EVALUATION, CHARACTERIZATION AND DIVERSITY ANALYSIS OF LOCAL GENOTYPES OF POINTED GOURD (*Trichosanthes dioca* Roxb.)

Ph. D. Thesis

by

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DEPARTMENT OF HORTICULTURE
FACULTY OF AGRICULTURE
COLLEGE OF AGRICULTURE
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EVALUATION, CHARACTERIZATION AND DIVERSITY ANALYSIS OF LOCAL GENOTYPES OF POINTED GOURD (*Trichosanthes dioca* Roxb.)

Thesis

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By

Ganeshi Lal Sharma

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JULY, 2015

CERTIFICATE - I

This is to certify that the thesis entitled **"Evaluation, characterization and diversity analysis of local genotypes of pointed gourd (*Trichosanthes dioca* Roxb.)"** submitted in partial fulfilment of the requirements for the degree of **"Doctor of Philosophy in Agriculture"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Ganeshi Lal Sharma** under my/our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by him.

Chairman

Date:

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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CERTIFICATE – II

This is to certify that the thesis entitled **"Evaluation, characterization and diversity analysis of local genotypes of pointed gourd (*Trichosanthes dioca* Roxb.)"** submitted by **Ganeshi Lal Sharma** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfilment of the requirements for the degree of **Ph.D. (Ag.)** in the Department of Horticulture has been approved by the External Examiner and Student's Advisory Committee after oral examination.

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Faculty Dean _____

Approved/Not approved

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Ganeshi Lal Sharma

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LIST OF NOTATIONS/SYMBOL

%	Per cent
@	At the rate
^{O}C	Degree Celsius
et al.	and others/ and co-workers
i.e.	That is
ex	Example
m^2	Square metre
t/ha	Tonnes per hectare
$Plant^{-1}$	Per plant
viz.	Namely

LIST OF ABBREVIATIONS

cm	Centimetre
cc	Cubic centimeter
Fig.	Figure
g	Gram
RH	Relative Humidity
Kg	Kilogram
M	Metre
t	Tonnes
m ha	Million hectare
Mg	Milligram
MT	Metric Tonnes
Lt	Litre
No.	Number
Avg.	Average
Sr. No.	Serial Number
Temp.	Temperature
Ha	Hectare
Hrs	Hours
mm	Millimetre
TSS	Total Soluble Solid
DAP	Days After Planting
NPK	Nitrogen, Phosphorus, Potassium
FYM	Farm Yard Manures
max.	Maximum
min.	Minimum
RH	Relative humidity
RF	Rain fall

THESIS ABSTRACT

a)	Title of the thesis:	:	Evaluation, characterization and diversity analysis of local genotypes of pointed gourd (*Trichosanthes dioca* Roxb.)
b)	Full name of the student	:	Ganeshi Lal Sharma
c)	Major subject	:	Horticulture
d)	Name and Address of the Major advisor	:	Dr. Vijay Kumar, Department of Horticulture, College of Agriculture, IGKV, Raipur
e)	Degree to be Awarded	:	Ph.D. (Ag) Horticulture

Signature of the Student

Signature of Major Advisor

Date: _____ Signature of Head of the Department

ABSTRACT

The present investigation entitled “Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)” was conducted at Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya Raipur (C.G.) during 2012-13 and 2013-14.

The experiment comprised of twenty four genotypes of pointed gourd and was laid out in Randomized Block Design (RBD) with three replications. Experiment was undertaken to study the characterization of collected genotypes, mean performance of genotypes, genetic variability, heritability, genetic advance, correlation, path coefficient and genetic divergence analysis of diverse genotypes to identify suitable pointed gourd genotypes with higher fruit yield. The second part of the experiment was aimed for the use of molecular markers based on DNA sequence polymorphism independent of environmental conditions.

The analysis of variance significantly differentiated for all the characters. According to mean performance of pointed gourd in respect to fruit yield per plant,

IPG-8 was found significantly superior than the other genotypes evaluated. The phenotypic coefficient of variance was higher than the genotypic coefficient of variance for all the characters.

Correlation coefficient analysis of fruit yield per plant was significantly and positively correlated with leaf width, average internodal length, days taken for appearance of first female flower, node of the first female flower, petiole length, fruit length, fruit diameter, number of fruits per plant, number of seeds per fruit, average fruit weight, and days taken from fruit set to harvest maturity. The improvement of yield per plant can be possible by practicing individual selection for number of fruits per plant and average fruit weight.

In path coefficient analysis, fruit yield per plant expressed a positive direct effect on fruit set to harvest maturity, fruit diameter, average fruit weight, number of fruits per plant, fruit length whereas, number of seeds per fruit showed the highest negative direct effect on fruit yield per plant. The average fruit weight showed higher positive direct effect on fruit yield per plant followed by leaf width, number of fruits per plant, fruit diameter, and fruit length whereas, leaf length, vine length, internodal length and petiole length showed negative direct effect on the fruit yield per plant.

The twenty four genotypes were grouped into four clusters. Cluster number IV had the highest 8 genotypes followed by cluster number I (7 genotypes), cluster number III (6 genotypes) and the lowest was in cluster number II (3 genotypes). Cluster I had the highest intra cluster distance of 2.761 followed by cluster IV (2.610), cluster III (2.598) and cluster II (2.522). The inter cluster distance was observed highest between cluster I and IV (4.554). The inter cluster D^2 values were also high between cluster I and III (4.373), cluster I and II (3.120), cluster II and III (4.616), Cluster III and IV (4.180). The lowest inter cluster D^2 value was found between cluster II and IV (2.843).

Genetic diversity analysis based on molecular markers in pointed gourd genotypes results showed that there is higher similarity at genetic level amongst the genotypes of point gourd. Only one genotype IPG-16 showed genetic diversity as compared to other twenty three genotypes.

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CHAPTER- I
INTRODUCTION

Pointed Gourd *(Trichosanthes dioica* Roxb.) is a perennial, dioecious, tropical cucurbitaceous vegetable crop which gives continuous production for about 7-8 months of the year except winter season when the plants goes under dormancy. It is known by the various vernacular names like *parwal*, *palwal*, *parmal, parora, patal, patola* or *potal* in different parts of India. Pointed gourd is believed to have originated in Indian subcontinent or Indo-Malayan region is as its original home (Seshadri,1986). It is one of the important cucurbitaceous vegetable of northern India. This crop is extensively cultivated in eastern Uttar Pradesh, Bihar, West Bengal and Assam and to a lesser extent in small pockets in Odisha, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu and Gujarat. Recently, it has been introduced in and around Hyderabad and Bangalore region (Bhardwaj, 2011). In the gangetic plains, it is mostly grown on sandy soils in river beds. In Chhattisgarh state, its cultivation is mostly confined to the parts of Raigarh, Sarguja, Surajpur and Jashpur districts. Pointed gourd is coveted vegetable during summer and rainy seasons. It is considered to be highly remunerative vegetable crop by the farmers as it is one of the choicest cucurbit which is liked by the consumers. Owing to comparatively low cost of production, high return and suitability for riverbed cultivation, pointed gourd is mostly grown by small and marginal farmers. This vine vegetable has better keeping and handling quality and can be transported to long distance to other states where it is not under cultivation.

Recent molecular phylogenetic data have indicated that genus, *Trichosanthes*, is the largest genus in the Cucurbitaceae family, with over 90 species (Boer and Thulin, 2012) of which 22 are found in India (Singh *et al.* 2009). Although, the Bengal-Assam area in India is considered as its primary centre of origin, the species and wild forms of *Trichosanthes* are found in many parts of India. The related species are *Trichosanthes japonica* and *Trichosanthes multiloba*

which occur in the north-eastern region; along with semi-wild *Trichosanthes dioica*. A widely distributed species is *Trichosanthes bracteates* which occurs in eastern India, extending to the south, and sporadically in the Himalaya. *Trichosanthes cordata* (related to *Trichosanthes anguina)*, occurs in the peninsular region extending to north-eastern plains and hills.

The green tender fruit is the edible part of the plant, which is cooked in various ways either alone or in combination with other vegetables. The fruit is also utilized to make special sweets. Its tender shoots and leaves are also used as pot herbs particularly in West Bengal. The fruits of pointed gourd are rich in neutra-ceutical properties. They are rich in protein and vitamin A. Fruits also contains ample quantities of various nutrients and mineral elements. It contains protein 2.0 g, fat 0.3 g, carbohydrate 2.2 g, fiber 3.1 g, Mg, 9.0 mg, Na 2.6 mg, K 83.0 mg, Cu 1.1 mg, S 17.0 mg, phosphorus 40.0 mg, calcium 30.0 mg, thiamine 0.05 mg, nicotinic acid 0.5 mg and oxalic acid 7.0 mg per 100 grams of edible portions.

The fruits are easily digestible and diuretic in nature and are also reported to have anti-ulcerous effects and many other medicinal properties. Apart from being a rich source of carbohydrates and vitamins, the stem and leaves of pointed gourd also contains many active bio-compounds with great medicinal properties (Sharma *et al.,* 1990; Rai *et al.,* 2010). It also invigorates the heart and brain. It is purported that pointed gourd possesses the medicinal property of lowering total cholesterol and blood sugar. These claims are supported by preliminary clinical trials with rats (Chandra Sekar *et al.,* 1988) and rabbits (Sharma and Pant 1988; Sharma *et al.,* 1988). Pointed gourd is useful in the disorders of the circulatory system. The fruit shows some prospects in the control of certain cancer like conditions. According to Ayurveda, leaves of the plant are used as antipyretic, diuretic, cardio tonic, laxative, antiulcer, etc. Juice of leaves of *T. dioica* is used as tonic, febrifuge, in edema, alopecia, and in sub-acute cases of enlargement of liver (Nadkarni, 1982). In Charaka Samhita, leaves and fruits find mention for treating alcoholism and jaundice (Khare, 2004).

