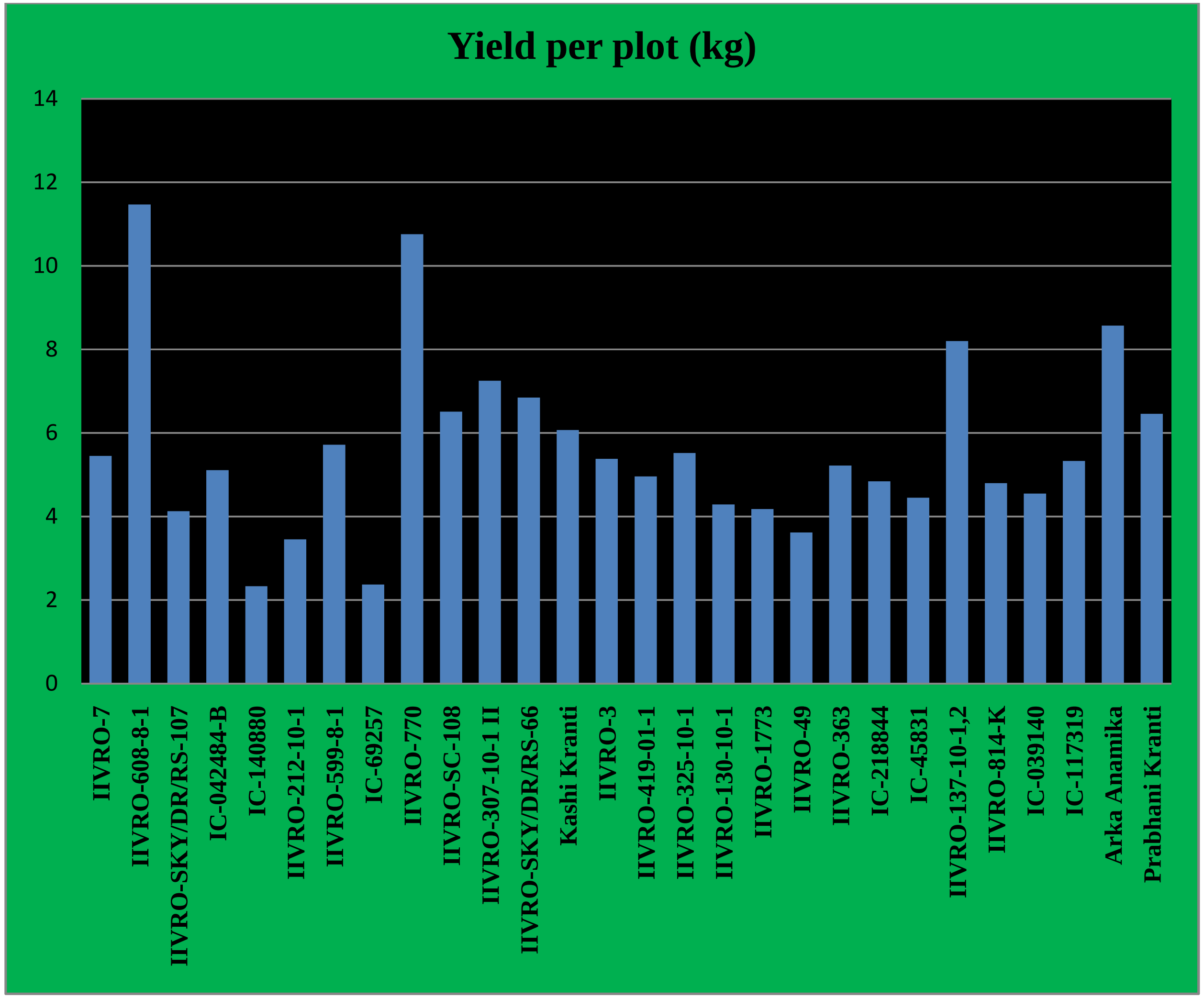

Figure 4.20: Yield attributes of various okra genotypes on yield per plot.

to the genetic potential of the cultivars. Similarly Katung (2007) also reported that okra cv. White Velvet produced more fruits.

4.2.8 Projected yield per hectare

The data pertaining to the projected yield per hectare are presented in table 4.22 and Fig 4.21. The data revealed significant difference among the genotypes in respect to projected yield per hectare. The genotype IIVRO-608-8-1 recorded maximum projected yield per hectare (19.90 t) followed by genotype IIVRO-770 (18.67 t). The minimum projected yield per hectare (4.05 t) was found in genotype IVRO-IC-140880. .

As the data regarding pod yield per hectare was derived from pod yield per plant and number of plants in a hectare, therefore the data per hectare presented the same picture. Rao and Raj (1974) compared 15 okra hybrid varieties with standard variety Pusa Sawani, 10 out of which out-yielded Pusa Sawani by 10-14%. Variation in yield among different okra cultivars has also been reported by other workers Shaikh *et al*. (1987); Baloch *et al*. (1990); Arora *et al*. (1991); Somkuwar *et al*. (1997) and Amjad *et al*. (2001). In separate studies, similar results have been reported by Khan *et al.* (2002); Ashraful and Hossain (2006) and Hussain *et al.* (2006) who observed variations in yield per hectare in different okra cultivars. Several researchers have noted that the yield advantage of one variety over the other variety varies by environment (Foley *et al.*, 1986; Wilcox, 1998). The findings of Jamala *et al.* (2011) is also in agreement with these findings who reported that the environment may not be favourable in same manner to all the varieties.

Table 4.22: Yield attributes of various okra genotypes on projected yield per hectare

Genotypes	Projected yield ha^{-1} (t)		
	2013	**2014**	**Pooled**
IIVRO-7	10.02	8.92	9.47
IIVRO-608-8-1	19.95	19.86	19.90
IIVRO-SKY/DR/RS-107	7.40	6.94	7.17
IC-042484-B	9.34	8.39	8.87
IC-140880	4.20	3.89	4.05
IIVRO-212-10-1	6.16	5.82	5.99
IIVRO-599-8-1	10.19	9.69	9.94
IC-69257	4.18	4.05	4.11
IIVRO-770	18.82	18.52	18.67
IIVRO-SC-108	11.55	11.04	11.30
IIVRO-307-10-1 II	12.86	12.31	12.58
IIVRO-SKY/DR/RS-66	11.94	11.84	11.89
Kashi Kranti	10.89	10.17	10.53
IIVRO-3	8.83	8.85	8.84
IIVRO-419-01-1	8.99	8.25	8.62
IIVRO-325-10-1	10.05	9.10	9.57
IIVRO-130-10-1	7.53	7.36	7.45
IIVRO-1773	7.45	7.07	7.26
IIVRO-49	6.27	6.30	6.29
IIVRO-363	9.44	8.66	9.05
IC-218844	8.66	8.16	8.41
IC-45831	7.88	7.57	7.73
IIVRO-137-10-1,2	14.97	13.51	14.24
IIVRO-814-K	8.40	8.28	8.34
IC-039140	8.37	7.41	7.89
IC-117319	9.79	8.70	9.25
Arka Anamika	15.40	14.34	14.87
Prabhani Kranti	11.27	11.16	11.21
SEm±	0.77	0.55	0.47
CD at 5%	2.17	1.56	1.32

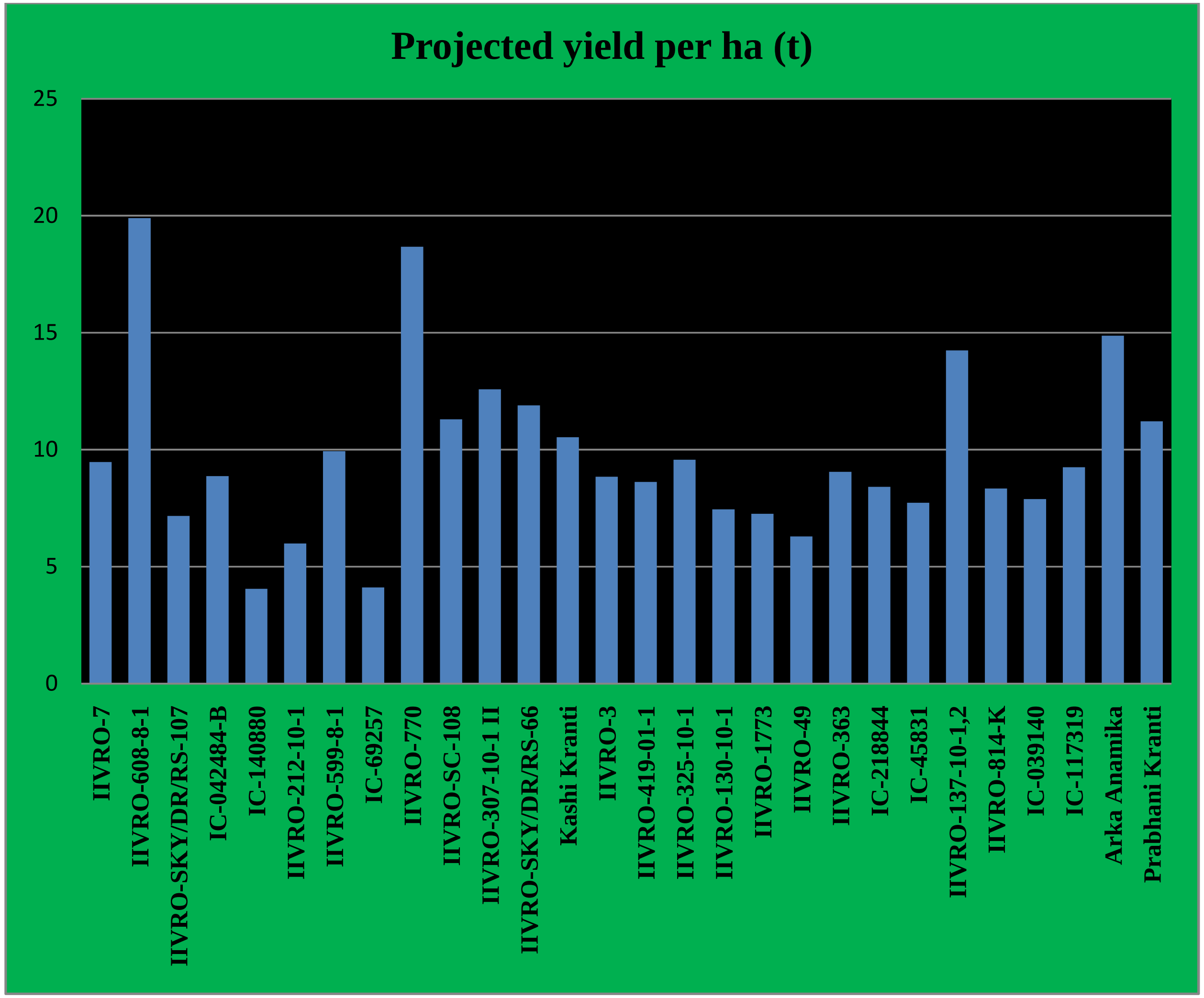

Figure 4.21: Yield attributes of various okra genotypes on projected yield per hectare

4.3 Quality characters

4.3.1 Protein content

Table 4.23 and Fig 4.22 presents the data on protein content of okra. The data revealed significant difference among the genotypes in respect to protein content. The genotype IC-218844 recorded maximum protein content (4.89%) followed by genotype IIVRO-363 (4.77%). The minimum protein content (2.67%) was found in genotype IIVRO-814-K.

These results are also supported by the previous findings of Gemede *et al.* (2015) who observed that the protein content of eight okra pod accessions varied significantly. Düzyaman and Vural (2003) reported that protein levels was higher in the lines from Turkey had top protein levels varying between 2.51- 4.55% while this remained between 2.9-3.3 % in the Indian material and 2.5-4.13 % in the USA material. The variation in protein content among the genotypes is determined by the genetic make-up of the genotypes. These results are in conformity with the findings of Petropoulous *et al.* (2018) who reported that the differences in protein content of the okra genotypes could be partly associated with differences in moisture content of fruit as well as to differences in genetic potential between the studied genotypes.

4.3.2 Vitamin C content

The data on vitamin C content of okra are presented in table 4.24 and Fig 4.23. The data revealed significant difference among the genotypes in respect to vitamin C content. The genotype Arka Anamika recorded maximum vitamin C

Table 4.23: Quality attributes of various okra genotypes on protein content.

Genotypes	Protein content (%)		
	2013	2014	Pooled
IIVRO-7	2.79	2.67	2.73
IIVRO-608-8-1	3.85	3.77	3.81
IIVRO-SKY/DR/RS-107	4.25	4.22	4.24
IC-042484-B	3.69	3.67	3.68
IC-140880	3.32	3.22	3.27
IIVRO-212-10-1	3.48	3.42	3.45
IIVRO-599-8-1	3.56	3.55	3.55
IC-69257	3.01	2.98	2.99
IIVRO-770	4.35	4.30	4.33
IIVRO-SC-108	4.63	4.59	4.61
IIVRO-307-10-1 II	4.55	4.47	4.51
IIVRO-SKY/DR/RS-66	4.59	4.58	4.59
Kashi Kranti	3.17	3.15	3.16
IIVRO-3	3.67	3.60	3.64
IIVRO-419-01-1	4.06	4.02	4.04
IIVRO-325-10-1	4.00	3.98	3.99
IIVRO-130-10-1	3.16	3.10	3.13
IIVRO-1773	3.54	3.52	3.53
IIVRO-49	3.50	3.49	3.50
IIVRO-363	4.81	4.72	4.77
IC-218844	4.92	4.85	4.89
IC-45831	3.20	3.19	3.20
IIVRO-137-10-1,2	3.42	3.39	3.41
IIVRO-814-K	2.83	2.51	2.67
IC-039140	3.90	3.85	3.88
IC-117319	4.28	4.23	4.26
Arka Anamika	4.19	4.15	4.17
Prabhani Kranti	4.70	4.65	4.67
SEm±	0.03	0.05	0.03
CD at 5%	0.08	0.15	0.08

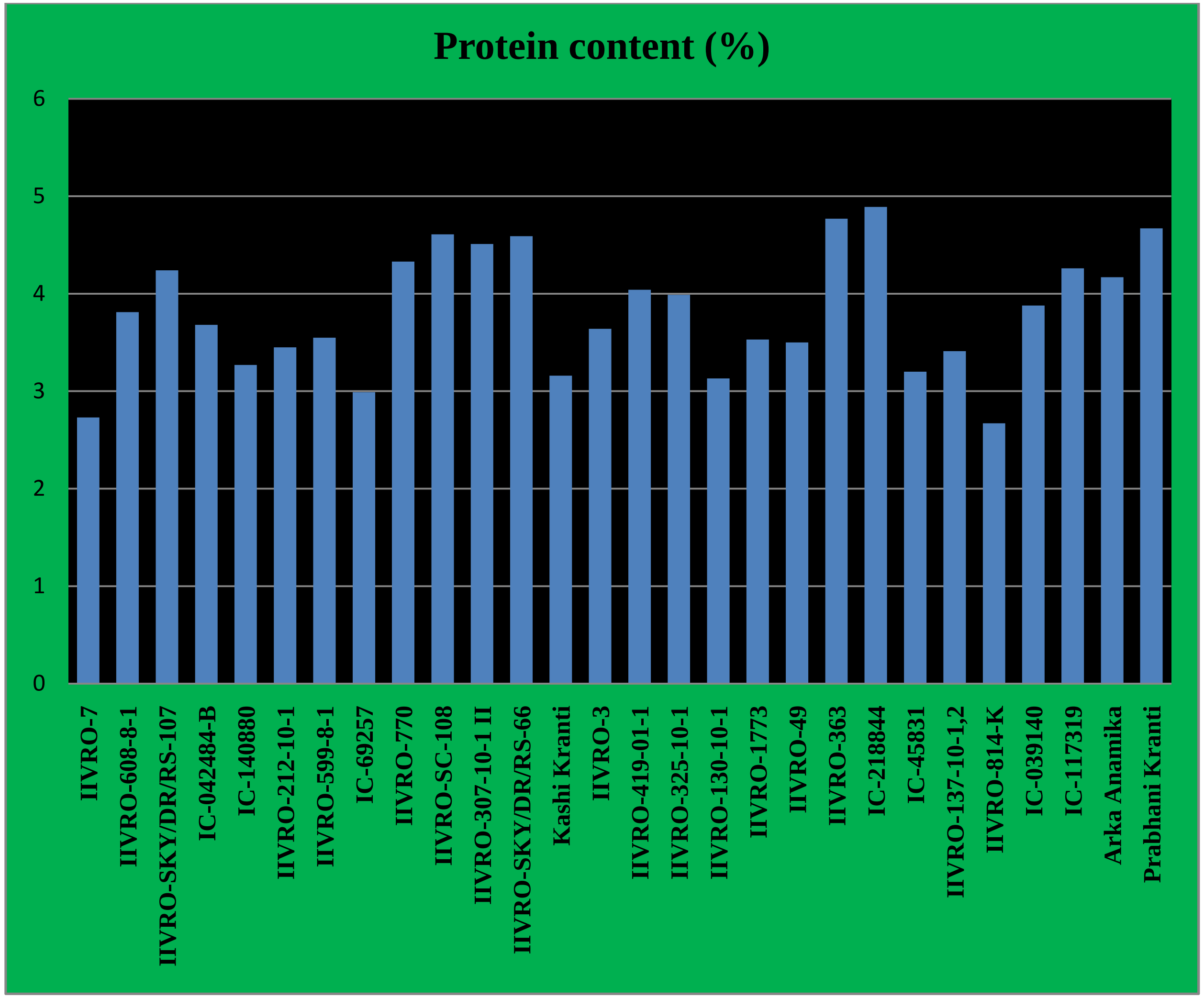

Figure 4.22: Quality attributes of various okra genotypes on protein content.

Table 4.24: Quality attributes of various okra genotypes on vitamin C

Genotypes	Vitamin C content (mg $100g^{-1}$ of fruit)		
	2013	**2014**	**Pooled**
IIVRO-7	22.53	21.65	22.09
IIVRO-608-8-1	15.26	14.64	14.95
IIVRO-SKY/DR/RS-107	20.62	20.48	20.55
IC-042484-B	19.93	19.62	19.78
IC-140880	17.72	17.31	17.51
IIVRO-212-10-1	17.00	16.04	16.52
IIVRO-599-8-1	16.39	15.46	15.92
IC-69257	14.50	14.05	14.28
IIVRO-770	14.57	14.28	14.42
IIVRO-SC-108	21.04	19.47	20.26
IIVRO-307-10-1 II	14.26	13.94	14.10
IIVRO-SKY/DR/RS-66	14.40	14.08	14.24
Kashi Kranti	15.80	15.48	15.64
IIVRO-3	17.40	16.83	17.12
IIVRO-419-01-1	20.40	20.07	20.23
IIVRO-325-10-1	14.33	14.11	14.22
IIVRO-130-10-1	18.01	16.95	17.48
IIVRO-1773	17.41	16.28	16.85
IIVRO-49	22.41	21.05	21.73
IIVRO-363	17.37	17.34	17.35
IC-218844	22.55	21.22	21.89
IC-45831	22.18	21.55	21.87
IIVRO-137-10-1,2	19.21	18.86	19.03
IIVRO-814-K	21.61	20.82	21.21
IC-039140	21.60	20.25	20.93
IC-117319	22.45	21.96	22.20
Arka Anamika	22.52	22.07	22.30
Prabhani Kranti	21.69	20.57	21.13
SEm±	0.55	0.39	0.34
CD at 5%	1.55	1.11	0.95

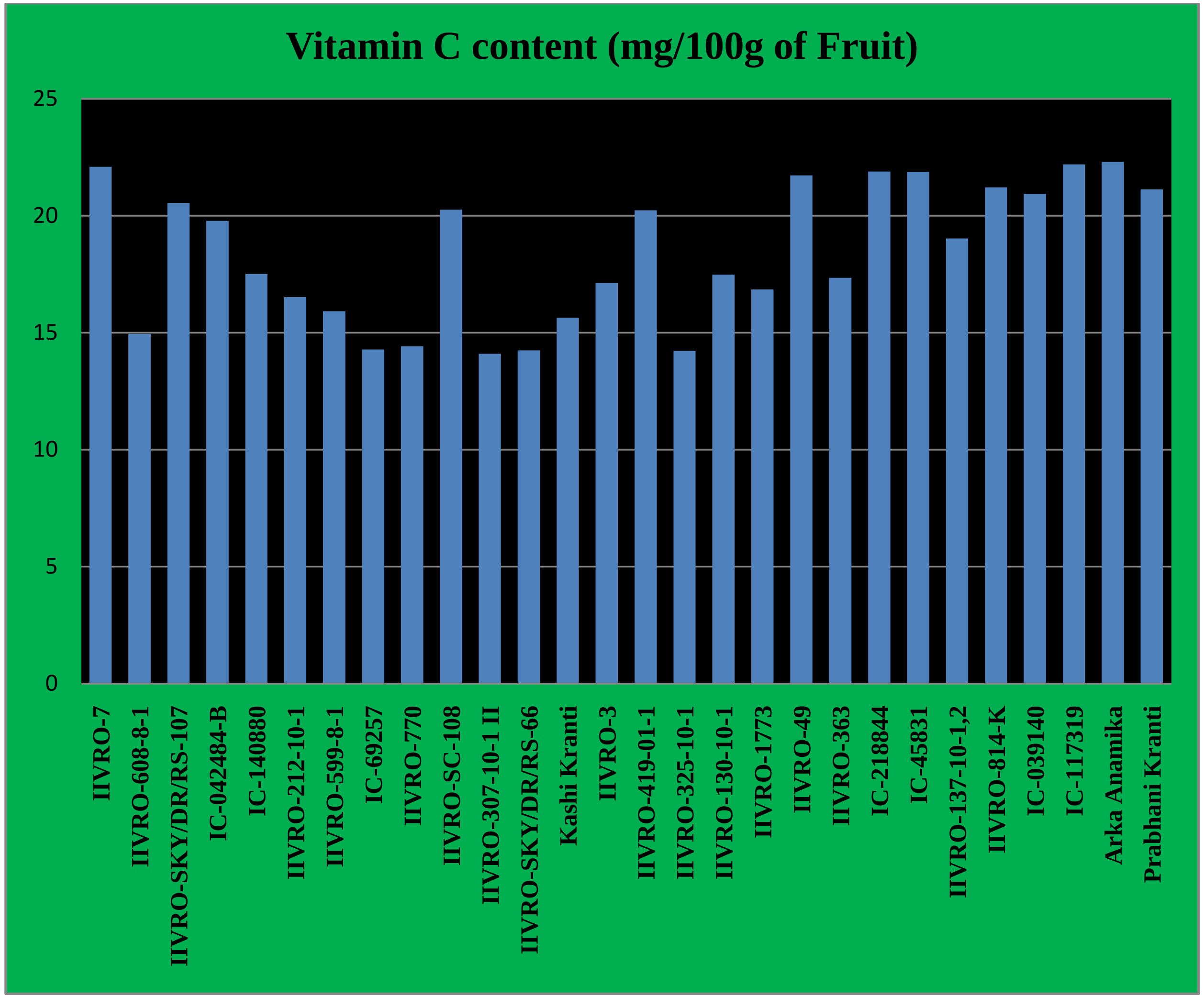

Figure 4.23: Quality attributes of various okra genotypes on protein content.

content (22.30%) followed by genotype IC-117319 (22.20%). The minimum vitamin C content (14.10%) was found in genotype IIVRO-307-10-1 II. The variation in vitamin C content among the genotypes is determined by the genetic make-up of the genotypes.

4.3.3 Fibre content

Table 4.25 and Fig 4.24 presents the data on fibre content of okra. From the experimental findings, it was observed that the fibre content varied significantly among the different genotypes. The genotype IIVRO-137-10-1, 2 recorded maximum fibre content (13.92%) while the minimum fibre content (8.57%) was found in genotype IIVRO-419-01-1.

Our results are in agreement with previous reports of El-Nahry *et al.* (1978) and Makhadmeh & Ereifej (2007) that indicated differences in fiber contents among okra cultivars. These findings are also similar to those reported by Gemede *et al.* (2015) who reported that the crude fiber content among the accessions of Okra pod varied from 11.97 g/100 g to 29.93 g/100 g whereas Adetuyi *et al.* (2011) reported that the fiber content of Okra pod ranges from 10.15 to 11.63 g/100 g. The present findings for fibre content in okra genotypes are within the range of reported result.

4.3.4 Dry matter content (%)

The data on dry matter content of okra are presented in table 4.26 and Fig 4.25. Dry matter content of okra was profoundly affected by the genotypes. The maximum dry matter content (15.65%) was recorded from the genotype IIVRO-

Table 4.25: Quality attributes of various okra genotypes on fibre content.