Although, well developed seeds are produced by the plants, seed propagation is not feasible mainly due to lower germination, slow growth rate of seedlings and segregating nature of the male and female plants (Kumar *et al.,* 2008 a). The dioecious nature of the plant has been the major constraint in initiating a substantial breeding programme in pointed gourd. It shows severe gender bias in favour of female plants and the ratio of female to male plant is normally 2.5:1. The plant strictly maintains the sexual phenotypes of male and female indicating clear genetic difference between both the sexes. However, there is little or no substantial morphological difference between male and female of *T. dioica* to identify the sex type before reproductive time.

Genetic diversity and variability play a vital role for a successful breeding programme and it is essential to meet the diversified goals of plant breeding such as breeding for increasing yield, wider adaptation and desirable quality. Wide genetic variability of pointed gourd is available in Chhattisgarh. Since the genotypes collected are poorly characterized and at the beginning of any breeding programme, it is significant to discriminate among available genotypes to establish the level of genetic diversity so as to, identify the most suitable materials for utilization as cultivar for the farmers. No systematic efforts have been made till date to study the genetic diversity of this important vegetable crop in Chhattisgarh. Genetic diversity among individuals or populations can be determined using morphological and molecular markers. In contrast to morphological markers, molecular markers based on DNA sequence polymorphism, are independent of environmental conditions. Identification of genotypes based on morphological markers requires observations at all the stages of plant growth till flowering and fruiting and is not also very reliable because many traits of interest have low heritability and may be genetically very complex. Molecular markers provide a quick and reliable method for estimating genetic relationships among genotypes of any organism (Thormann *et al.,* 1994).

In view of this background the present investigation entitled **"Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)"** was conducted with the following objectives:

Objectives:

i. Characterization of local genotypes of Pointed Gourd.

ii. To find out high-yielding and desirable genotypes of Pointed Gourd suitable for Chhattisgarh state.

iii. To study the genetic variability, heritability, genetic advance, correlation and path analysis of yield and its components.

iv. To find out genetic divergence among local genotypes of Pointed Gourd.

v. Molecular analysis of selected pointed gourd genotypes.

CHAPTER -II
REVIEW OF LITERATURE

In this chapter an attempt has been made to collect and review the available literature pertaining to different aspects of the present investigation entitled **"Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)".** Little attention has been given by the scientists on systematic crop improvement work of pointed gourd. Therefore, very little information is available in the literature on the topic under investigation. Hence, the review of the literature has been little widened to include related perennial cucurbits like ivy gourd, snake gourd and spine gourd. Keeping in view the objectives of the present investigation, relevant available literature is reviewed and presented in the following headings:

2.1 Collection and evaluation of germplasm

2.1.1 Characterization of genotypes.

2.1.2 Genotypic and phenotypic variability

2.1.3 Heritability and genetic advance

2.1.4 Correlation coefficient studies

2.1.5 Path coefficient analysis

2.1.6 Genetic divergence analysis

2.2 Molecular markers studies.

2.1 Collection and evaluation of Germplasm

2.1.1 Characterization of genotypes

In the improvement of any crop, the study of existing variability amongst available germplasm is the foremost step. Therefore, the observation and analysis of the genetic variability including their characterization is very useful in designing selection procedure to identify desirable genotypes.

Twelve genotypes of pointed gourd were studied by Prasad and Singh (1990 b) for nine agronomic and fifteen morphological characters during 1986-89. They reported that CHES12 had the highest yield/plot (3.9 kg) followed by CHES 7 (2.6 kg) and found that fruit weight ranged from 25 g in CHES 6 to 34.6 g in CHES 14.

Hazara *et al.*(1998) attempted grouping and characterization 68 female clones of pointed gourd collected from major growing areas of West Bengal and some parts of Bihar in a field experiment conducted in Mondouri, Nadia, West Bengal, India during 1996-97. The clones were classified under four groups on the basis of fruit shape and size namely, plants bearing small-sized fruits (group 1), spindle-shaped fruits (group 2), oval-shaped fruits (group 3) and nearly cylindrical fruits (group 4). Seventeen growth, fruit and yield characters were considered by them to test the significance of means between the groups. Fruit characters namely, fruit length, girth, volume, weight, pulp content, pericarp thickness and seed number per fruit were reported to be reliable categories in plant grouping and characterization.

Singh *et al.* (2001) conducted a study on biochemical components of 16 varieties/strains of pointed gourd grown in Faizabad, Uttar Pradesh and reported wide variation for various components among different genotypes.

Dora *et al*. (2002) conducted a study to determine the important yield-attributing characters required for the selection of high-yielding types of 11 selections of pointed gourd collected from different parts of Orissa and Bihar, India. The fruit diameter, fruit length, days taken from fruit set to marketable maturity, days taken for appearance of female flower, fruit weight, number of nodes per plant, fruit retention percentage and numbers of fruits per plant were the component characters of yield. Among these, fruit retention percentage and the number of fruits per plant were the most important yield-attributing characters. Hence, these two characters must be given priority in the selection of high-yielding genotypes.

The eighteen germplasm of pointed gourd were characterized by Srivastava *et al.* (2005). They recorded observations for days taken to edible maturity, number of fruits per plant, fruit yield and fruit size (polar & equatorial diameter). The three years mean data have been used for the analysis. The range of edible maturity varied from 11.33 to 16.78 days with mean value of 14.30 days. The minimum number of days taken for edible maturity was observed in KPG-2, while, maximum in KPG-12 genotype. Average number of fruits per plant ranged from 56.45 to 158.56 with a mean of 96.28. The maximum bearing was found in KPG-6, while, minimum in KPG-18. They found that regarding yield performance, the genotype KPG-7 gave maximum yield of 4.82 kg per plot while, minimum was recorded in KPG-18 (0.99 kg).

Thirty two genotypes of spine gourd evaluated by Bharathi *et al.*(2005) and data was recorded on twelve characters namely, vine length, days to flowering, node number on which first flower appears, internodal length, mature leaf size, pedicel length, petiole length, fruit weight, fruit length, fruit girth, number of fruits per plant and yield per plant. The analysis of variance revealed significant differences among the genotypes for all the characters studied.

Pariari *et al.* (2005) evaluated the performance of 21 cultivars of *T. dioica* collected from West Bengal, Bihar and Uttar Pradesh at Mohanpur, West Bengal for 3 years. They found that cultivars obtained from West Bengal produced the longest vines. BC-24 recorded the greatest average vine length (6.10 m), number of primary branches per plant (7.19), number of fruits per plant (38.33) and yield per plant (1.72 kg). BC-65 produced the longest internodes (8.21 cm). The average fruit length was greatest in BC-64 (8.72 cm), whereas the average fruit diameter was greatest in BC-5 (3.84 cm). BC-6 had the lowest average number of seeds per fruit (11.34). BC-53 registered the highest average fruit weight (49.98 g). The high-yielding accessions BC-24, BC-53 (1.53 kg per plant) and BC-15 (1.38 kg per plant) were recommended for cultivation in West Bengal. BC-1, BC-5, BC-6, BC-7 and BC-34 were also suitable breeding materials for the improvement of the yield components of *T. dioica.*

Dubey *et al.* (2005) collected and evaluated eighteen genotypes of pointed gourd in a RBD with three replications at Kalyanpur, Kanpur. The observations were recorded on days to edible maturity, number of fruits, yield per plot (kg) and fruit size (both polar and equatorial diameter) on five competitive plants in each replication which was found significant for yield and fruit size (polar). Deviations from regression (s^2di) were highly significant for a number of traits in genotypes KPG-6 and KPG-10. The regression coefficient (bi) was highly significant for KPG-6 genotype for yield. The maximum average fruit size (polar) was recorded in KPG-6 genotype. They reported that on the basis of experimental findings, lines KPG-6 & KPG-7 may be utilized for general cultivation after extensive testing.

Nineteen genotypes of snake gourd *(Trichosanthes anguina)* collected from various parts of southern India were evaluated in Kerala by Narayanankutty *et al.* (2005) during 1998-99, 1999-2000, 2000-01 and 2001-02 for stability in six quantitative traits *viz.*, number of days to first female flowering, number of fruits per plant, fruit length, fruit girth, fruit weight and fruit yield per plant. The linear and non-linear components of variation were significant for the expression of number of days to female flowering opening, number of fruits per plant and yield per plant. They reported that for earliness, genotypes TA 6, TA 8, TA 10, TA 11, TA 12 and TA 17 showed above-average stability and greater resistance to environmental changes. The fruit yield per plant varied from 6.79 (TA 12) to 12.98 kg (TA 8). However, they reported that the genotype, TA 11 was the only high-yielding genotype which was found stable across environments. Thus, this genotype, which had desirable mean values for 5 of the 6 traits, and exhibited stability for earliness, fruit length and fruit yield, could be utilized in future breeding programmes.

Sarnaik *et al.* (2002) collected 36, 11, 3 and 42 numbers of germplasm from remote area of Abuzmar. District Bastar (Chhattisgarh), Gujarat, Maharashtra and from North-eastern region (Assam) respectively. Thus, 93 genotypes were evaluated under Chhattisgarh condition. Two genotypes *viz.*, Acc. No. 5 (roundish fruits) and Acc. No. 35 (long fruit) were found promising for growing in Chhattisgarh State. They reported that genotype Acc. No. 5 has 4.30 cm fruit

length, 2.63 cm fruit diameter and 22.94 kg per plant yield and genotype Ac. No. 35 has 6.0 cm fruit length, 2.43 cm fruit diameter and 21.08 kg per plant yield.

Bharathi *et al.*(2006) collected and assessed genetic variability of thirty two genotypes of spine gourd (*Momordica dioica*) at Bhubaneswar for ten characters namely days to flowering, vine length, number of nodes on which first flower appears, internode length, fruit length, girth, weight and volume, number of fruits, and yield per plant.

Bharathi and Vishalnath (2011) collected and evaluated total of twenty two varieties/land races of pointed gourd from different parts of Uttar Pradesh, Bihar and Orissa. They observed a wide range of variation for internodal length (5.50–13.67 cm), node number bearing first flower (6.00– 16.83), number of fruits per plant (79.86–502.00), fruit weight (14.31-37.98 g), fruit length (4.17-8.73 cm) and yield per plant (2.48-10.21 kg).They reported that the accessions showed a considerable level of variabilityfor qualitative traits such as fruit colour (light green to dark green), fruit striping (striped to without striped), fruit shape (round to oblong), leaf surface (smooth to rough).