Genotypes	Fibre content (%)		
	2013	2014	Pooled
IIVRO-7	13.11	13.00	13.06
IIVRO-608-8-1	11.50	11.34	11.42
IIVRO-SKY/DR/RS-107	11.43	11.00	11.22
IC-042484-B	10.26	10.29	10.28
IC-140880	12.10	11.75	11.93
IIVRO-212-10-1	10.61	10.26	10.44
IIVRO-599-8-1	11.39	11.10	11.25
IC-69257	13.08	12.91	13.00
IIVRO-770	12.76	12.82	12.79
IIVRO-SC-108	11.37	11.16	11.27
IIVRO-307-10-1 II	12.81	12.65	12.73
IIVRO-SKY/DR/RS-66	12.16	12.01	12.09
Kashi Kranti	10.26	9.91	10.09
IIVRO-3	10.23	10.26	10.25
IIVRO-419-01-1	8.62	8.52	8.57
IIVRO-325-10-1	10.45	10.13	10.29
IIVRO-130-10-1	13.53	13.25	13.39
IIVRO-1773	10.19	9.88	10.03
IIVRO-49	9.75	9.73	9.74
IIVRO-363	12.63	12.19	12.41
IC-218844	10.52	10.33	10.43
IC-45831	9.92	9.61	9.77
IIVRO-137-10-1,2	14.00	13.83	13.92
IIVRO-814-K	9.48	9.19	9.33
IC-039140	9.97	9.80	9.89
IC-117319	11.51	10.94	11.22
Arka Anamika	12.60	12.05	12.33
Prabhani Kranti	11.82	11.34	11.58
SEm±	0.42	0.28	0.25
CD at 5%	1.19	0.78	0.70

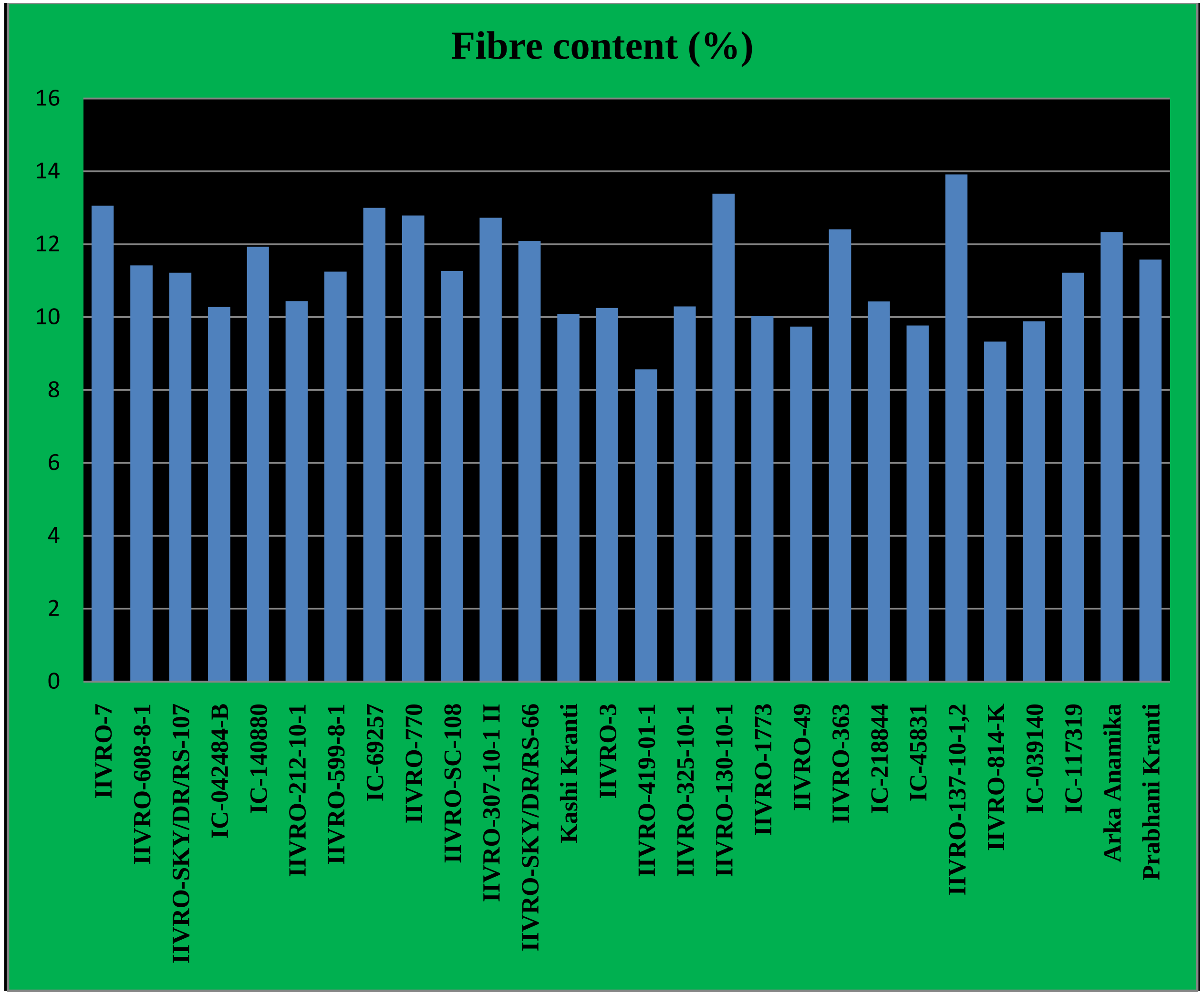

Figure 4.24: Quality attributes of various okra genotypes on fibre content.

Table 4.26: Quality attributes of various okra genotypes on dry matter content

Genotypes	Dry matter content (%)		
	2013	2014	Pooled
IIVRO-7	15.17	15.05	15.11
IIVRO-608-8-1	14.54	14.47	14.50
IIVRO-SKY/DR/RS-107	14.00	14.00	14.00
IC-042484-B	14.31	14.27	14.29
IC-140880	14.78	14.70	14.74
IIVRO-212-10-1	13.62	13.60	13.61
IIVRO-599-8-1	13.40	13.37	13.39
IC-69257	14.97	14.90	14.93
IIVRO-770	13.88	13.75	13.82
IIVRO-SC-108	14.22	14.10	14.16
IIVRO-307-10-1 II	15.70	15.60	15.65
IIVRO-SKY/DR/RS-66	14.08	13.95	14.01
Kashi Kranti	13.92	13.90	13.91
IIVRO-3	13.26	13.20	13.23
IIVRO-419-01-1	14.54	14.50	14.52
IIVRO-325-10-1	14.47	14.42	14.45
IIVRO-130-10-1	13.30	13.20	13.25
IIVRO-1773	13.92	13.78	13.85
IIVRO-49	14.76	14.70	14.73
IIVRO-363	14.23	14.15	14.19
IC-218844	12.36	12.30	12.33
IC-45831	14.62	14.60	14.61
IIVRO-137-10-1,2	14.05	13.95	14.00
IIVRO-814-K	15.22	15.15	15.19
IC-039140	13.00	12.94	12.97
IC-117319	14.04	13.96	14.00
Arka Anamika	15.10	15.00	15.05
Prabhani Kranti	14.85	14.79	14.82
SEm±	0.37	0.37	0.26
CD at 5%	1.05	1.04	0.73

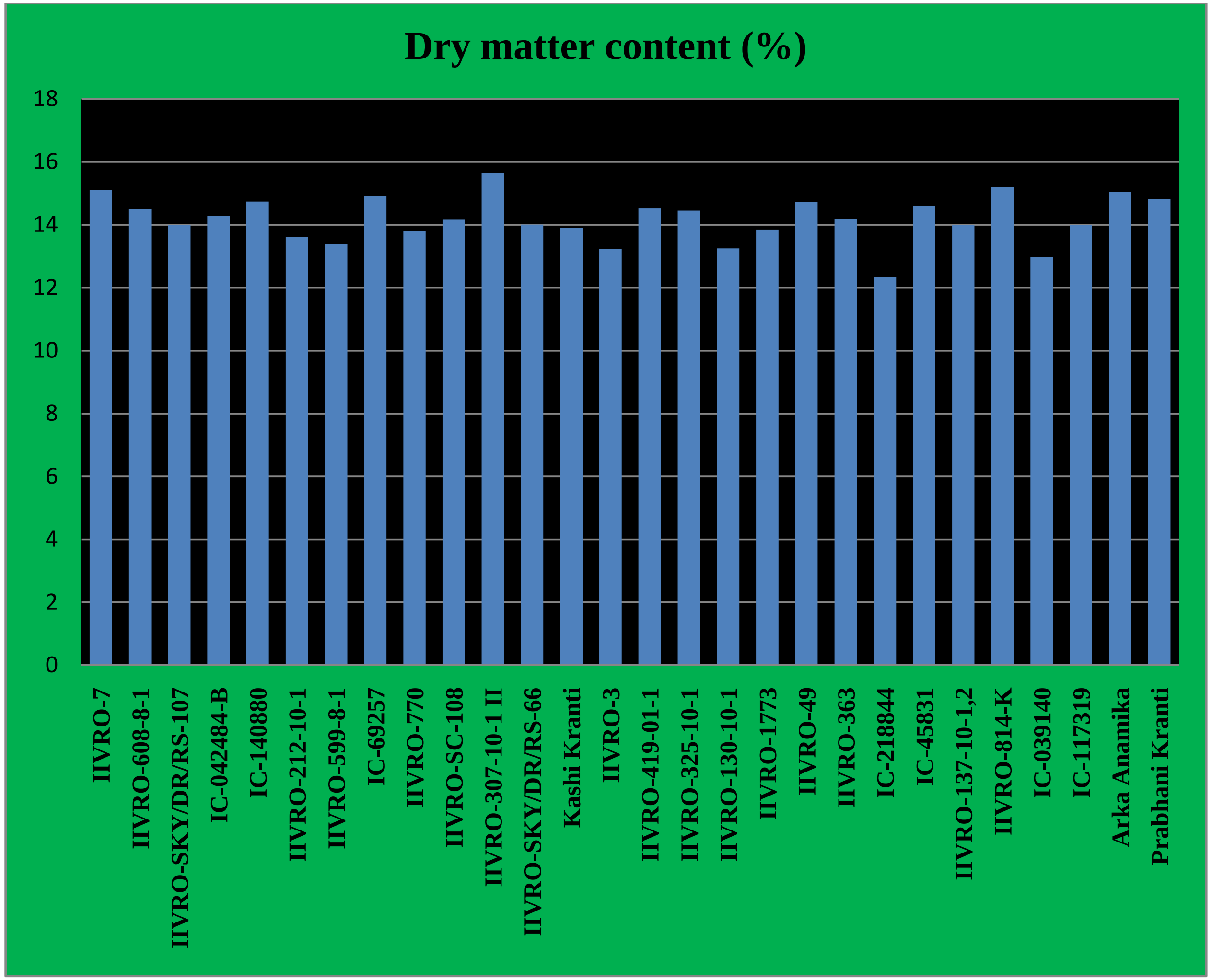

Figure 4.25: Quality attributes of various okra genotypes on dry matter content

307-10 II while the minimum dry matter content (12.33%) was exhibited by the genotype IC-218844.

The differences among the genotypes in regard to the dry matter content may be due to the genetic constitution of the genotypes. These results are in conformity with the findings of Duzyaman and Vural (2003) who reported that dry matter accumulation remained in between 15.6 – 13.6 in the Indian genotypes. The present result is within the range of reported result. . Makhadmeh & Ereifej (2007) also reported that there was a significant variation among okra genotypes in their fiber content.

4.4 Insect and disease incidence

4.4.1 Incidence of blister beetle

The data on incidence of blister beetle on okra genotypes are presented in Table 4.27 and Fig. 4.26. Incidence of blister beetle on okra genotypes was profoundly affected by the genotypes. Incidence of blister beetle on okra genotypes ranged between 3.45-34.55%. The maximum incidence of blister beetle (34.55%) was recorded from the genotype IIVRO-SKY/DR/RS-107 followed by IC-45831 while the minimum incidence of blister beetle (3.45%) was exhibited by the genotype IIVRO-599-8-1.

The serious infestation of blister beetle, *M. phalerata* on okra at Manipur has been mentioned by Barwal and Rao (1988). Under mid hill conditions of Himachal Pradesh, blister beetle has been reportedly observed attacking okra flowers and thus lowering the yield (Kakar and Dogra, 1988; Even, Nath (1992)

Plate 3: Incidence of Mellow Vein Mosaic virus under field conditions

Plate 4: Infestation of blister beetle (Mylabris pustulata)) in the field conditions.