Nag *et al.* (2012) conducted an evaluation trial of eight genotypes of ivy gourd (*Coccinia cordifolia* L.) under Allahabad agro-climatic condition. The eight genotypes studied were, namely Arka Neelachal Sabuja, Arka Neelachal Kunkhi, AAIIG-1, AAIIG-2, AAIIG-3, AAIIG-4, AAIIG-5 and AAIIG-6. The observations were recorded for sixteen characters *viz.*, days to first female flower anthesis, plant height, internodal length, petiole length, fruit length, fruit diameter, average fresh fruit weight, number of seeds per fruit, number of fruits per plant, yield per plant, yield per hectare, TSS (°Brix) and ascorbic acid content. They reported that genotype AAIIG-1 and Arka Neelachal Sabuja showed minimum days to female flower anthesis. The highest fruit length and fruit diameter were obtained in Arka Neelachal Kunkhi and AAIIG-1, respectively and maximum fruit weight was exhibited by genotypes AAIIG-1. The most promising genotype was AAIIG-1 for maximum number of fruit per plant and fruit yield per plant followed by Arka Neelachal Sabuja.

2.1.2 Genotypic and phenotypic variability

The scope of the crop improvement depends on the basic requirements of variability. There are two kinds of variability in crop plants, genetic and non-genetic. It is the genetic variability which is the pre-requisite for any successful breeding programme. The non-genetic variability is the result of genetic and environmental interactions. The non-genetic or phenotypic component of variability is however, not of much use to breeders, since it cannot be perpetuated from generation to generation. The study of genetic variability was made for the first time by the great biologist Fisher (1918) and subsequently the estimates of genotypic and phenotypic variation was used to predict the expected genetic response. Therefore, knowledge of the genetic variability is very useful in designing selection procedure to a segregating and variable population. The genetic and phenotypic variability has been studied by many scientists in a number of crops. The information in respect of pointed gourd is reviewed here.

Prasad and Singh (1990) studied genotype x environment interactions of twelve genotypes of pointed gourd for six yield and fruit characters. They found that CHES 12 and CHES 7 were the most stable genotypes and thus most suitable for larger cultivation in the Chotanagpur region whereas genotypes, CHES 19 and CHES 29 were reported to be promising for less favourable environments.

Prasad and Singh (1991) derived information from their studies on five yield components on genotype and environment interactions of twelve genotypes which were grown during 1984-85 and 1986-87. They reported that genotypes CHES 12 and CHES 7 exhibited the highest mean yields of 3.87 and 2.62 kg per plant, respectively.

Maharana *et al.*(1995) studied variability and heritability in thirty four spine gourd (*Momordica dioica*) genotypes at Bhubaneswar and reported data on internodal length, petiole length, leaf area, fruit weight, total number of fruits per plant and yield per plant.

The extent of genetic variability, heritability and genetic advance in respect of eight yield and yield contributing characters in thirty five germplasm of Ivy-

gourd were studied by Sarnaik *et al.* (2002). They found that number of fruits per plant and yield per plant exhibited high values of genotypic and phenotypic coefficient of variations, high estimated heritability and the expected genetic advance, indicating scope for improvement by selection.

Dora *et al.* (2003) studied eleven selections of pointed gourd to estimate genetic variability for yield and its attributes. High genetic coefficient of variation (GCV) estimate was observed by them for the characters such as node at which first female flower appears, length of vine, number of nodes per plant, and number of fruits per plant.

Bharathi *et al.* (2006) assessed genetic variability of thirty two genotypes of spine gourd (*Momordica dioica*) for ten characters. The analysis of variance revealed significant differences among the genotypes studied. Phenotypic coefficient of variation (PCV) ranged from 15.26% for fruit girth to 34.28% for fruit weight, while genotypic coefficient of variation (GCV) ranged from 14.38% for fruit girth to 33.52% for fruit weight.

Panchbhai *et al.* (2006) evaluated a total of 113 *M. dioica* genotypes from different parts of India for genetic variation at Akola. They recorded eleven yield characters which included sprout number per tuberous root, vine length, branch number, leaf area, days to initiation of flowering, days to fruit ripening, fruit number per vine, fruit weight, yield per plant, yield per hectare and seed number per fruit. They found that genotypes AKSG-5, AKSG-35 and AKSG-12 showed the maximum number of characters that recorded mean values higher than the general mean.

Rajkumar and Karuppaiah (2007) conducted field studies in Tamil Nadu during 2003 to 2005 to determine the genetic variation including the mean, genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV), heritability and genetic advance with thirty genotypes of snake gourd (*Trichosanthes cucumerina*). They noted significant differences among genotypes for all the characters studied. All the characters exhibited less difference between GCV and PCV values. They reported characters namely, flesh thickness, number

of fruits per plant, days to fruit maturity and 100-seed weight showed equal GCV and PCV values indicating less influence of environment in their expression.

Khan *et al.* (2009) conducted an experiment with 24 accessions of pointed gourd at the Regional Agricultural Research Station, Pabna, Bangladesh during the growing season of 2005-2006. Evaluation of these accessions for yield and yield components revealed high phenotypic and genotypic coefficients of variation (PCV and GCV, respectively). Wide variations among the accessions in respect of plant, leaf, flower, fruit and seed characters were recorded. The accessions varied significantly for days required to first flowering, number of node at first harvest, inter node length at first harvest, vine length at first harvest, fruit length, fruit breath, fruit weight, pulp weight per fruit, pulp seed ratio, number of fruits per plant, weight of fruits per plant, number of seeds per fruit, weight of seed per fruit and yield.

In Kerala, Celine *et al.* (2010) evaluated twenty diverse accessions of snake gourd (*Trichosanthes anguina* L.) collected from different parts at College of Agriculture, Vellayani, Thiruvananthapuram during three seasons. They noticed remarkable variability for yield and yield attributes in all the seasons. The results of pooled analysis revealed that there is no significant difference between seasons for yield and fruit number while the genotypes differed significantly. But for fruit length and girth, they found significant difference between genotypes, while difference over seasons was also significant. The lowest pooled means for fruit length and girth was during summer. The average fruit weight and days to flowering showed significant variation among seasons and genotypes. They reported that genotype, TA 17 recorded the highest yield and fruit number which also showed consistency in performance over seasons and can be recommended for commercial cultivation. Yield pattern for the harvest period of two months showed a gradual increase in yield per harvest from the first week which peaked in the fifth and sixth weeks and declined gradually thereafter.

Bharathi *et al.* (2010) collected twenty-six accessions of spine gourd (*M. dioica* Roxb.), from eastern India and evaluated them to study the diversity and other genetic parameters. On the basis of estimates of genotypic coefficient of

variation and phenotypic coefficient of variation for all the characters, they indicated that selection can be done on the basis of phenotype alone. They also found that accessions of spine gourd from eastern India showed an immense variation and can be used as a potential source of germplasm for crop improvement.

2.1.3 Heritability and genetic advance

Heritability is the quantitative statement of the relative importance of heredity and environment. The partitioning of phenotypic variation in genetic and environmental variation was first done by Fisher (1918). Broad sense heritability is defined as the ratio of genotypic variance to total variance.

The biometrician Johnson *et al.* (1955a) stated that the broad sense heritability estimates may vary greatly depending upon the unit for which the variance is considered. He further emphasized that it indicated the effectiveness with which selection of genotypes can be based on the phenotypic performance.

The amount of progress expected through selection for obtaining the best individual cannot be made on the basis of heritability alone. The genetic progress would enhance with an increase in heritability estimate. Hence, the heritability estimate could be best utilized in conjugation with genetic advance in predicting genetic gain. Genetic advance denotes the improvement in the genotype values of the new population. So, the knowledge of genetic advance, to be expected by applying selection pressure to a segregating and variable population is useful in designing an effective breeding programme.

High heritability along with high genetic advance for fruit length, average weight of fruit, number of fruit per plant and fruit volume was reported by Singh and Prasad (1989), Dora *et al.* (2003), Narayanankutty *et al.* (2006) and Raj Kumar and Karuppaiah (2007).

Dora *et al.* (2003) studied genetic advance among 11 pointed gourd genotypes (BPS-1 to BPS-11) using Mahalanobis D^2-statistics and numerical taxonomic approach. They reported high heritability estimate for all the characters

and found that characters having high genetic co-efficient of variation (GCV) also exhibited high genetic advance.

Srivastava *et al.* (2005) studied eighteen germplasm of pointed gourd and reported that heritability (broad sense) values ranged from 95.00 to 99.00% (yield and number of fruits), whereas percentage of genetic advance ranged from 21.02 to 95.70% (for polar fruit size and yield per plot).

Bharathi *et al.* (2006) studied genetic variability of thirty two genotypes of spine gourd (*Momordica dioica*) for ten characters and they recorded high heritability coupled with high genetic advance for fruit weight, fruit volume and number of fruits per plant, indicating the preponderance of additive gene effects for these characters and their potential use in selection programmes to improve spine gourd productivity.

Narayanankutty *et al.* (2006) estimated genetical parameters of thirty six snake gourd (*Trichosanthes cucumerina*) genotypes and their study indicated a good amount of genetic variation in the germplasm collections. They reported that characters such as fruit yield, fruit weight and seeds per fruit exhibited high values of heritability and genetic gain indicating that additive gene effects are important in determining these characters.

In Tamil Nadu, Rajkumar and Karuppaiah (2007) studied heritability and genetic advance with 30 genotypes of snake gourd (*Trichosanthes cucumerina*). The heritable estimate was found high for all the characters except days to first female flower. They observed maximum heritability for ascorbic acid content of the fruit, followed by the crude fibre content and nodes for first female flower. The genetic advance as a percentage of mean was high for fruits per plant and fruit length. High heritability coupled with high genetic advance was observed for fruits per plant and fruit length. They are governed by additive genes and could be effectively improved through selection.

2.1.4 Correlation coefficient studies

Yield of plant is not a unitary character but it depends on the development of various plant characters. Contribution of each character towards increasing yield

varies from crop to crop. Some of them have substantial contribution while others have meager role. Correlation helps in finding out the association between different characters and measures the strength of relationship between two variables. Correlation coefficient is a statistical measure which is used to find out the degree and direction of relationship between two or more variables.