Table 4.27: Incidence of various okra genotypes to blister beetle (*Mylabris pustulata*)

Genotypes	Incidence (%)			Level of resistance
	2013	2014	Pooled	
IIVR0-7	18.06	26.35	22.21	Resistant
IIVRO-608-8-1	20.83	22.66	21.75	Resistant
IIVRO-SKY/DR/RS-107	31.94	37.16	34.55	Moderately Resistant
IC-042484-B	5.56	10.85	8.21	Highly Resistant
IC-140880	18.06	22.52	20.29	Resistant
IIVRO-212-10-1	12.50	17.88	15.19	Resistant
IIVRO-599-8-1	1.39	5.51	3.45	Highly Resistant
IC-69257	9.72	11.49	10.61	Highly Resistant
IIVRO-770	22.22	26.71	24.47	Moderately Resistant
IIVRO-SC-108	18.06	24.16	21.11	Resistant
IIVRO-307-10-1 II	18.06	25.07	21.56	Resistant
IIVRO-SKY/DR/RS-66	23.61	25.40	24.51	Moderately Resistant
Kashi Kranti	13.89	16.61	15.25	Resistant
IIVRO-3	12.50	20.77	16.64	Resistant
IIVRO-419-01-1	23.61	29.26	26.44	Moderately Resistant
IIVRO-325-10-1	22.22	31.54	26.88	Moderately Resistant
IIVRO-130-10-1	8.33	10.03	9.18	Highly Resistant
IIVRO-1773	13.89	18.20	16.05	Resistant
IIVRO-49	12.50	12.57	12.54	Resistant
IIVRO-363	16.67	20.28	18.47	Resistant
IC-218844	6.94	10.05	8.50	Highly Resistant
IC-45831	25.00	31.46	28.23	Moderately Resistant
IIVRO-137-10-1,2	6.94	11.35	9.15	Highly Resistant
IIVRO-814-K	12.50	16.29	14.40	Resistant
IC-039140	9.72	15.20	12.46	Resistant
IC-117319	18.06	26.80	22.43	Resistant
Arka Anamika	11.11	20.22	15.67	Resistant
Prabhani Kranti	2.78	5.59	4.18	Highly Resistant
SE(M)±	3.22	4.05	2.59	–
CD at 5%	9.14	11.49	7.26	–

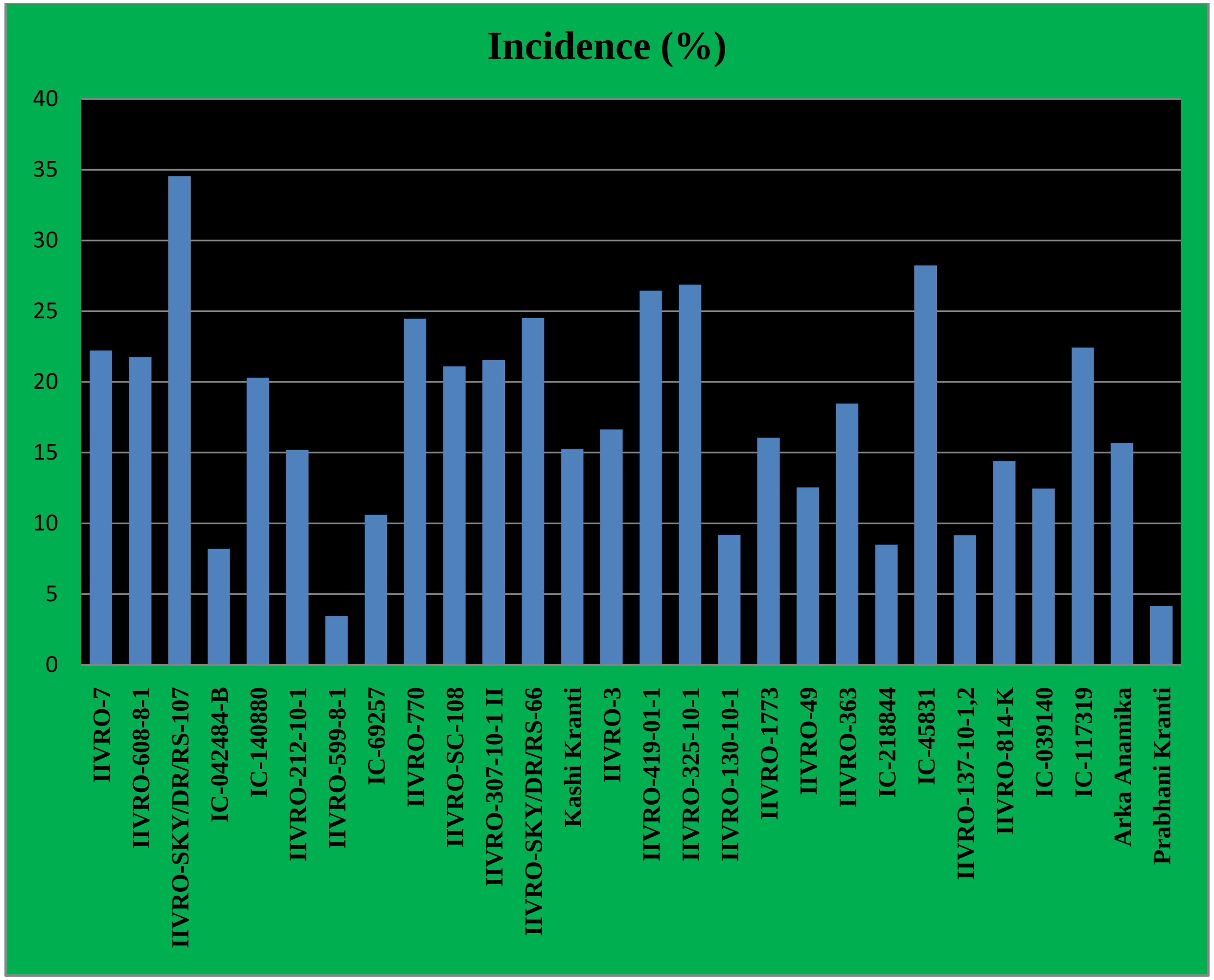

Figure 4.26: Incidence of various okra genotypes to blister beetle (*Mylabris pustulata*)

Table 4.28: Incidence of various okra genotypes to Yellow vein mosaic virus

Genotypes	Disease rating (%)			Level of resistance
	2013	2014	Pooled	
IIVR0-7	20.00	45.00	32.50	Moderately Resistant
IIVRO-608-8-1	26.77	28.57	27.67	Moderately Resistant
IIVRO-SKY/DR/RS-107	26.00	28.56	27.28	Moderately Resistant
IC-042484-B	25.33	25.96	25.65	Moderately Resistant
IC-140880	42.15	45.55	43.85	Low Resistant
IIVRO-212-10-1	61.05	69.45	65.25	Highly Susceptible
IIVRO-599-8-1	28.22	38.89	33.56	Moderately Resistant
IC-69257	27.69	42.86	35.28	Moderately Resistant
IIVRO-770	2.11	6.09	4.10	Highly Resistant
IIVRO-SC-108	4.17	27.38	15.77	Resistant
IIVRO-307-10-1 II	0.00	4.88	2.44	Highly Resistant
IIVRO-SKY/DR/RS-66	0.00	7.14	3.57	Highly Resistant
Kashi Kranti	20.00	27.17	23.58	Resistant
IIVRO-3	11.91	17.42	14.67	Resistant
IIVRO-419-01-1	23.33	28.57	25.95	Moderately Resistant
IIVRO-325-10-1	5.00	16.43	10.72	Highly Resistant
IIVRO-130-10-1	42.14	57.14	49.64	Susceptible
IIVRO-1773	26.80	37.50	32.15	Moderately Resistant
IIVRO-49	26.00	35.11	30.56	Moderately Resistant
IIVRO-363	0.00	5.88	2.94	Highly Resistant
IC-218844	0.00	5.56	2.78	Highly Resistant
IC-45831	31.87	46.88	39.38	Low Resistant
IIVRO-137-10-1,2	26.22	30.00	28.11	Moderately Resistant
IIVRO-814-K	51.00	57.29	54.15	Susceptible
IC-039140	11.26	36.66	23.96	Resistant
IC-117319	19.33	49.17	34.25	Moderately Resistant
Arka Anamika	25.00	30.00	27.50	Moderately Resistant
Prabhani Kranti	4.17	11.17	7.67	Highly Resistant
SE(M)±	4.60	4.70	3.29	–
CD at 5%	13.05	13.32	9.22	–

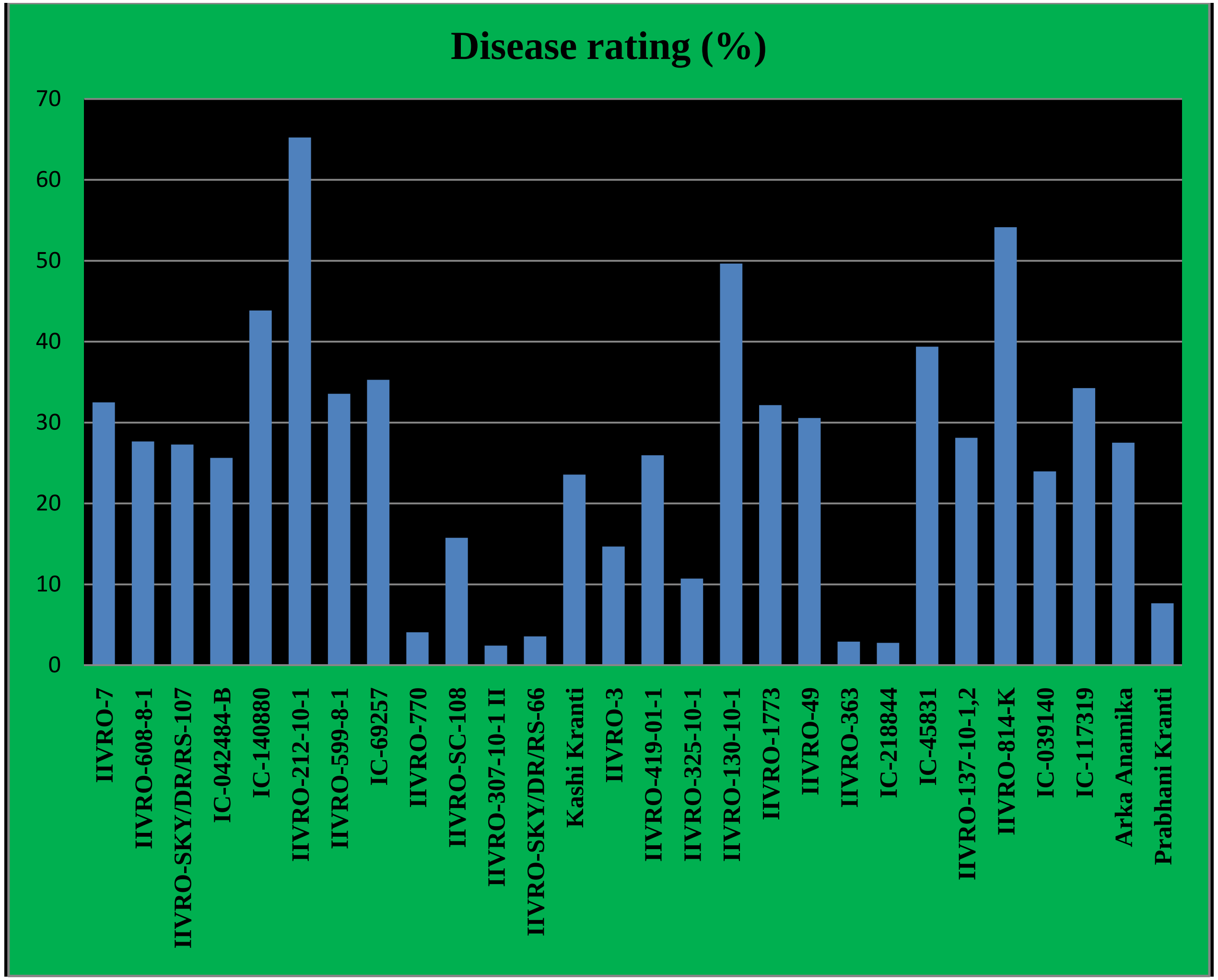

Figure 4.27: Incidence of various okra genotypes to Yellow vein mosaic virus

Note: 0 – 12% = Highly Resistant	12 – 24% = Resistant
24 – 36% = Moderately Resistant	36 – 48% = Low Resistant
48 – 60% = Susceptible	60 – 72% = Highly Susceptible

observed *Mylabris* spp. to be causing principal damage to okra in Solan valley of Himachal Pradesh. Sharma (2004) reported 4 species of Mylabris associated with okra crop.