The original concept of correlation was represented by Galton (1888) and he suggested the need of co-efficient of correlation to describe the degree of association between variables. Later the theory of correlation was developed by Pearson (1904). Thereafter Searle (1961) described the mathematical implication of correlation co-efficient at phenotypic, genotypic and environmental levels.

Singh and Prasad (1989) derived information on heritability, genetic variability and yield correlations for twelve cultivars on eight characters from their experiment conducted during 1984

Prasad and Singh (1990) studied nine genotypes of pointed gourd and noted positive correlations for yield per plot with late flowering, and number of seeds per fruit with fruit weight.

Sarkar (1999) studied correlation of 16 divergent types of pointed gourd and indicated that fruit weight, fruit diameter and number of primary branches/plant were positively and significantly correlated with yield/plant at genotypic and phenotypic levels.

Sarnaik *et al.* (2002) estimated correlation coefficient in thirty five genotypes of Ivy-gourd at genotypic and phenotypic levels. In general, genotypic correlation coefficient was higher than phenotypic correlation coefficient. Yield per plant showed positive and significant correlation with number of fruits per plant and diameter of fruits at genotypic and phenotypic levels. The yield was also significantly and positively correlated with the length of internode at genotypic level.

Hazra *et al*. (2003) evaluated sixty eight diverse female clones of *T. dioica* for growth, morphological, yield and quality characters as well as their relationship

through correlation. The magnitude of genotypic correlation coefficients was higher than phenotypic correlation coefficients for all the pairs of characters, and in most cases, a wide gap was recorded between the two estimates of correlation coefficients, indicating the influence of environment on the correlated response of the pair of characters. Most of the character pairs showed negligible or insignificant correlation that might have resulted due to simultaneous vegetative and reproductive growth in the plant. Only fruit number per plant had significant positive correlation with yield, whereas fruit weight showed highest positive direct effect on yield. However, from the overall study, most of the fruit characters, viz. fruit weight, pulp content of fruit, fruit number per plant and fruit volume, and growth traits, such as leaves per plant and leaf length, were identified as important yield contributors.

Eleven genotypic selections of pointed gourd were studied by Dora *et al.* (2003) for correlation of yield and its attributes and they reported that yield per plant had a significant positive correlation with number of fruits per plant, fruit set and fruit retention.

Srivastava *et al.* (2005) studied eighteen germplasm of pointed gourd and they found that yield is positively and significantly correlated with number of fruits per plant and fruit size. Thus, their study revealed that the major yield component is number of fruits per plant, which should be taken into consideration while making selection for the improvement of pointed gourd.

Narayanankutty *et al.* (2006) studied thirty six genotypes of snake gourd (*Trichosanthes cucumerina*).The character association analysis of the observations revealed that yield was strongly correlated with fruit weight, fruits per plant, fruit girth, fruit length, days to first harvest, flesh thickness and days to first female flower opening. They found that the fruit weight and fruits per plant have the maximum positive direct effects on yield and the indirect contribution of other characters was mainly through days to first harvest, seeds per fruit and 100-seed weight.

Kumaresan *et al.* (2006) investigated correlations among different economic parameters and their direct and indirect effects on fruit yield in six snake gourd (*Trichosanthes cucumerina*) cultivars and their 30 hybrids. They reported that yield per vine in snake gourd was positively associated with main vine length, number of fruits per vine, fruit weight, number of seeds per fruit, seed weight per fruit and ascorbic acid content of the fruits. However, they observed negative association with days to first female flower opening, days to first male flower opening, fruit length, fruit girth and acid content of the fruit. They recommended that the selection for these characters will simultaneously result in improving the yield per vine.

Twelve cultivars of pointed gourd were collected by Singh *et al.*(2007) which were evaluated for seven characters *viz.,* vine length, number of days for first female flower appearance, node number for first female flower appearance, number of fruits per plant, fruit length, fruit diameter and fruit weight during 1999-2000 and 2000-01 in Bhagalpur (Bihar). Correlation and path analyses of the data showed that the number of fruits per plant, fruit length, fruit diameter and fruit weight were major contributing factors towards yield. Selection based on these characters can be effective for developing high yielding cultivars.

2.1.5 Path coefficient analysis

Path coefficient analysis allows a detailed examination of specific forces acting to produce a given correlation and measures the relative importance of such casual factor. It has been widely employed in selection work in many crop plants.

Path coefficient analysis is used as an effective tool in finding out the direct and indirect attributes of different contributing characters towards yield. Each component possesses a large direct effect on yield and its important indirect effect result via different yield components. (Fonseca and Patterson, 1968).

Sarkar (1999) studied path-coefficient of 16 divergent types of pointed gourd and it revealed that fruit volume followed by fruit weight and fruit diameters have maximum positive direct effects on yield. The indirect effects of all the components through fruit volume were relatively high in magnitude irrespective of

direction. Therefore, emphasis should be given on fruit weight followed by fruit diameter, fruit volume and number of primary branches/plant in selecting good genotype for improvement of yield in pointed gourd.

Kumaresan *et al.* (2006) conducted field experiments at Madurai in Tamil Nadu, during the 2000 rabi season, on 6 snake gourd (*Trichosanthes cucumerina*) cultivars and their 30 hybrids. Their studies on path coefficient analysis revealed that it would be highly rewarding to lay emphasis on the number of fruits per vine and fruit weight to increase the yield per vine directly.

Malek *et al.* (2007) studied on twenty five genotypes of pointed gourd. Their study revealed that path coefficient analysis showed that number fruits per plant had direct positive effects on fruit yield. This indicates that this character was the major contributor to fruit yield. Therefore, maximum weightage should be given to this character for improvement of the yield in pointed gourd.

Bharti *et al.* (2008) studied on path coefficient analysis of ivy gourd and their study revealed that number of fruits per plant has maximum direct effect on yield while number of branches per plant has maximum indirect effect via fruit per plant.

Khan *et al.* (2009) worked out path analysis of pointed gourd and they found that days to first flowering showed highly negative direct effect on yield per plant. It also showed negative indirect effect on yield per plant through fruit weight, pulp seed ratio and weight of fruits per plant. On the other hand, it showed positive direct effect on yield via number of node at first harvest, fruit length, fruit breadth and number of fruits per plant. Number of node at first harvest showed highly negative direct effect on yield per plant. But positive direct effect on yield via days to first flowering, fruit breadth and number of fruits per plant, whereas fruit length had positive direct effect on yield per plant through number of node at first harvest, fruit weight, pulp seed ratio and number of fruits per plant. Fruit breadth had positive direct effect on yield per plant but it showed negative indirect effect on yield through days to first flower, number of node at first harvest, fruit

length, fruit weight, and pulp seed ratio, number of fruits per plant and weight of fruit per plant.

2.1.6 Genetic divergence analysis

The concept of D^2 statistics was originally developed by P.C. Mahalonobis (1936). Then C.R. Rao (1952) suggested the application of this technique for the arrangement of genetic diversity in plant breeding. Now, this technique is extensively used in vegetable breeding for the study of genetic divergence in the various breeding material including germplasm. This analysis also helps in the selection of diverse parents for the development of hybrids.

Dora *et al.*(2001)collected eleven genotypes of pointed gourd from Orissa and Bihar, which were studied during 1995-96 for genetic divergence in yield and yield components. The yield components studied included number of branches per plant, fruit diameter, fruit length, fruit weight, vine length, and number of nodes per plant. On the basis of their analysis, the genotypes studied were grouped into four clusters based on Mahalanobis D2 statistics. They found that the clustering pattern did not reflect a significant association between geographical distribution and genetic diversity. Intercluster distances were greater than intracluster distances, indicating considerable genetic diversity among genotypes. The highest D2 value (9840.3) was recorded between cluster II (BPS-2, BPS-5, BPS-6, and BPS-7) and cluster IV (BPS-11). They also reported that the genotypes included in these clusters may give useful transgressive segregates in segregating generations.

Ram *et al.* (2001) performed cluster analysis using 167 genotypes/accessions of pointed gourd (*T. dioica*) collected from different eco-geographic regions of India. Data were recorded for the agro-morphological traits included yield per plant, number of fruits per plant, individual fruit weight, fruit length, fruit diameter, Internodal length and female flower length. The genotypes were grouped into eight non-overlapping clusters, with cluster IV comprising the most number of genotypes (37 accessions) and cluster VI comprising the lowest number of genotypes (6 accessions). Intracluster distance ranged from 1.258 in cluster I to 1.655 in Cluster VII. Clusters VIII and V were the most diverse as indicated by the maximum inter cluster distance between them (6.049). The results

indicated the potential for a wide scope of varietal improvement through hybridization and selection due to the wide genetic diversity present in the accessions studied.

Dora *et al* (2003) studied eleven pointed gourd genotypes (BPS-1 to BPS-11) utilizing both Mahalanobis D^2-statistics and numerical taxonomic approach. On the Basis of D^2-statistics, the eleven genotypes were grouped into four clusters. Clusters I and II comprised four genotypes each, cluster III comprised two genotypes and cluster IV comprised of a single genotype. However, in the case of numerical taxonomic approach, the number of clusters was 3, 4, 6 and 8 at 65, 70, 75 and 80% phenon level, respectively. Their study indicated that numerical taxonomic approach was more potent for clustering biological populations over the D^2-statistics.

Bharathi *et al.* (2005) evaluated thirty two genotypes of spine gourd and data were recorded on twelve characters. Mean data were further subjected for multivariate analysis of Mahalanobis (1936). The genotypes were grouped in various clusters following Tocher's methodas described by Rao (1952).. Based on the D2 values all genotypes were grouped in to 7 clusters. The maximum numbers of genotype (11) were included in cluster III followed by 9 genotypes in cluster IV and 4 genotypes in cluster VI. Three cluster II, V & VII included two genotypes each. The pattern of group constellations indicated that genetic diversity was not directly related to the geographic diversity. The intra and inter cluster distance among seven clusters were also studied and the intra-cluster distance ranged from 30.34 (cluster I) to 371.56 (cluster III).

Khan *et al.* (2008) studied genetic diversity among 64 pointed gourd genotypes assessed through multivariate analysis in an experiment conducted at Regional Agricultural Research Station, Pabna in Bangladesh. The genotypes were grouped into twelve clusters. The cluster V consisted of highest number of genotypes and it was nine, the cluster VI and cluster VIII contained the lowest number of genotypes and it was two in each. The clustering pattern of the genotypes under this study revealed that the genotypes collected from the same location were grouped into different clusters. The highest inter genotype distance

(366.3) was observed between the genotypes P0022 and P0007 and the lowest (2.6) was observed between the genotypes P0043 and P0044. Cluster V had the highest cluster mean value for internodal length, fruit weight per plant and yield. The highest inter-cluster distance was noticed between cluster III and II (45.71) and the lowest between cluster VII and VI (3.33). The highest intra cluster distance was computed for cluster III and that was lowest for the cluster II. The first five axes accounted for 77.65% of the total variation among the 13 characters describing 64 pointed gourd genotypes. Fruit weight, seeds per fruit and fruit weight per plant contributed maximum to the total divergence. The also reported that results obtained by D^2 analysis were confirmed by canonical analysis.

In Bangladesh, Kabir *et al*. (2009) conducted an experiment to estimate the genetic diversity among 24 genotypes of pointed gourd by using Mahalanobis D^2 statistics for nine characters. The genotypes were grouped into five clusters. The cluster I and III consisted of highest number of genotypes and it was six. The cluster IV contained the lowest number of genotypes and it was three. The clustering pattern of the genotypes under this study revealed that the genotypes collected from the same location were grouped into different clusters. The inter cluster distance were larger than the intra cluster distance suggesting wider genetic diversity among the genotypes of different groups. The highest intra cluster distance was computed for cluster IV (35.80) and the minimum intra cluster distance was found in cluster III (18.37). The clusters IV and II were more diverse as indicated by maximum inter cluster distances between them (41.56) and the minimum inter cluster divergence was observed between cluster III and II (6.84). Cluster II had the highest cluster mean value for number of fruits per plant (391), weight of fruit per plant (11.72kg) and yield (35.28t/ha). Genotypes of the cluster V had late maturity.

Khatun *et al.* (2010) conducted experiment at the field and laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from April 2004 to September 2004 to study the nature and magnitude of genetic diversity of thirty-eight snake gourd (*Trichosanthes cucumerina*) genotypes collected from different regions of the country. Based on

D^2 analysis, they grouped the genotypes studied into four different clusters, where the cluster I possessed maximum number (21) of genotypes followed by the cluster II (8), III (7), and IV (2). Clustering pattern revealed that geographical diversity was not associated with genetic diversity *i.e.,* genotypes collected from same location were grouped into different clusters. They observed maximum inter-cluster distance between the clusters III and IV and that of minimum in between the clusters I and II. In case of intra-cluster distance, the maximum distance was observed in the cluster IV and that of minimum was observed in the cluster III. They found that considering cluster mean, the genotypes of cluster IV could be selected for yield per plant and other yield contributing characters.

Bharathi and Vishalnath (2011) on the basis of D^2 values grouped the twenty two accessions into five clusters. The pattern of group constellations indicated that genetic diversity was not directly correlated to the geographic diversity. Cluster I was largest comprising 12 accessions, whereas cluster V was smallest with a single accession. The intra-cluster distance ranged from 0.00 (cluster V) to 26.67 (cluster I) and inter-cluster distances varied from 17.60 (cluster III Vs cluster V) to 47.76 (cluster IV Vs cluster V). Cluster IV could be characterized with genotypes early in flowering (<55 days), higher values for fruit characters (fruit weight-32.78 g; fruit length-8.72 cm) and yield per plant (9.59 kg). Though maximum number of fruits per plant (466.01) was recorded in cluster II it stood second in terms of yield per plant which may be due to less fruit weight recorded by this group.

In Tamil Nadu, Devi and Mariappan (2013) investigated genetic diversity among fifty genotypes of snake gourd (*Trichosanthes anguina* L.) and Mahalanobis D^2statistic analysis was worked out. Based on the D^2 analysis results, the genotypes were grouped into four different clusters, where the cluster I possessed higher number (32) of genotypes followed by the cluster II (2), III (15) and IV (1). Clustering pattern revealed that geographical diversity was not associated with genetic diversity that is, genotypes collected from same location were grouped into different clusters. The maximum inter-cluster distance was observed between the clusters III and cluster IV and that of minimum in between

the Clusters I and Cluster II. In case of intra-cluster distance, the maximum distance was observed in the cluster III and that of minimum was observed in the cluster IV. Among the nine traits studied, maximum contribution was made by average fruit weight (31.84%) followed by days to first male flower appearance (25.96%), yield per hectare (23.59%) and fruit length (17.31%). Considering cluster mean, the genotypes of cluster I and cluster III could be selected for yield and yield attributing characters. The wider genetic diversity was observed in cluster II, III and IV which indicate the potentiality of this diverse genotype collection for providing basic material for future breeding programmes.

2.2 Molecular markers studies

Among the different types of molecular markers available, random amplified polymorphic DNA(RAPD) are useful for the assessment of genetic diversity because of their simplicity, fast and easy to perform and comparatively cheaper and requires no prior knowledge of DNA sequences (Williams *et al.,* 1990 and Welsh *et al.,* 1991). RAPD markers have been used to classify accessions (Horejsl and Staub, 1999), identify cultivar and hybrids (Sharma *et al.,* 1995) and genetic diversity (Sureja *et al.,* 2006). Additionally, RAPDs are also advantageous over isozyme analysis since they detect more polymorphism at about the same cost of analysis (McDonald *et al.,* 1994). Hence the present investigation was carried out for analysing the amount of genetic variation in pointed gourd accessions (Khan *et al*. 2009) and classifying them to assist in selection of better genotypes.

Singh *et al*. (2002) studied genetic and molecular basis of dioecism in *T. dioica* in 16 female and four male accessions which were collected from Bihar and West Bengal, India by random amplified polymorphic DNA (RAPD). Of the decamer primers identified from pooled DNA extracted from the female and male accessions, 5 primers which produced probable female-related bands were selected to confirm the presence and absence of bands in each of the entries. The 567 bp band amplified by the OPC07 primer from the genomic DNA of all female entries was absent in all the male entries. This band appeared to be the female sex-related DNA marker in *T. dioica.*

Ning *et al.* (2007) at Institute of Horticulture, Academy of Anhui Agricultural Science, Hefei, China studied twenty-eight accessions of snake gourd (*T. kirilowii*) by RAPD molecular markers. They reported that genetic distance between Diaogua from Zhejiang province and a snake gourd accession from Anhui province was very large. They found that snake gourd accessions from Anhui province were diverse and classified them into 5 categories. Marked variation in botanical and biological characters was observed in the same category. They also noted that Damazi and Damazierhao had a similar appearance, but the genetic distance between the cultivars was slightly pronounced.

Kumar *et al.*(2008) screened forty-one random decamer primers with the three bulks in order to identify markers associated with sex expression. DNA samples were extracted separately from 10 male and 10 female sexual progeny of pointed gourd (*Trichosanthes dioica*) and 3 plants from a parthenocarpic clone (IIVRPG-105); the DNAs were bulked by sex type. A total of 509 amplification products were obtained of which six were associated with sex expression. These six markers were then tested with individual plant DNA samples, and three sex-associated RAPD markers were identified. A 1000 bp amplification product from the primer OPC05 was found to be present in all the male and absent from all the female and parthenocarpic plants. In contrast, a 400 bp amplification product from the primer OPC14 was present only in the female individuals. Thus the two RAPD markers, male-specific marker OPC 051000 and female-specific marker OPC 14400, together can reliably differentiate between male and female plants of *T. dioica*. The third marker, OPN 011030, was due to the primer OPN 01, which amplified a 1030 bp fragment from male and female DNAs, but failed to do so from the parthenocarpic plant DNAs.

Genetic variation in 64 pointed gourd accessions was investigated by Khan *et al*. (2009) using the Randomly Amplified Polymorphic DNA (RAPD) in Bangladesh. Out of 45 random primers screened five were selected, which gave 38 clear and bright fragments, out of which 30 (79.5%) fragments were considered polymorphic. The proportion of polymorphic loci across all loci was 96%. The number of bands per primer was five to eleven. The highest genetic distance

0.6419 was observed between the accession PG 035 and PG 051, PG 035 and PG 056 and PG 035 and PG 021. While the lowest genetic distance (0.00) was observed between the accessions PG 042 and P 043 and between PG 042 and PG 044. The UPGMA dendogram constructed based on RAPD analysis in 64 pointed gourd accessions were found to be grouped in twelve major clusters. Cluster VIII is a broad one which includes 21 accessions and only a single accession formed in cluster VII (PG021). RAPD analysis showed promise as an effective tool in estimating genetic polymorphism in different accessions of pointed gourd.

Goswami and Tripathi (2010) utilized molecular markers and studied 22 cultivars of male and female of *T. dioica* from various agro-climatic regions of India which have been fingerprinted by RAPD and ISSR markers utilizing 37, 15 primers respectively. To understand genetic relationships among these cultivars, Jaccard's similarity coefficient and UPGMA clustering algorithm were applied to the two marker data sets. The percentage of polymorphism range for RAPD is from 89 to 45% while for ISSR is from 88 to 100%, the UPGMA dendogram obtained from the cluster analysis of RAPD and ISSR data gave similar clustering pattern, with Jaccards similarity coefficient ranging from 0.23 to 0.93. Their study showed that RAPD and ISSR markers could provide a practical and efficient tool in quality control of the *T. dioica*.

Molecular tool like Random amplification of polymorphic DNA (RAPD) was used to identify female plants before pre-flowering stage in Spine gourd *(Momordica dioica* Roxb.) by Baratakke *et al.* (2013).They utilized a total of 50 random decamer primers for screening of specific Random amplification of polymorphic DNA markers in male and female populations. Only one primer OPA-15 amplified genomic DNA in different patterns in male and female genotypes. This sex specific band OPA-15900 was identified only in female lines but not in male lines. They reported that this marker may be efficiently used as effective, convenient and reliable molecular markers for female identification in *Momordica dioica* at pre-flowering stages so that it can be cultivated and utilized for its medicinal purpose.