4.4.2 Incidence of yellow vein mosaic virus

The data on incidence of yellow vein mosaic virus on okra genotypes are presented in table 4.28 and fig 4.27. Incidence of yellow vein mosaic virus on okra genotypes was profoundly affected by the genotypes. Incidence of yellow vein mosaic virus on okra genotypes ranged between 2.44-65.25%. The maximum incidence of yellow vein mosaic virus (65.25%) was recorded from the genotype IIVRO-212-10-1 followed by IIVRO-814-K at 54.15% while the minimum incidence of yellow vein mosaic virus (2.44%) was exhibited by the genotype IIVRO-307-10-1 II.

The data revealed that all the okra genotypes were infected by yellow vein mosaic virus although they varied in disease severity. Similarly, Asare-Bediako (2016) revealed that all the okra genotypes tested in both the rainy and dry seasons were infected by OkMV although they varied in disease severity. This finding is comparable to that of Udengwu and Dibua (2014) where all 15 okra cultivars screened under field conditions were susceptible to OMD and OLCD. Similarly, Nataraja *et al*. (2013) found that 23 cultivars of okra tested under field conditions were susceptible to Okra yellow vein mosaic and sucking pests. The observed variation in disease severity could be due to different interaction effects between different genotypes and OkMV. Similar reasons also apply to the variations in the incidence and severity of Okra yellow leaf curl virus among tomato genotypes tested (Azizi *et al*., 2008; Abu *et al*., 2011) and to variation in the susceptibility of *Arabidopsis thaliana* accessions to *Turnip yellows virus* (Asare-Bediako *et al*. 2012).

4.5 Estimation of genetic parameters

The analysis of variance indicated highly significant differences among genotypes for all the characters. The results clearly indicated the presence of high amount of variability for yield and yield components among the genotypes studied.

4.5.1 Range and mean

Range and mean performance (maximum and minimum) of the twenty-eight genotypes of okra for all 14 growth characters are presented in table 4.29, table 4.30 and table 4.31.

4.5.1.1 Growth attributes

4.5.1.1.1 Plant height (cm)

Plant height at 105 DAS ranged from 97.47 to 176.23 cm with an overall mean performance of 139.58 cm. Genotype IIVRO-SKY/DR/RS-66 recorded the maximum plant height (176.23 cm) while genotype IC-140880 exhibited minimum plant height (97.47 cm) at 105 DAS.

4.5.1.1.2 Number of leaves per plant

Number of leaves per plant varied from 13.01 to 44.06 with an overall mean performance of 24.48 at 105 DAS. Genotype IIVRO-608-8-1 recorded the maximum number of leaves per plant (44.06) while genotype IC-140880 exhibited minimum number of leaves per plant (13.01) at 105 DAS.

4.5.1.1.3 Size of leaf (cm^2)

Size of leaf varied from 218.40 to 680.17 with an overall mean performance of 383.45 cm^2. Genotype IIVRO-608-8-1 recorded the maximum size of leaves (680.17 cm^2) while genotype IC-140880 exhibited minimum size of leaves (218.40 cm^2).

4.5.1.1.4 Cumulative leaf area (m^2)

Cumulative leaf area varied from 0.29 to 3.00 with an overall mean performance of 1.00 m^2. Genotype IIVRO-608-8-1 recorded the maximum cumulative leaf area (3.00 m^2) while genotype IC-140880 exhibited minimum cumulative leaf area (0.29 m^2).

4.5.1.1.5 Leaf area index

The leaf area index in the pooled data ranged from 2.12 to 22.25 with an overall mean of 7.40. The maximum leaf area index was recorded from IIVRO-608-8-1 at 22.25 with IC-140880 recording the least leaf area index at 2.12.

4.5.1.1.6 Number of branches per plant

The number of branches per plant varied from an average of 0.74 to 2.45 at an overall mean of 1.61. The highest average was found in the variety IIVRO-SKY/DR/RS-107 recorded at 2.45 whereas IC-45831 stood at an average of 0.74 recording the lowest.

4.5.1.1.7 Days to first flowering

The number of days for first flowering ranged from an average of 42.52 to 53.68 with an overall mean of 47.34 days. IC-039140 recorded the most number of days at an average of 53.68 days while IIVRO-770 recorded the least number of days at 42.52.

4.5.1.1.8 Number of nodes for first flower

The number of nodes for first flower ranged from 4.95 to 7.30 with an overall average of 6.15. The maximum number of nodes was seen in IIVRO-3 with an average of 6.90 while the lowest was seen in IIVRO-770 with 4.95.

4.5.1.1.9 Duration of flowering

The duration of the flowering period ranged from 51.32 to 62.48 days with a mean period of 91.05 days. The maximum duration of flowering was seen in IIVRO-770 and the minimum was seen in IC-039140.

Table 4.29: Genetic parameters on growth attributes of thirteen (13) characters in various okra genotypes during 2013 -14

Sl. No.	Characters	Year	Mean	Range	Variance		Coefficient of variation		Heritability (%)	Genetic advance as % of mean
					Phenotypic variance (σ^2p)	Genotypic variance (σ^2g)	PCV (%)	GCV (%)		
1.	Plant height (cm)	2013	142.70	100.62 - 180.00	1172.42	1077.65	23.99	23.00	91.92	64.83
		2014	136.47	94.32 - 172.45	1147.20	1072.06	24.82	23.99	93.45	65.20
		Pooled	139.58	97.47 - 176.23	1159.81	1074.85	24.40	23.49	92.68	65.02
2.	Number of leaves plant^{-1}	2013	25.53	13.50 - 46.23	212.31	206.58	57.07	56.29	97.30	29.21
		2014	23.44	12.52 - 41.90	201.13	195.74	60.51	59.69	97.32	28.43
		Pooled	24.48	13.01 - 44.06	206.72	201.16	58.72	57.93	97.31	28.82
3.	Size of leaf (cm)	2013	395.21	227.07 - 698.50	39344.93	37900.25	50.19	49.26	96.33	39.36
		2014	371.69	209.74 - 661.83	36484.02	35847.13	51.39	50.94	98.25	38.66
		Pooled	383.45	218.40 - 680.17	37914.48	36873.69	50.78	50.08	97.25	39.10
4.	Cumulative leaf area (m^2)	2013	1.07	0.31 - 3.23	0.45	0.42	62.66	60.66	93.72	1.29
		2014	0.93	0.26 - 2.78	0.36	0.35	64.85	63.60	96.18	1.19
		Pooled	1.00	0.29 - 3.00	0.41	0.38	63.77	62.09	94.82	1.24
5.	Leaf area index (cm^2)	2013	7.92	2.29 - 23.93	24.60	23.05	62.66	60.66	93.72	9.58
		2014	6.87	1.95 - 20.57	19.88	19.12	64.85	63.60	96.18	8.83
		Pooled	7.40	2.12 - 22.25	22.24	21.09	63.77	62.09	94.82	9.21
6.	Number of branches plant^{-1}	2013	1.63	0.75 - 2.47	0.73	19.88	52.67	51.19	94.47	1.67
		2014	1.59	0.73 - 2.43	0.70	22.24	52.65	50.86	93.32	1.61
		Pooled	1.61	0.74 - 2.45	0.72	0.67	52.66	51.03	93.91	1.64
7.	Days to first flowering	2013	47.03	42.83 - 53.23	23.83	14.74	10.38	8.16	61.86	6.22
		2014	47.65	42.20 - 54.13	24.94	18.36	10.48	8.99	73.61	7.57
		Pooled	47.34	42.52 - 53.68	24.38	16.55	10.43	8.59	67.87	6.90

Conti…

Sl. No.	Characters	Year	Mean	Range	Variance		Coefficient of variation		Heritability (%)	Genetic advance as % of mean
					Phenotypic variance (σ^2p)	Genotypic variance (σ^2g)	PCV (%)	GCV (%)		
8.	Number of nodes for first flower	2013	6.07	4.90 - 6.80	1.10	0.99	17.31	16.41	89.84	1.94
		2014	6.23	5.00 - 7.00	1.32	1.02	18.40	16.20	77.53	1.83
		Pooled	6.15	4.95 - 6.90	1.21	1.01	17.88	16.31	83.15	1.88
9.	Duration of flowering (Days)	2013	57.97	51.77 – 62.17	23.83	14.74	8.42	6.62	61.86	6.22
		2014	57.35	50.73 – 62.80	24.94	18.36	8.71	7.47	73.61	7.57
		Pooled	57.66	51.32 – 62.48	24.38	16.55	8.56	7.06	67.87	6.90
10.	Days to fruit setting	2013	49.03	43.87 – 54.20	22.99	14.19	9.98	7.84	61.73	6.10
		2014	49.20	43.23 – 55.17	24.81	18.37	10.26	8.83	74.05	7.60
		Pooled	49.11	43.55 – 54.68	23.90	16.28	10.12	8.35	68.12	6.86
11.	Days to marketable maturity	2013	56.29	50.80 - 64.90	38.54	29.79	11.03	9.70	77.29	9.88
		2014	56.73	51.10 - 64.60	41.33	32.67	11.33	10.07	79.04	10.47
		Pooled	56.51	50.95 - 64.75	39.94	31.23	11.18	9.89	78.19	10.18
12.	Days from fruit setting to harvesting	2013	8.26	6.17 - 13.40	17.81	14.61	51.07	46.26	82.05	7.13
		2014	8.17	6.10 - 11.87	7.88	6.92	34.38	32.22	87.81	5.08
		Pooled	8.21	6.22 - 12.63	12.85	10.77	43.63	39.95	83.82	6.19
13.	Number of ridges fruit^{-1}	2013	5.43	5.07 - 7.13	1.50	1.48	22.54	22.38	98.63	2.49
		2014	5.38	5.00 - 7.13	1.52	1.50	22.89	22.78	99.10	2.52
		Pooled	5.41	5.03 - 7.13	1.51	1.49	22.71	22.58	98.87	2.50

Table 4.30: Genetic parameters on yield attributes of eight (8) characters in various okra genotypes during 2013 and 2014

Sl. No.	Characters	Year	Mean	Range	Variance		Coefficient of variation		Heritability (%)	Genetic advance as % of mean
					Phenotypic variance (σ^2p)	Genotypic variance (σ^2g)	PCV (%)	GCV (%)		
1.	Number of fruits plant^{-1}	2013	12.58	6.15 - 18.45	29.50	24.03	43.18	38.98	81.48	9.12
		2014	12.15	6.15 - 18.40	28.53	24.70	43.96	40.91	86.57	9.53
		Pooled	12.36	6.15 - 18.42	29.01	24.36	43.57	39.93	83.98	9.32
2.	Length of fruit (cm)	2013	13.05	10.15 - 16.95	7.20	5.19	20.56	17.46	72.08	3.99
		2014	12.83	10.00 - 16.82	7.00	5.68	20.61	18.58	81.24	4.43
		Pooled	12.94	10.08 - 16.89	7.10	5.44	20.59	18.02	76.59	4.20
3.	Diameter of fruit (cm)	2013	1.83	1.59 - 2.07	0.07	0.05	14.22	12.48	76.99	0.41
		2014	1.82	1.57 - 2.05	0.07	0.05	14.27	12.75	79.82	0.43
		Pooled	1.83	1.58 - 2.06	0.07	0.05	14.24	12.61	78.40	0.42
4.	Weight of fruit (g)	2013	18.81	12.06 - 26.05	37.24	28.75	32.44	28.51	77.21	9.71
		2014	18.36	11.85 - 25.85	35.13	27.46	32.28	28.54	78.17	9.54
		Pooled	18.59	11.96 - 25.95	36.19	28.11	32.37	28.53	77.68	9.63
5.	Number of seeds fruit^{-1}	2013	43.87	32.95 - 56.20	156.53	114.46	28.52	24.38	73.12	18.85
		2014	39.41	28.95 - 51.98	153.05	106.71	31.39	26.21	69.72	17.77
		Pooled	41.64	30.95 - 54.09	154.79	110.58	29.88	25.25	71.44	18.31
6.	Yield plant^{-1} (g)	2013	241.53	100.33 - 478.77	26111.06	23064.27	66.90	62.88	88.33	29.40
		2014	228.16	93.45 - 476.55	25162.19	22520.38	69.52	65.77	89.51	29.24
		Pooled	234.85	97.19 - 477.66	25636.62	22792.33	68.18	64.28	88.91	29.32
7.	Yield plot^{-1} (kg)	2013	5.80	2.41 - 11.49	15.04	13.29	66.90	62.88	88.33	7.06
		2014	5.48	2.24 - 11.44	14.49	12.97	69.52	65.77	89.51	7.02
		Pooled	5.64	2.33 - 11.47	14.77	13.13	68.18	64.28	88.91	7.04
8.	Projected yield ha^{-1} (t)	2013	10.03	4.20 - 19.95	43.13	41.37	65.48	64.13	95.92	12.98
		2014	9.50	3.89 - 19.86	41.24	40.33	67.57	66.82	97.79	12.94
		Pooled	9.77	4.05 - 19.90	42.19	40.85	66.50	65.44	96.83	12.96

4.5.1.1.10 Days to fruit setting

The average number of days for fruit setting ranged between 43.55 to 54.68 days. The maximum duration required for fruit setting was seen in IC-039140 with 54.68 days while the minimum was seen in IIVRO-770.