Nanda *et al.* (2013) developed an ISSR based STS marker for identification of male and female at the seedling stage in pointed gourd (*Trichosanthes dioica* Roxb.). They used screening of genomic DNA with inter simple sequence repeat (ISSR) primers for early detection of male and female plants in this study. Using pooled DNA from male and female genotypes and 40 ISSR primers, a putative male specific marker *TdMSM* was produced. It was converted into a sequence tagged marker *TdSTSM* which could successfully amplify 720 bp product in male but not in the female. Southern blotting confirmed it as a single copy locus found only in male plant. Further, the *TdSTS M*marker was used to accurately detect 9 males and 6 females from 15 individuals of pointed gourd with unknown sex. They thus found that the STS primers designed from ISSR fragment *TdMSM* could be used as an effective and reliable molecular marker for early sex diagnosis in *T. dioica*.

CHAPTER - III
MATERIALS AND METHODS

The details of materials used and the techniques adopted during the course of study entitled **"Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)"** are briefly described in this chapter.

3.1 Location of experimental site

The present investigation was conducted at Horticulture Farm and Dr. R.H. Richharia lab, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Kharif and Summer* seasons of years 2012-13 and 2013-14.

3.2 Geographical situation

Raipur is situated at the 21^0 16' N latitude and 81^0 36' E longitudes at an altitude of 289.56 meters above mean sea level. Raipur, the place of investigation, is a sub-humid region. It comes under the seventh agro-climatic zone of the country that is Eastern Plateau and Hills.

3.3 Agro-climatic conditions

Climatologically, Raipur is characterized as slightly moist hot zone. The average annual rainfall ranges between 1200-1400 mm and most of it is received during the period from June to end of September, with occasional light showers during winter and summer season. A major portion of rainfall is received by the South-Western monsoon. The pattern of rainfall during June to September months has great variation from year to year. May and December are the hottest and the coolest months of the year, respectively. The average maximum and minimum temperatures are 42.6 ^{0}C and 10.1 ^{0}C respectively.

3.4 Weather conditions & during crop growth period

The meteorological observations recorded during the investigation period on the basis of weather data of Meteorological Observatory, IGKV, Raipur are given in annexure-A & B and depicted through Fig. 3.1 and 3.2.

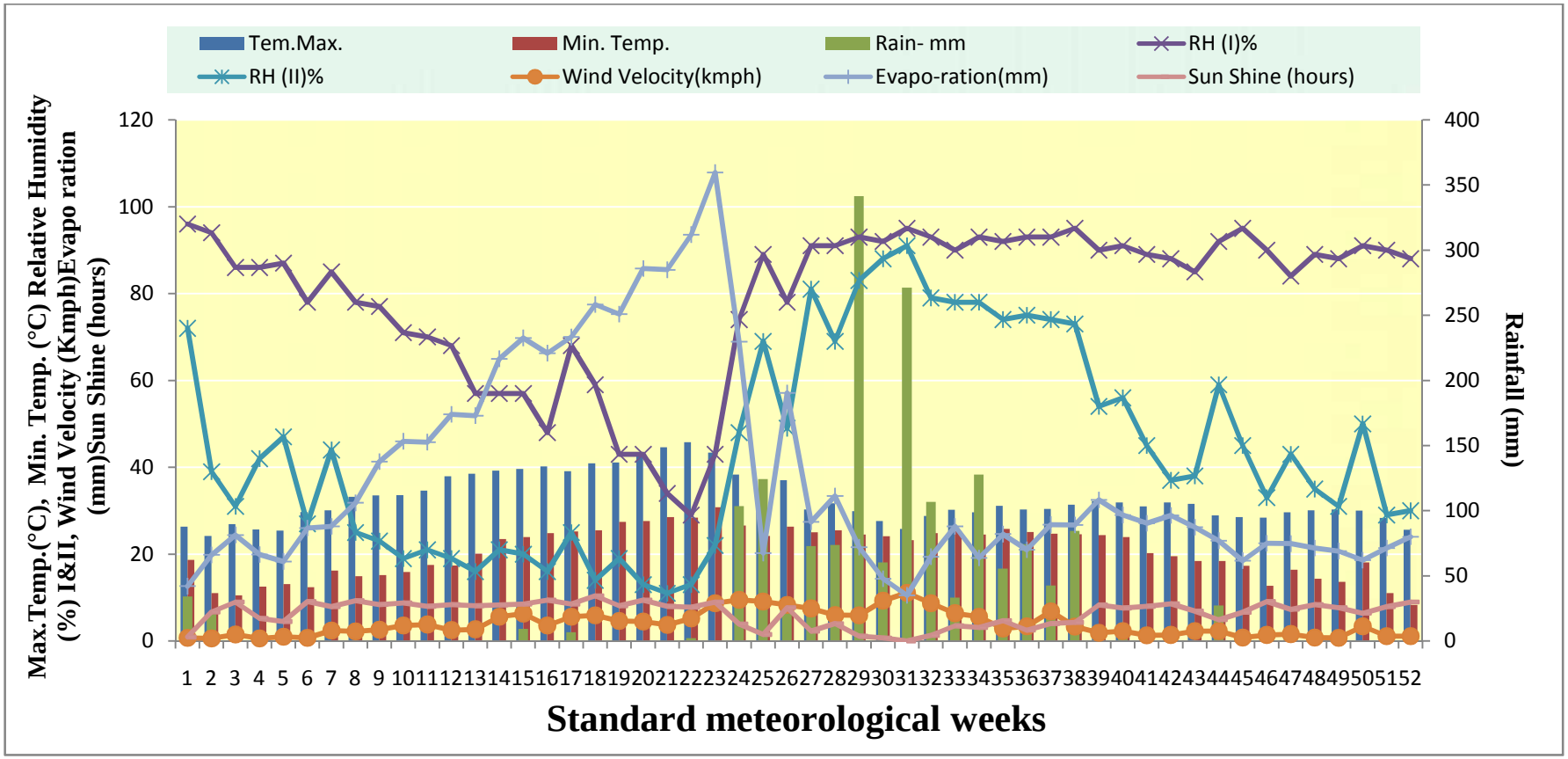


Fig. 3.1 Meteorological graph during crop period 2013

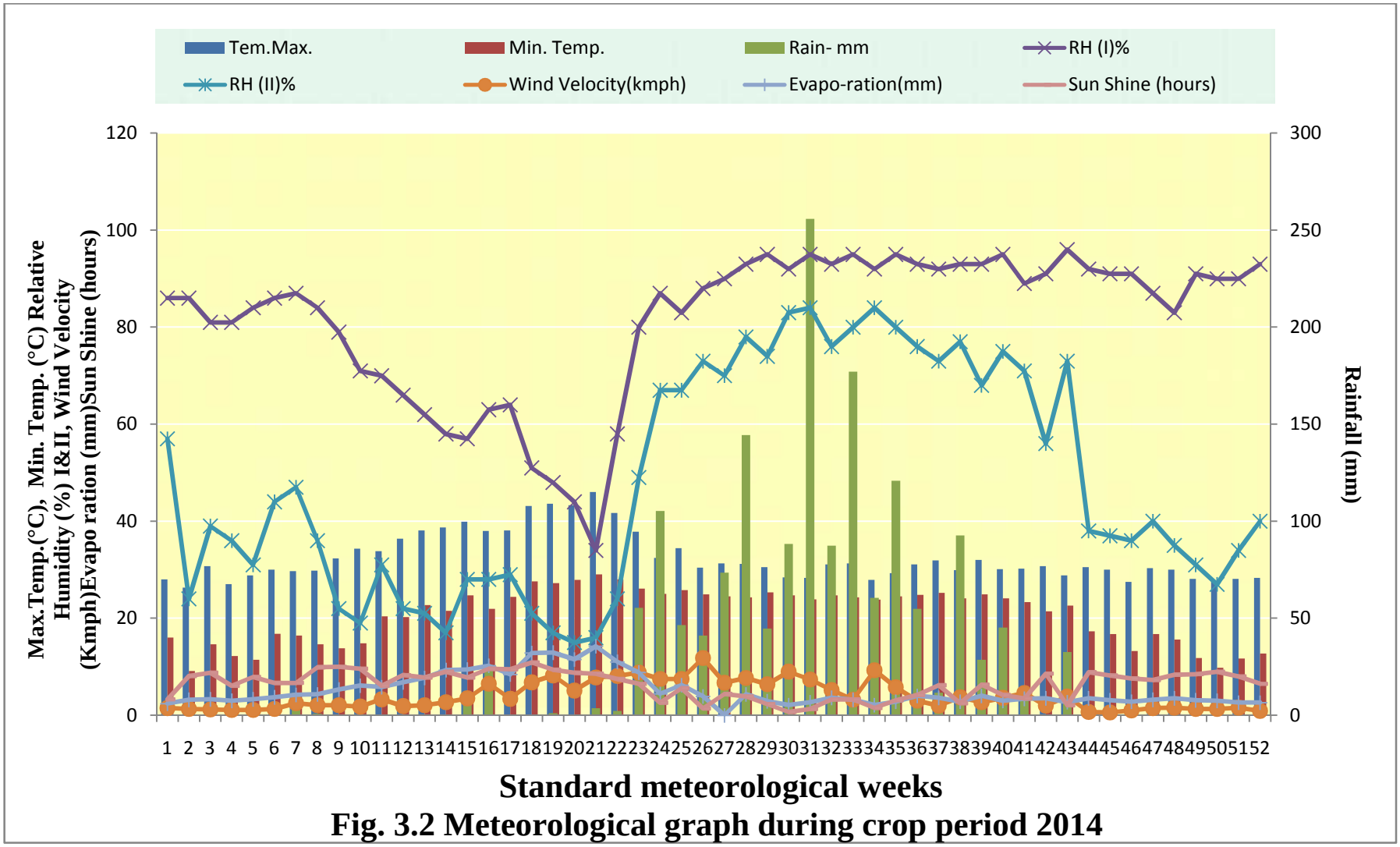


Fig. 3.2 Meteorological graph during crop period 2014

3.5 Physico- chemical properties of soil

The soil samples were collected randomly from six places of the experimental field before lay out of the experiment during first year (2012-13). The samples were mixed well and a uniform composite sample was analysed for assessing the initial physico-chemical properties of the soil. The physio-chemical composition of soil of experimental field is presented in Table 3.1.

Table 3.1: Physico-chemical properties of the soil

Particular	Analysis Values	Rating	Method used
A. Physical properties			
1.Mechanical composition			
Sand (%)	44	-	International Pipette method (Black,1965)
Silt (%)	34	-	
Clay (%)	22	-	
Texture class		Sandy loam (Inceptisol)	
B.Chemical composition			
1. Available N (kg ha^{-1})	250	Low	Alkaline Permangnate Method (Subbiah and Asija, 1956)
2. Available P (kg ha^{-1})	28.175	High	Olsen's Method (Olsen, 1954)
3. Available K (kg ha^{-1})	400	High	Flame Photometric Method (Jackson, 1967)
4. pH	6.96	Neutral	Glass Electrode pH meter (Piper, 1967)

3.6 Planting materials

In all, twenty four genotypes were collected from Department of Horticulture, IGKV, Raipur and HARP, Ranchi, Jharkhand and details of different genotypes are given below in Table 3.2.

Table 3.2. Details of genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)

S. No.	Collection No. and Name	Notation	Sources of Material
1.	Indira Pointed Gourd-1	IPG-1	Department of Horticulture, IGKV
2.	Indira Pointed Gourd-2	IPG-2	Department of Horticulture, IGKV
3.	Indira Pointed Gourd-3	IPG-3	Department of Horticulture, IGKV
4.	Indira Pointed Gourd-4	IPG-4	Department of Horticulture, IGKV
5.	Indira Pointed Gourd-5	IPG-5	Department of Horticulture, IGKV
6.	Indira Pointed Gourd-6	IPG-6	Department of Horticulture, IGKV
7.	Indira Pointed Gourd-7	IPG-7	Department of Horticulture, IGKV
8.	Indira Pointed Gourd-8	IPG-8	Department of Horticulture, IGKV
9.	Indira Pointed Gourd-9	IPG-9	Department of Horticulture, IGKV
10.	Indira Pointed Gourd-10	IPG-10	Department of Horticulture, IGKV
11.	Indira Pointed Gourd-11	IPG-11	Department of Horticulture, IGKV
12.	Indira Pointed Gourd-12	IPG-12	Department of Horticulture, IGKV
13.	Indira Pointed Gourd-13	IPG-13	Department of Horticulture, IGKV
14.	Indira Pointed Gourd-14	IPG-14	Department of Horticulture, IGKV
15.	Indira Pointed Gourd-15	IPG-15	Department of Horticulture, IGKV
16.	Indira Pointed Gourd-16	IPG-16	Department of Horticulture, IGKV
17.	Indira Pointed Gourd-17	IPG-17	Department of Horticulture, IGKV
18.	Indira Pointed Gourd-18	IPG-18	Department of Horticulture, IGKV
19.	Indira Pointed Gourd-19	IPG-19	Department of Horticulture, IGKV
20.	Indira Pointed Gourd-20	IPG-20	Department of Horticulture, IGKV
21.	Indira Pointed Gourd-21	IPG-21	Department of Horticulture, IGKV
22.	Indira Pointed Gourd-22	IPG-22	Department of Horticulture, IGKV
23.	Swarna Alaukik	Swarna Alaukik	HARP, Ranchi, Jharkhand
24.	Swarna Rekha	Swarna Rekha	HARP, Ranchi, Jharkhand

3.7 Experimental details

The experiment was laid out in Randomized Complete Block Design (RCBD) with 24 genotypes of pointed gourd with three replications. The genotypes were grown randomly in each replication/block in a total of 24 rows of 3m x 0.75 m each containing 50 plants per row.

3.8 Treatment details

Twenty two locally collected indigenous genotypes of pointed gourd were used in this experiment as treatment factor for evaluation of morphological characteristics, yield attributing characters, and characterization of genotypes. The two released and notified varieties namely, ‘Swarna Alaukik’ and ‘Swarna Rekha’ were utilized as standard check.

3.9 Preparatory cultivation

The experimental field was prepared by two ploughing with power tiller up to a depth of 30 cm and FYM was thoroughly mixed with soil. The pointed gourd tuberous roots were planted in rows in the bower system already established in Horticulture Farm.

3.10 Experimental details

Details of Experiment are summarized below:

Location of experiment	: Horticulture Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh
Design of the experiment	: Randomized Complete Block Design (RCBD)
Number of treatments (Genotypes)	: 22 (Collected from Chhattisgarh) 02 (Standard Check) 1.Swarna Alaukik 2.Swarna Rekha

Number of replications : Three

Spacing (Row to Row & Plant to Plant) : 3.0 m x 0.75 m

Number of plants row^{-1} : 50

Fertilizer application : FYM @ 20 tones/ha, N: 80 kg/ha, P_2O_5: 40 kg/ha, K_2O: 40 kg/ha,

Date of planting : 26thFeb, 2013 and 23thFeb, 2014

3.11 Observations recorded

Observations were recorded on five randomly selected plants in each treatment/replication and observed mean value was used for statistical analysis. Characterization of genotypes was also done as per IIVR unpublished descriptor of Pointed Gourd (*Trichosanthes dioica* Roxb.).

3.11.1. Morphological parameters

3.11.1.1 Stem pubescence

The stem pubescence was observed as sparse or dense and recorded for all genotypes.

3.11.1.2 Stem shape

The stem shape was observed as round or angular and noted for all genotypes.

3.11.1.3 Leaf shape

The shape of leaf was observed as cordate, oblong, ovate, obovate, and orbicular shapes and recorded for all genotypes.

3.11.1.4 Leaf pubescence nature

The leaf pubescence nature was observed for its presence and absence and noted for all genotypes for all genotypes.

3.11.1.5 Leaf margin

The margins of the leaves for each genotype were observed as entire, serrated or multifid and noted.

3.11.1.6 Leaf blade: number of lobes

The number of lobes of leaves was observed and counted and recorded as less than 5, 5-7 or more than 7 for all the genotypes under study.

3.11.1.7 Leaf blade: depth of lobing

The depth of the lobing of the leaves was observed as shallow, medium or deep and noted for all genotypes under study.

3.11.8 Leaf colour (Light/dark green)

The colour of the leaves for each genotype were observed as light or dark green and noted.

3.11.9 Leaf type (Blunt/Pointed)

The tip of the leaves for each genotype were observed as blunt or pointed and noted.

3.11.1.10Fruit: shape

The shape of fruit was observed as club shaped, cylindrical, oval, spindle and tapering shapes and recorded for all genotypes.

3.11.1.11 Fruit: skin primary colour

The primary skin colour of the fruits of each genotype was observed as green or dark green and noted.

3.11.1.12 Fruit striped pattern (surface color pattern)

The surface color pattern of the fruits was observed as uniform, mottled or, striped and recorded for all genotypes.

3.11.1.13Colour of fruit stripe

The colour of the fruits stripe of each genotype was observed as light green or white and noted.

3.11.1.14 Fruit: glossiness

The glossiness of the fruits was observed as non-glossy or glossy and recorded for all the genotypes under study.

3.11.1.15 Fruit curvature (straight/curved)

The straightness of the fruits of each genotype was observed as straight or curved and noted.

3.11.1.16 Pericarp hardness of the fruit

The pericarp or outer skin hardness of the fruits was observed as soft or, hard and recorded for all genotypes.

3.11.1.17 Flesh color

The flesh colour of the fruits of each genotype was observed as white, creamy or any other colour and noted.

3.11.1.18 Blossom end fruit shape

The blossom end shapes of the fruits was observed as depressed, flatten, round, or pointed and recorded for all genotypes under investigation.

3.11.1.19 Seediness

The absence or presence the seeds for each genotype were observed under seediness by cutting of the fruits.

3.11.1.20 Sex Type

The sex type of flowers of each genotype were observed as monoecious or dioecious.

3.11.2 Growth and yield parameters

3.11.2.1 Leaf blade: Length (cm)

The length of the leaf blade from full grown five leaves from randomly selected five plants from each replication was measured in centimeters with the help of scale and average values were recorded.

3.11.2.2 Leaf blade: width (cm)

The width of the leaf blade from full grown five leaves from randomly selected five plants from each replication was measured in centimeters with the help of scale and average values were recorded for further analysis.

3.11.2.3 Average internodal length (cm)

The length of the internodes of the middle portion of the full grown vine was measured in centimeters with the help of scale from randomly selected five plants from each replication and average values were recorded for further analysis.

3.11.2.4 Days taken for appearance of first female flower

The field was regularly observed. The days taken for appearance of first female flower on the five randomly selected plants from each genotype in every replication were noted. The number of days from date of planting to days to appearance of first female flower was calculated. The average value was taken.

3.11.2.5 Petiole: length (cm)

The length of the petiole of the full grown five leaves was measured in centimeters with the help of scale from randomly selected five plants from each replication and average values were recorded for further analysis.

3.11.2.6 Node of the first female flower

The field was regularly observed. The number of nodes for appearance of first female flower on the five randomly selected plants from each genotype in every replication was noted. The number of nodes for appearance of first female flower was calculated and the average value was taken.

3.11.2.7 Fruit length (cm)

The length of fruit was measured in centimeters for five fruits at marketable stage from randomly selected plants from each replication at time of peak harvest and average values were taken.

3.11.2.8 Fruit diameter (cm)

The diameter of fruit was measured in centimeters for five fruits at marketable stage from randomly selected plants from each replication at time of peak harvest and average values were taken.

3.11.2.9 Number of fruits per plant

Number of fruits counted from the five randomly selected and tagged plants from each replication at each harvest. Total number of fruits per plant was calculated by summation of number of fruits of all the pickings and taking average of it.

3.11.2.10 Number of seeds per fruit

The number the seeds of the five fruits of each genotype from every replication were counted after the cutting of the fruits and average values were noted.