4.5.1.1.11 Marketable maturity

The time for marketable maturity stood between 50.95 days to 64.75 days with a mean of 56.51 days. The minimum maturity period was required by IC-45831 at 64.75 days while IIVRO-SKY/DR/RS-107 needed the maximum period to mature at an average of 50.95 days.

4.5.1.1.12 Days from fruit set to harvesting

The period from fruit setting to harvesting ranged from 5.35 days to 12.63 days with a mean period of 8.21 days. Fruit setting was seen earliest in IC-117319 within 5.35 days while IC-45831 took the longest period of time (12.63 days).

4.5.1.1.13 Number of ridges per fruit

The number of ridges per fruit ranged from 5.03 to 7.13 with a mean of 5.41. Most number of ridges was seen in IIVRO-770 with an average of 7.13 ridges per fruit while IC-117319 scored the lowest with an average of 5.03.

4.5.1.2 Yield Attributes

4.5.1.2.1 Number of fruits per plant

The number of fruits per plant ranged from an average of 6.15 to 18.42 with a mean of 12.58. The highest number of fruits per plant was harvested from IIVRO-608-8-1 with an average of 18.42 and the lowest number of fruits per plant was 6.15 in IC-69257.

4.5.1.2.2 Length of fruits (cm)

The length of the fruits varied from 10.08 cm from the variety IC-140880 to a minimum of 16.89cm in IIVRO-1773.

4.5.1.2.3 Diameter of fruits (cm)

The range of the diameter of the fruits ranged from 1.58cm to 2.06cm with a mean of 1.83. IIVRO-608-8-1 and IIVRO-770 recorded the maximum diameter of the fruits at 2.06cm while IIVRO-1773 recorded the least diameter at 1.58cm.

4.5.1.2.4 Weight of fruits (g)

The weight of fruits per plant ranged from an average of 11.96 g to 25.96 g with a mean of 18.59 g. The maximum weight of fruits was harvested from IIVRO-608-8-1 with an average of 25.96 g and the lowest weight of the fruits was 11.96 g in IC-140880.

4.5.1.2.5 Number of seeds per fruit

The average number of seeds per fruit ranged from 30.95 to 54.09 at a mean of 41.64. The highest number of seeds was recorded at IIVRO-608-8-1 with 54.09 and the lowest was seen in IIVRO -130-10-1.

4.5.1.2.6 Yield per plant (g)

The differences in the yields per plant varied from 97.19 g to 477.66 g with a mean of 234.85. The highest yield was seen in IIVRO-608-8-1 with an average yield of 477.66 g while IVRO-IC-140880 with 97.19 g recorded the lowest yield.

4.5.1.2.7 Yield per plot (kg)

The range of yields per plot varied from 2.33 kg to 11.47 kg per plot with an average mean of 5.64 kg. The highest yield was seen in IIVRO-608-8-1 with an average yield of 11.47Kgs while IVRO-IC-140880 with 97.19 kg recorded the lowest yield.

4.5.1.2.8 Projected yield per hectare (t)

The projected yield per hectare of the varieties under investigation ranges from 4.05 t to 19.90 t at a mean of 17.39 t. IIVRO-608-8-1 projects the highest yield at 19.90 tonnes per hectare whereas IC-140880 recorded an average low of 4.05 t.

4.5.1.3 Quality attributes

4.5.1.3.1 Protein content (%)

The protein content of the varieties under investigation ranged from 2.67% to 4.89% with an overall average of 3.78%. The protein content was seen in IC-218844 with 4.89% while IIVRO-814-K recorded the lowest protein content at 2.67%.

4.5.1.3.2 Vitamin C content (mg 100g^{-1} of fruit)

Studies on the content of vitamin concluded that the highest content of vitamin was found in Arka Anamika with 22.30% while a low of 14.10% was found in IIVRO-307-10-1 II. The average mean vitamin was found to be 18.42%.

4.5.1.3.3 Fibre content (%)

The amount of fibre recorded ranged from 8.57 to 13.92% with a mean of 11.24. The highest being IIVRO-137-10-1, 2 at 13.92% and the lowest at 8.57% with IIVRO-419-01-1.

4.5.1.3.4 Dry matter content (%)

The total dry matter content ranged from 12.33% to 15.65% at a mean average of 14.19%. The highest dry matter content was seen in IIVRO-307-10 II with 15.65% while IC-218844 recorded the lowest dry matter at 12.33%.

4.5.2 Phenotypic and Genotypic Coefficient of Variation

The components of variation such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are being computed. It is essential to know about the selection by separating out the environmental influence from the total variability. This indicates the accuracy with which a genotype can be identified by its phenotypic performance. The data for phenotypic and genotypic coefficient of variation are presented in table 4.29, table 4.30 and table 4.31 and results presented and discussed as follows.

4.5.2.1 PCV and GCV for growth attributes

The highest phenotypic coefficient of variation (PCV) for growth attribute was recorded for cumulative leaf area (63.77) and leaf area index (63.77), followed by number of leaves per plant(58.72), number of branches per plant (52.66), size of leaf (50.78) and plant height (24.40), days from fruit setting to harvesting (43.63) and number of ridges per fruit (22.71) whereas, moderate PCV was recorded in number of nodes for first flower (17.88) followed by days to marketable maturity (11.18), days to first flowering (10.43) and days to fruit setting (10.12). The low PCV was recorded in duration of flowering (8.56).

High estimate of GCV was recorded for cumulative leaf area (62.09) followed by leaf area index (62.09), number of leaves per plant (57.93), number of branches per plant (51.03), size of leaf (50.08), days from fruit setting to harvesting (39.95), plant height (23.49) and number of ridges per fruit (22.58) whereas the moderate GCV are recorded for number of nodes for first flower (16.31) and low GCV was recorded in duration of flowering (7.06) followed by

Table 4.31: Genetic parameters on quality attributes of four (4) characters in various okra genotypes during 2013 and 2014

Sl. No.	Characters	Year	Mean	Range	Variance		Coefficient of variation		Heritability (%)	Genetic advance as % of mean
					Phenotypic variance (σ^2p)	Genotypic variance (σ^2g)	PCV (%)	GCV (%)		
1.	Protein content (%)	2013	3.85	2.79 - 4.92	1.16	1.16	28.07	28.03	99.77	2.21
		2014	3.68	2.51 - 4.85	1.23	1.22	29.30	29.21	99.35	2.27
		Pooled	3.78	2.67 - 4.89	1.19	1.19	28.68	28.62	99.56	2.24
2.	Vitamin C content (mg $100g^{-1}$ of fruit)	2013	18.75	14.26 - 22.55	28.46	27.56	28.44	27.99	96.83	10.64
		2014	18.09	13.94 - 22.07	25.19	24.73	27.75	27.49	98.16	10.15
		Pooled	18.42	14.10 - 22.30	26.82	26.14	28.12	27.76	97.46	10.40
3.	Fibre content (%)	2013	11.36	8.62 - 14.00	6.03	5.51	21.63	20.67	91.31	4.62
		2014	11.12	8.52 - 13.83	5.76	5.53	21.59	21.15	96.05	4.75
		Pooled	11.24	8.57 - 13.92	5.90	5.52	21.61	20.91	93.62	4.68
4.	Dry matter content (%)	2013	14.23	12.36 - 15.70	1.95	1.53	9.81	8.70	78.76	2.26
		2014	14.15	12.30 - 15.60	1.91	1.51	9.78	8.69	79.04	2.25
		Pooled	14.19	12.33 - 15.65	1.93	1.52	9.79	8.70	78.90	2.26

days to fruit setting (8.35), days to first flowering (8.59) and days to marketable maturity(9.89).

High estimates of PCV and GCV recorded for number of leaves per plant, leaf area index and plant height were reported by Patro and Ravisankar (2004) whereas high estimates of PCV and GCV for cumulative leaf area was also reported by Singh *et al*. (2006). Similar result of high estimate of PCV and GCV for plant height and number of branches was reported by Nasit *et al*. (2009). Similarly high estimate of PCV and GCV for size of leaf, days from fruit setting to harvesting and number of ridges per fruit was reported by Kumar *et al.* (2013) for number of ridges per fruit**,** Reddy *et al*. (2014) for size of leaf and Singh *et al*. (2007) for days from fruit setting to harvesting. The high estimate of PCV and GCV for these traits among the genotype suggests that maximum variability exist among these traits and therefore lot of scope for selection.

Moderate estimate of GCV and PCV recorded for number of nodes for first flower are in conformity with Shanthakumar and Salimath (2010).

Low estimates of PCV and GCV recorded in duration of flowering indicated the presence of less genetic variability as a result of which less scope for selection. Similar results were reported by Kumar *et al.* (2013) and Reddy *et al*. (2014).

4.5.2.2 PCV and GCV for yield attributes

In case of phenotypic variance for yield attributes, the estimate of PCV was recorded to be highest for yield per plant (68.18) followed by yield per plot

(68.18), projected yield per ha (66.50), number of fruits per plant (43.57), weight of fruit (32.37) and number of seeds per fruit (29.88) whereas moderate PCV was recorded in length of fruit (16.71) and diameter of fruit (14.24).

In case of GCV for yield attributes, the estimate of GCV was recorded to be highest for projected yield per ha (64.29) followed by yield per plant (64.28), yield per plot (65.44), number of fruits per plant (39.93), weight of fruit (28.53) and number of seeds per fruit (25.25) whereas moderate GCV was recorded in length of fruit (14.63) and diameter of fruit (12.61).

High estimates of PCV and GCV recorded for yield per plant, yield per plot and projected yield per hectare indicating the presence of high degree of genetic variability and thus a greater scope for selection. Similar results were reported by Mulge *et al.* (2004) and Reddy *et al*. (2014). Similarly high estimate of PCV and GCV for weight of fruit and number of seeds per fruit was also reported by Singh *et al*. (2006) and Das *et al*. (2012) for number of seeds per fruits and Kumar and Singh (2013) for fruit weight. Moderate phenotypic and genotypic coefficient of variation for fruits length and fruits diameter was also reported by Shanthakumar and Salimath (2010) for fruit length and Mulge *et al.* (2004) for both fruit length and fruit diameter.

4.5.2.3 PCV and GCV for quality attributes

In case of phenotypic variance for quality attributes, the estimate of PCV was recorded to be highest for protein content (28.68) followed by vitamin C content (28.12) and fibre content (21.61) whereas dry matter (9.79) recorded low PCV.

In case of GCV for quality attributes, the estimate of GCV was recorded to be highest for protein content (28.62) followed by vitamin C content (27.76) and fibre content (20.91) whereas low GCV was recorded in dry matter (8.70).

High estimate of PCV and GCV are recorded for protein content, vitamin C content and fibre content. Similar result of high PCV and GCV for protein content was reported by Nasit *et al*. (2009). Similarly high estimate of PCV and PCV for vitamin C content was reported by Vijay and Manohar (1990) which indicated high degree of genetic variability for these quality traits. However, low estimate of PCV and GCV was recorded in dry matter which suggests less scope for selection due to less variability.

4.5.3 Heritability (h^2_{bs}) and Genetic advance (GA)

The estimates of heritability alone fail to indicate the response to selection (Johnson *et al.* 1955). Therefore, the heritability estimates appear to be more meaningful when accompanied by estimates of genetic advance. The genetic advance as percent mean was also estimated. Heritability usually considered to be low if it is less than 30%, moderate between (30-60%) and high if it is more than 60% (Johnson *et al.*, 1955). The range of genetic advance as percent of mean is classified as low if it is less than 10%, moderate between (10-20%) and high if more than 20% (Johnson *et al.*, 1955). The data for heritability (h^2_{bs}) and genetic advance (GA) are presented in table 4.18, table 4.19 and table 4.20.

4.5.3.1 h^2_{bs} and GA for growth attributes

The highest heritability in broad sense was observed in number of ridges per fruit (98.87%) followed by number of leaves per plant (97.31), size of leaf (97.25) cumulative leaf area (94.82), leaf area index (94.82), number of branches per plant (93.91), plant height (92.68), days from fruit setting to harvesting (83.82), number of nodes for first flower (83.15), days to marketable maturity (78.19), days to fruit setting (68.12), duration of flowering (67.87) and days to first flowering (67.87).

Genetic Advance (GA) as percentage of mean for different growth characters showed a wide variation. It was highest for plant height (65.02%) followed by size of leaf (39.10%) and number of leaves per plant (28.82%) whereas moderate GA was recorded in days to marketable maturity (10.18). Low genetic advance was estimated for leaf area index (9.21) followed by days to first flowering (6.90), duration of flowering (6.90), days to fruit setting (6.86), days from fruit setting to harvesting (6.19), number of ridges per fruit (2.50), number of nodes for first flower (1.88), number of branches plant (1.64) and cumulative leaf area (1.24).

High estimate of heritability with low genetic advance was recorded in number of nodes for first flower, duration of flowering, days to fruit setting, days from fruit setting to harvesting and dumber of ridges per fruit which indicate that high heritability is exhibited due to favorable influence of environment rather than genotypic and selection for such traits may not be rewarding. Similar results were reported by Sunil *et al.* (2007) for number of nodes for first flower and duration of flowering. Also, Saifullah and Rabbani, (2009) for number of ridges per fruit and Akotkar *et al*. (2010) for number of ridges per fruit and days to fruits setting. Similarly, high heritability with low genetic advance recorded in cumulative leaf area, leaf area index, number of branches per plant and days to first flowering are in conformity with Sunil *et al.* (2007) for number of branches and days to first flowering and Akotkar *et al*. (2010) for leaf area index.

High estimate of heritability with moderate genetic advance for days to marketable maturityis in conformity with Jindal *et al.* (2010). High estimate of heritability accompanied with high genetic advance was recorded in plant height, number of leaves per plant and size of leaf. Similar result was reported by Vishalkumar *et al*. (2006) and Singh *et al*., (2007) for plant height and number of leaf. Similarly high estimate of heritability accompanied with high genetic advance for size of leaf was reported by Shanthakumar and Salimath (2010). The high estimate of heritability accompanied with high genetic advance suggest preponderance of additive genes and effective for selection.

4.5.3.2 h^2_{bs} and GA for yield attributes

The highest heritability in broad sense was observed for projected yield per hectare (96.83), yield per plant (88.91) followed by yield per plot (88.91), number of fruits per plant (83.98), diameter of fruit (78.40), weight of fruit (77.68), length of fruit (76.59) and number of seeds per fruit (71.44).

Genetic advance (GA) as percentage of mean for different yield characters showed a wide variation. It was highest for yield per plant (29.32%), moderate for number of seeds per fruit (18.31%) and projected yield per hectare (12.96%). Low genetic advance was estimated for diameter of fruit (0.42%) followed by length of fruit (4.20%) and yield per plot (7.04%), number of fruits per plant (9.32) and weight of fruit (9.36).

High heritability coupled with high genetic advance for traits like yield per plant, and projected yield per hectare suggested the preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes as these characters are governed by additive gene actions. The findings are in agreement to the findings of Singh *et al. (*2006) and Vishalkumar *et al*. (2006). Similarly, Shanthakumar and Salimath(2010) also reported high heritability coupled with high genetic advance for fruit yield per plant indicating the involvement of additive type of gene action in controlling these characters. Hence, selection could be effective.

High estimate of heritability with moderate genetic advance recorded in number of seed perplant was also reported by Kumar and Singh *(*2013).

High estimate of heritability coupled with low genetic advance for number of fruits per plant, diameter of fruit, weight of fruit, fruit length and yield per plot indicates that character is highly influenced by environment effects and selection will be ineffective. This finding is in conformity of Dhall *et al*. (2000) for weight of fruit and fruit length. Similarly, Akotkar *et al*. (2010) also reported high heritability coupled with low genetic advance for number of fruits per plant and diameter of fruit.

4.5.3.3 h^2_{bs} and GA for quality attribute

Heritability in broad sense for quality attributes was estimated to be highest for protein content (99.56%) followed by vitamin C content (97.46%), fibre content (93.62%) and dry matter content (78.90%).

Genetic Advance (GA) was highest for vitamin C content (10.40%) whereas low genetic advance was estimated for fibre content (4.68%), dry matter content (2.26%) and protein content (2.24%).

High estimate of heritability with moderate genetic advance for vitamin C content indicate less response of selection this finding are in conformity with the finding of Vijay and monohar (1990) for this quality character however high heritability with low genetic advance was recorded in protein content, fibre content and dry matter content high heritability in protein content was also reported by Kumari (2016), the high heritability with low genetic advance for this quality traits indicated that the character is highly influenced by environmental effects and selection will be ineffective.

4.5.4 Correlation studies

Simple correlation coefficient at phenotypic and genotypic levels, were computed for twenty-two characters and their significance was tested at 0.05 and 0.01 levels of significance which are presented in table 4.32, table 4.33 and table 4.34.

4.5.3.1 Phenotypic and Genotypic correlation of characters with yield per plant:

Yield per plant showed highly significant positive genotypic correlation coefficients with leaf area index (0.586), size of leaf (0.575), number of leaves (0.548), number of fruit per plant (0.501), weight of fruit (0.478), fruit length (0.479), number of ridges per fruit (0.460), number of seeds per fruit (0.448) and fruit diameter (0.411) at phenotypic level. Yield per plant exhibited significant positive association with leaf area index (0.574), size of leaf (0.558), number of leaves (0.523), number of fruit per plant (0.507), weight of fruit (0.498), number of ridges per fruit (0.452), fruit length (0.444), number of seeds per fruit (0.436) and fruit diameter (0.394).

These findings are in conformity with the earlier observations of Dhankhar and Dhankhar (2002), and Somashekhar *et al.* (2011) for number of fruits per plant and Mihretu *et al*. (2014) and Saryam *et al*. (2015) for fruit diameter, number of seeds, weight of fruits, number of fruits per plant and fruit length, the correlation between yield with leaf area index and number of leaves per plant was reported by Jaiprakashnarayan and Mulge (2004) and Nagre *et al*. (2011),Singh *et al*. 2007 and Alam and Hossain (2008) reported positive association of yield per plant with size of leaf and number of ridges per fruits.

4.5.3.2 Phenotypic and Genotypic correlation amongst characters:

Number of leaves per plant exhibited positive and highly significant genotypic association with yield per plant (0.548), number of seeds per fruit (0.454), number of fruits per plant (0.453), size of leaf (0.425) and leaf area index (0.402), Whereas number of leaves per plant also exhibited positive and highly significant phenotypic association with yield per plant (0.523), number of seeds per fruit (0.428), number of fruits per plant (0.418), size of leaf (0.409) and leaf area index (0.398), Similar positive association of number of leaf per plant was also reported by Dhankhar and Dhankhar (2002) for leaf area index, yield per plant and size of leaf , Singh *et al*. (2007) reported positive association of number of leaf per plant with number of seed per fruit.

Table 4.32: Phenotypic correlation (r_p) and genotypic correlation (r_g) among quantitative and qualitative characters in various okra genotypes during 2013 and 2014 (Pooled)

Characters	No. of leaves plant^{-1}	Size of the leaf (cm)	Leaf area index (cm^2)	No. of branches plant^{-1}	Days to first flowering	No. of nodes for first flower	Duration of flowering (Days)	Days to fruit setting	Days to marketable maturity	Days from fruit setting to harvesting	No. of fruit plant^{-1}	No. of ridges fruit^{-1}	Fruit length (cm)	Fruit diameter (cm)	Weight of fruit (g)	No. of seeds fruit^{-1}	Protein content (%)	Ascorbic acid content (mg 100g^{-1} of fruit)	Fibre content (%)	Dry matter content (%)	Yield plant^{-1}
1	0.180 (0.177)	0.176 (0.179)	0.164 (0.173)	0.102 (0.109)	-0.170 (-0.207)	-0.213 (-0.215)	-0.205 (-0.212)	-0.157 (-0.203)	-0.199 (-0.252)	-0.214 (-0.218)	0.189 (0.215)	-0.052 (-0.055)	0.156 (0.163)	0.108 (0.129)	0.178 (0.174)	0.138 (0.138)	0.172 (0.187)	0.138 (0.131)	0.010 (0.012)	0.112 (0.144)	0.178 (0.188)
2	1.000	0.409* (0.425*)	0.398* (0.402*)	0.199 (0.219)	-0.156 (-0.155)	-0.170 (-0.180)	-0.145 (-0.147)	-0.146 (-0.153)	-0.149 (-0.181)	-0.151 (-0.155)	0.418* (0.453*)	0.233 (0.240)	0.157 (0.176)	0.162 (0.202)	0.256 (0.287)	0.428* (0.454*)	0.206 (0.223)	0.151 (0.155)	0.187 (0.193)	-0.119 (-0.123)	0.523** (0.548**)
3		1.000	0.394* (0.393*)	0.167 (0.170)	-0.146 (-0.176)	-0.128 (-0.133)	-0.170 (-0.171)	-0.144 (-0.171)	-0.163 (-0.185)	-0.140 (-0.162)	0.423* (0.453*)	0.400* (0.402*)	0.443* (0.472*)	0.375* (0.378*)	0.416* (0.438*)	0.385* (0.412*)	0.244 (0.247)	-0.180 (-0.184)	0.143 (0.149)	-0.127 (-0.126)	0.558** (0.575**)
4			1.000	0.202 (0.203)	-0.159 (-0.175)	-0.145 (-0.154)	-0.166 (-0.167)	-0.159 (-0.166)	-0.160 (-0.180)	-0.131 (-0.150)	0.446* (0.468*)	0.395* (0.397*)	0.211 (0.231)	0.220 (0.233)	0.407* (0.430*)	0.361 (0.387*)	0.224 (0.227)	-0.072 (-0.066)	0.180 (0.183)	-0.102 (-0.108)	0.574** (0.586**)
5				1.000	-0.142 (-0.151)	0.121 (0.115)	-0.144 (-0.144)	-0.157 (-0.154)	-0.160 (-0.165)	-0.121 (-0.149)	0.146 (0.145)	0.162 (0.163)	-0.131 (-0.145)	0.378* (0.415*)	0.206 (0.217)	0.159 (0.189)	-0.116 (-0.128)	-0.104 (-0.108)	0.170 (0.173)	0.135 (0.135)	0.188 (0.191)
6					1.000	0.219 (0.235)	0.441* (0.512**)	0.583** (0.569**)	0.486* (0.461*)	0.146 (0.072)	-0.136 (-0.158)	-0 023 (0.014)	-0.110 (0.101)	-0.124 (0.107)	0.108 (-0.120)	0.142 (0.109)	-0.152 (-0.173)	0.149 (0.177)	-0.039 (-0.027)	-0.143 (-0.151)	-0.123 (-0.153)
7						1.000	0.213 (0.228)	0.211 (0.231)	0.173 (0.177)	-0.026 (-0.034)	-0.110 (-0.118)	-0.162 (-0.168)	0.140 (0.145)	-0.117 (0.131)	-0.146 (-0.141)	0.111 (-0.123)	-0.163 (-0.176)	-0.180 (-0.188)	0.127 (0.136)	-0.022 (-0.012)	-0.124 (-0.125)
8							1.000	0.440* (0.512**)	0.314 (0.370)	0.156 (0.169)	-0.144 (-0.156)	0.027 (0.023)	-0.110 (-0.107)	-0.135 (-0.133)	-0.132 (-0.136)	0.135 (0.134)	-0.173 (-0.175)	0.171 (0.172)	-0.166 (-0.170)	-0.040 (-0.037)	-0.149 (-0.156)
9								1.000	0.497** (0.455*)	0.139 (0.182)	-0.141 (-0.149)	-0.102 (-0.101)	-0.035 (0.029)	-0.052 (0.037)	-0.057 (-0.042)	0.141 (0.119)	-0.155 (-0.162)	0.152 (0.172)	-0.145 (-0.131)	-0.150 (-0.138)	-0.136 (-0.147)
10									1.000	0.481* (0.541**)	-0.192 (-0.214)	-0.112 (-0.112)	-0.171 (-0.149)	-0.168 (-0.150)	-0.132 (-0.154)	0.146 (0.142)	-0.185 (-0.200)	0.138 (0.156)	-0.034 (-0.022)	-0.153 (-0.139)	-0.170 (-0.187)
11										1.000	-0.212 (-0.230)	-0.116 (-0.120)	-0.187 (-0.208)	-0.144 (-0.201)	-0.145 (-0.162)	0.127 (0.147)	-0.169 (-0.197)	0.037 (0.026)	-0.028 (0.030)	-0.042 (-0.054)	-0.175 (-0.190)
12											1.000	0.197 (0.212)	0.224 (0.269)	0.229 (0.237)	0.467* (0.480*)	0.191 (0.219)	0.256 (0.274)	-0.115 (-0.116)	0.196 (0.197)	0.143 (0.141)	0.507** (0.501**)
13												1.000	0.188 (0.198)	0.203 (0.212)	0.254 (0.267)	0.208 (0.224)	0.167 (0.167)	-0.063 (-0.060)	-0.152 (-0.155)	-0.145 (-0.152)	0.452* (0.460*)
14													1.000	0.149 (0.133)	0.434* (0.462*)	0.186 (0.199)	0.046 (-0.050)	-0.144 (-0.152)	-0.137 (-0.147)	-0.102 (0.115)	0.444* (0.479*)
15														1.000	0.417* (0.492**)	0.172 (0.168)	0.177 (0.179)	-0.263 (-0.284)	0.205 (0.229)	-0.107 (0.117)	0.394* (0.411**)
16															1.000	0.149 (0.153)	0.142 (0.142)	-0.190 (-0.206)	0.172 (0.186)	0.105 (-0.114)	0.498** (0478**)
17																1.000	0.199 (0.220)	-0.035 (-0.020)	-0.140 (-0.141)	-0.115 (-0.135)	0.436* (0.448*)
18																	1.000	-0.042 (-0.036	0.022 (0.021)	-0.162 (-0.168)	0.212 (0.220)
19																		1.000	-0.190 (-0.194)	0.012 (0.007)	-0.169 (-0.175)
20																			1.000	0.154 (0.150)	0.203 (0.209)
21																				1.000	0.134 (0.125)

Note: *Values in the column are phenotypic correlation coefficients (r_p) and those in parenthesis are genotypic correlation coefficients (r_g)*

df = (28-2) = 26 *$r_{0.05}$ = 0.374* *$r_{0.01}$ = 0.479*

**, **: Significant at 5% and 1% level of significance respectively*

1) Plant height (cm), 2) Number of leaves plant^{-1}, 3) Size of leaf (cm), 4) Leaf area index (cm^2), 5) Number of branches plant^{-1}, 6) Days to first flowering, 7) Number of nodes for first flower, 8) Duration of flowering (Days), 9) Days to fruit setting, 10) Days to marketable maturity, 11) Days from fruit setting to harvesting, 12) Number of fruits plant^{-1}, 13) Number of ridges fruit^{-1}, 14) Length of fruit (cm), 15) Diameter of fruit (cm), 16) Weight of fruit (g), 17) Number of seeds fruit^{-1}, 18) Protein content (%), 19) Ascorbic acid content (mg 100g^{-1} of fruit), 20) Fibre content (%), 21) Dry matter content (%) and 22) Yield plant^{-1} (g)

Size of leaf per plant exhibited positive and highly significant genotypic association with yield per plant (0.575), fruit length (0.472), number of fruits per plant (0.453), weight of fruits (0.438), number of seeds per fruit (0.412), number of ridges per fruit (0.402),leaf area index (0.393) and fruit diameter (0.378), size of leaves per plant had highly significant positive phenotypic correlations with yield per plant (0.558), fruit length (0.443), number of fruits per plant (0.423), weight of fruits (0.416), number of ridges per fruit (0.400), leaf area index (0.394), number of seeds per fruit (0.385) and fruit diameter (0.375) the correlation between size of leaf with yield was also reported by Alam and Hossain (2008).

Leaf area index showed significant positive genotypic association with yield per plant (0.586), number of fruits per plant (0.468), weight of fruit (0.430), number of ridges per fruit (0.397) and number of seeds per fruit (0.387).

Leaf area index also exhibited significant positive phenotypic association with yield per plant (0.574), number of fruits per plant (0.446), weight of fruit (0.407) and number of ridges per fruit (0.395) The association of leaf area index with yield was also reported by Saryam *et al*. (2015).

Number of branches per plant exhibited positive and highly significant genotypic association with fruit diameter (0.415). Number of branches per plant also exhibited positive and highly significant phenotypic association with fruit diameter (0.378). Similar positive association of number of branches per plant with fruits diameter was also reported by Nwangburuka *et al*. (2012).

Days to first flowering showed significant positive genotypic association with days to fruit setting (0.569), days to marketing maturity (0.461) and duration of flowering (0.512). Days to first flowering also showed significant positive phenotypic association with days to fruit setting (0.583), days to marketing maturity (0.486) and duration of flowering (0.441).These findings are in conformity with the earlier observations of Jagan *et al*. (2013) for positive correlation between day to first flowering and days to fruit setting.

Duration of flowering showed significant positive genotypic and phenotypic association with days to fruits setting (0.512 and 0.441) also days to fruit setting showed significant positive genotypic and phenotypic association with days to marketable maturity (0.455 and 0.497) similarly days to marketable maturity exhibited significant positive genotypic and phenotypic association with days from fruits setting to harvesting (0.541 and 0.481).

Number of fruits per plant exhibited positive and highly significant genotypic association with yield per plant (0.501) and weight of fruit (0.480 Also, positive and significant phenotypic association for these traits were observed in yield per plant (0.507) and weight of fruit (0.467), Similar results were reported by Singh *et al.* (2007), Bello *et al.* (2006), Mehta *et al*. (2006), Reddy *et al.* (2013), Dhankhar and Dhankhar (2002) for positive association of number of fruits with yield per plant. Singh *et al.* (2007) also reported positive association with weight of fruits per plant.

Number of ridges per fruit showed highly significant positive genotypic and phenotypic correlation with yield per plant (0.460 and 0.452). Mihretu *et al*.

(2014) also reported the association of number of ridges per fruit with yield per plant.

Fruit length also exhibited highly significant positive genotypic correlation with yield per plant (0.479), and weight of fruit (0.462i), and significant positive phenotypic correlation with yield per plant (0.444) and weight of fruit (0.434). Similar findings were also reported by Sreenivas *et al*. (2015).

Fruit diameter exhibited positive and highly significant genotypic association with weight of fruit (0.492) and yield per plant (0.411), Fruit diameter also exhibited positive and highly significant phenotypic association with weight of fruit (0.417) and yield per plant (0.394) similar results were also reported by Mihretu *et al*. (2014) and Saryam *et al*. (2015).

Weight of fruit showed highly significant positive phenotypic and genotypic correlation with yield per plant (0.478 and 0.498). The genotypic association of weight of fruits with yield per plant was also reported by Reddy *et al.* (2013), Mihretu *et al*. (2014) and Chand *et al.* (2014).

Number of seeds per fruit also showed highly significant positive phenotypic and genotypic correlation with yield per plant (rg0.448 and rp0.436).Similar results were also reported by Mihretu *et al*. (2014) and Saryam *et al*. (2015).

CHAPTER IV

SUMMARY

AND

CONCLUSION

SUMMARY AND CONCLUSION

The present investigation entitled, "Performance of various okra genotypes for growth, yield and quality attributes under foothill condition of Nagaland" was carried out in the experimental farm of School of Agricultural Sciences and Rural Development (SASRD) Medziphema campus, Nagaland University during 2013-2014. The investigation was carried out with the following objectives –

1. To study the growth and yield attributes of okra genotypes.
2. To study the quality attributes of okra genotypes.
3. To study the incidence of pest and diseases on various okra genotypes.
4. To determine the genetic variability of the genotypes.
5. To screen out the best okra genotype under existing agro-climatic condition.

The salient findings of the investigation may be summarized as follows:

Growth and yield attributes:

Under the present study, the growth and yield behavior of all the twenty eight genotypes varied considerably. Growth attributes with respect to number of leaves, leaf area, cumulative leaf area and leaf area index were recorded maximum in genotype IIVRO-608-8-1 whereas genotype IIVRO-770 exhibited least number of days to first flowering, number of nodes for first flower, number of days for fruit setting and maturity period. Genotype IIVRO-770 also exhibited maximum duration of flowering and number of ridges.

The findings also indicate that genotype IIVRO-608-8-1 recorded maximum result in yield attributes such as number of fruits, weight of fruits, number of seeds per fruit, yield per plant, yield per plot and projected yield per hectare.

Quality attributes:

It was observed that maximum protein content was observed in genotype IC-218844, maximum vitamin-C in Arka Anamika, maximum fibre content in genotype IIVRO-137-10-1,2 and maximum dry matter content in genotype IIVRO-307-10 II.

Pest and disease incidence:

Incidence of blister beetle on okra genotypes ranged between 3.45-34.55%. Genotype IIVRO-SKY/DR/RS-107 which recorded maximum incidence of blister beetle (34.55%) was found to be moderately resistant while the minimum incidence (3.45%) was recorded in genotype IIVRO-599-8-1 exhibiting high resistance to blister beetle infestation.

Incidence of yellow vein mosaic virus on okra genotypes ranged between 2.44-65.25%. Genotype IIVRO-212-10-1 was found to be highly susceptible to yellow vein mosaic virus with maximum incidence of 65.25% while the minimum incidence of yellow vein mosaic virus (2.44%) was exhibited by the genotype IIVRO-307-10-1 II showing high resistance to yellow vein mosaic virus.

Genetic parameters:

Genetic variability analysis in the present study revealed that the phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the traits which might be due to interaction of the genotypes with the environment to some degree or other explaining environmental factors influencing the expression of these characters. The genotypic and phenotypic coefficient of variation for growth attributes was highest for cumulative leaf area followed by leaf area index, number of leaves per plant, number of branches per plant, size of leaf, days from fruit setting to harvesting, plant height and number of ridges per fruit. Genotypic and phenotypic coefficient of variation for yield attributes was highest for yield per plant followed by yield per plot, projected yield per ha, number of fruits per plant, weight of fruit and number of seeds per fruit. Genotypic and phenotypic coefficient of variation for quality attributes was highest for protein content followed by vitamin C content and fibre content. Highest phenotypic and genotypic coefficient of variation was observed in cumulative leaf area for growth attributes, yield per plant for yield attributes and protein for quality attributes indicating the existence of wide range of genetic variability in the germplasm for these traits. Hence, there is a good scope for the further improvement of these characters through selection since they are controlled by additive gene action.

High heritability coupled with high genetic advance as percentage of mean was observed for traits like plant height, size of leaf, number of leaves per plant, yield per plant and projected yield per hectare which suggested that they can be improved through direct selection.

Correlation studies revealed that yield per plant showed highly significant positive genotypic correlation coefficients with leaf area index, size of leaf, number of leaves, number of fruit per plant, weight of fruit, fruit length, number of ridges per fruit, number of seeds per fruit and fruit diameter. At phenotypic level, yield per plant exhibited significant positive association with leaf area index, size of leaf, number of leaves, number of fruit per plant, weight of fruit, number of ridges per fruit, fruit length, number of seeds per fruit and fruit diameter.

CONCLUSION

- Among all the genotypes, two genotypes namely IIVRO-608-8-1 and IIVRO-770 were found better and superior for most of the growth characters. Whereas genotype IIVRO-608-8-1 exhibited superiority over the other genotypes for its yield.

- Genotype Arka Anamika was found to be superior in its vitamin-C content whereas other genotypes might be considered good source of protein and fibre. The investigated genotypes were found to be good source of vitamin-C, protein and fibre and most of these genotypes can be adopted for okra production in the region for their superior quality.

- The easiest and cheapest method of reducing pest and disease incidence of okra is the cultivation of resistant varieties. Genotype IIVRO-599-8-1 was found to be highly resistant to blister beetle infestation whereas genotype IIVRO-307-10-1 II showed high resistance to yellow vein mosaic virus.

- Considering all the genetic variability studies carried out, it can be concluded that the genetic stocks of okra used in this investigation had wide range of variability.. As such, there is enough scope for improvement of these characters by selection.

- The correlation studies indicated that yield per plant showed highly significant positive genotypic correlation coefficients with leaf area index, size of leaf, number of leaves, number of fruit per plant, weight of fruit, fruit length, number of ridges per fruit, number of seeds per fruit and fruit diameter signifying the importance of these traits in selection for yield and are identified as yield attributing characters on which selection can be relied upon for the genetic improvement of yield.

- Based on the mean performance of the twenty eight genotypes of okra, it can be concluded that genotype IIVRO-608-8-1, IIVRO-770 and Arka Anamika were among the best performing genotypes. Genotype IIVRO-608-8-1 performed better in most of the measured parameters. High yield potential exhibited by genotype IIVRO-608-8-1 confirmed that it is the best okra genotype under existing agro-climatic condition.

Suggestions for further work

1. The genotypes showing greater yield potential with other desirable qualities may be tested under different agro climatic conditions and those found suitable could be recommended for commercial cultivation to the vegetable growers.

2. Characters having desirable association with yield should be given due consideration for genetic improvement in okra.

3. Traits identified for high heritability coupled with high or moderate genetic advance may be considered well in selection for the improvement of crop.

4. Further research should be done to test okra against pest and diseases in other seasons and locations to assure that highly resistant varieties could be recommended for commercial cultivation.

CHAPTER VI

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