3.11.2.11 Average fruit weight (g)

The individual weight of five randomly selected fruits from each replication was measured at marketable stage from randomly selected plants from each plot at time of peak harvest and average values were taken.

3.11.2.12 Days taken from fruit set to harvest maturity

The days taken from fruit set to harvest maturity on the five randomly selected plants from each genotype in every replication were recorded and the average value was derived.

3.11.2.13 Yield per plant (kg)

The yield from each of the five randomly selected and tagged plants from each replication at each harvest was recorded. The average fruit yield per plant was calculated by summation of fruit yield from each selected plant from all the pickings and taking average of it.

3.11.2.14 Yield per hectare (q)

The total yield of fruits of all the pickings from each plant was calculated in kilogram and converted to quintals per hectare.

3.12 Statistical analysis

3.12.1 Analysis of variance

The analysis of variance was carried out for each character separately as per method of Panse and Sukhatme (1967). Significance of differences among genotypes was tested using the following skeleton.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F value	
				Calculated	Table at 5%
Replication	(r-1)	RSS			
Treatment	(t-1)	TrSS	M_1	M_1/M_2	
Error	(r-1)(t-1)	ErSS	M_2		
Total	(rt-1)	TSS			

Where,

r = Number of replications
t = Number of treatments
RSS = Sum of squares due to replication
TrSS = Sum of squares due to treatment (genotypes)
ErSS = Sum of squares due to error
M_1 = Mean sum of squares due to treatment
M_2 = Mean sum of squares due to error

a. Critical difference

CD = SEd x t Value at 5% error degree of freedom

$$SEd = \sqrt{\frac{2EMS}{r}}$$

Where,

S Ed = Standard error of diffrerence between two treatment means

EMS = Error Mean of square

r = Number of replication

b. Standard error of mean

$$SEm \pm = \sqrt{\frac{EMS}{r}}$$

c. Coefficient of variation (CV) (%)

Coefficient of variation is standard deviation expressed as percentage of Mean

$$CV\ \% = \frac{SD}{\bar{x}} \times 100$$

Where,

SD = Standard deviation

$\overline{X}$ = Mean of character

3.12.2 Parameters of variation

A. Range

The range of the distribution was expressed by the limit of the smallest and the largest value of each observation.

B. Mean

This was found by summing up all the observations and dividing the sum by the number of observations.

C. Variability

The phenotypic and genotypic components of variance were computed according to formulae given by Lush (1940). However, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) in percentage were calculated according to Burton and De Vane (1953).

$$\sigma^2 g = \frac{Mg - Me}{r}$$

Where,

$\sigma^2 g$ = Genotypic Variance

Mg = Treatment Mean Square

Me = Error Mean Square ($\sigma^2 e$)

a. phenotypic coefficient of variation (PCV)

$$\sigma^2 p = \sigma^2 g + \sigma^2 e$$

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

$$\{\sigma p = \sqrt{\sigma^2 p}\}$$

Where,

$\sigma^2 p$ &σp = phenotypic variance and its standard deviation,

$\sigma^2 g$ &σg = Genotypic variance and its standard deviation,

$\sigma^2 e$ = Environmental variance

$\overline{X}$ = General Mean

b. Genotypic coefficient of variation (GCV)

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

$$\{\sigma p = \sqrt{\sigma^2 g}\}$$

The estimates of PCV and GCV were classified as low, moderate and high according to Sivasubramanian and Madhavamenon (1973).

< 10 % = Low

10-12 % = Moderate, and

> 20 % = High

D. Heritability

Heritability in broad sense (h^2b) is defined as the proportion of the genotypic variance to the total variance (phenotypic variance) was estimated by using the formula given by Hansen *et al.* (1956).

$$h^2b = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

The broad sense heritability estimates were classified as low, moderate and high suggested by Robinson (1966) as follows:

<50 % = Low

50-70 % = Moderate, and

> 70 % = High

E. Genetic advance

Expected genetic advance (GA) was calculated as per the method suggested by Johnson *et al*. (1955).

$$GA = K.\sigma ph^2$$

Where,

K=Constant (Standard selection differential) having value of 2.06 at 5% selection intensity.

σp =Phenoytpic standard

h^2 = Heritability estimates

Genetic advance as percentage of mean

Genetic advance as percentage of mean was calculated by the following formula.

$$\text{Genetic advance as percentage of mean} = \frac{\text{Genetic advance X 100}}{\overline{X}}$$

GA= Genetic advance

$\overline{X}$=Mean of character

The GA was categorized as,

< 10 % = Low

10-20 % = Moderate, and

> 20 % = High

3.12.3 Association analysis

3.12.3.1 Correlation coefficient (Character association)

Correlation coefficients were calculated for all possible combination among the characters at genotypic, phenotypic and environmental levels were estimated as given by Searle (1961)

i.Phenotypic correlation between characters x and y.

$$r_x\ (p) = \frac{\text{Cov xy (p)}}{\sqrt{\text{var x (p)} \times \text{var y(p)}}}$$

Where,

$r_{(xy)}$ = Correlation coefficient between character x and y

Var(x) = Variance of x character

Var(y) = Variance of y character

i. Genotypic correlation between characters x and y

$$r_x\ (g) = \frac{\text{Cov xy (g)}}{\sqrt{\text{var x (g)} \times \text{var y(g)}}}$$

ii. Environmental correlation between characters x and y

$$r_x\ (e) = \frac{\text{Cov xy (e)}}{\sqrt{\text{var x (e)} \times \text{var y(e)}}}$$

Where,

Covxy(p), covxy(g), covxy(e) = Phenotypic, genotypic & environmental co variances between character x and y, respectively.

Varx(p), var x(g), var x(e) = Phenotypic, genotypic & environmental covariances character x, respectively.

Vary(p), var y(g), var y(e) = Phenotypic, genotypic & environmental covariances character y, respectively.

The significance of correlation coefficient (r) was tested by comparing‘t’ value at (n-2) degree of freedom.

$t = \sqrt{r\,(n\text{-}2 / 1\text{-}r^2)}$

If calculated‘t’ is greater than tabulated ‘t’ at (n-2) degree of freedom at given probability level, the coefficient of correlation is taken as significant.

3.12.3.2 Path coefficient analysis

The genotypic correlation coefficients were further partitioned into direct and indirect effects with the help of path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects.

Path coefficient was estimated using, simultaneous equations, the equations showed a basic relationship between correlation coefficient and path coefficient. These equations were solved by presenting them in matrix notations.

$A = B.C$

The solution for the vector ‘C’ may be obtained by multiplying both sides by inverse of ‘B’ matrix i.e. $B^{-1} A = C$

After calculation of values of path coefficient i.e. ‘C’ vector, it is possible to obtain path values for residual (R). Residual effect was calculated using formula referred from Singh and Chaudhary (1985).

$R = \sqrt{1 - \Sigma di \times r_{ij}}$

Where,

Di = direct effect of i^{th} character

rij = correlation coefficient of i^{th} character with j^{th} character

A direct and indirect effect of different characters on bulb yield was calculated at genotypic level.

3.12.3.3. Cluster analysis

The Mahalanobis (1936) D^2 statistic was used to measure the genetic divergence between the populations. The D^2 value was estimated on the basis of 'P' character by the formula:

$$D^2p = \sum_{i=1}^{p} = \sum_{j=1}^{p} = (\lambda\ ij)\lambda i\ \lambda j$$

Where,

(λ i, j) is the reciprocal or (λ i, j), the pooled common dispersion matrix (i.e. error matrix)

i = the difference in the mean value for the i^{th} character

j = the difference in the mean value for the j^{th} character

For calculating the D^2 values, the variance and covariance were calculated. The genotypes were grouped into different clusters by Tocher's method. The population was arranged in order of their relative distances from each other. For including a particular population in the clusters, a level of D^2 was fixed by taking the maximum D^2 values between any two populations in the first row of the table where D^2 values were arranged in increasing order of magnitude.

3.13 Molecular analysis

Twenty four genotypes as depicted in Table 3.2 were subjected to molecular characterization as methods described under following headings:

3.13.1. Genomic DNA isolation

The five to seven fresh leaves of each of the genotypes were collected in plastic bags under natural condition. These leaves samples were stored in refrigerator and used for isolation of genomic DNA.

3.13.2. DNA extraction protocol

DNA was isolated by modified CTAB method of DNA Extraction as suggested by Jonathan and Wended (1990).The stepwise procedure is described as here under:

1. The leaf tissues were cut in a 2.0 ml eppendorf tube.
2. 700 µl CTAB buffer was added in this and kept at 4 °C for 3-4 hours.
3. Grinded the leaf and add some more CTAB (300µl) buffer.
4. Kept it in water bath at 65°C for 20 minutes.
5. 750 ml of Chloroform isoamyl alcohol (24:1) was added and then vortexed the sample.
6. Centrifuged it for 20 minutes at 14000 rpm.
7. Transferred the upper clear layer in new 1.5 ml appendorf tube (repeated twice from step 5 to 8).
8. About 175 µl (1/10 of supernatant) of 3M Sodium acetate and 400 µl of ice cold isopropanol was added and kept it for incubation at 4°C for 2 hours or kept 20°C for over night.
9. Centrifuged at 14000 rpm for 20 minutes and discarded the supernatant.
10. Then wash the pellet with 70% ethanol (50µl).
11. Centrifuged it for 10 minutes. Air dried the pellet.
12. Added 100 µl of TE buffer and dissolved the pellet.

3.13.3. Quantification of isolated DNA

Quantification of DNA samples isolated from each line was quantified on Nano Drop Spectroscopy (*NANODROP, 2000c)* at 260 nm.

Table 3.3: Composition of CTAB extraction buffer:

S. No.	Components	Quantity
1	DDW	200 ml

2	100mM Tris HCl	2.42g
3	1.4 M NaCl	16.3g
4	20 mM EDTA	1.49g
5	CTAB	6g
6	pH	8.0
7	Autoclave	20 Minutes

3.13.4. Dilution of the DNA samples

For PCR amplification the concentrated DNA was diluted with sigma water such that the final concentration of DNA was maintained 40 ηg / µl for better amplification.

3.13.5 PCR amplification

PCR amplification was performed for 12 ISSR markers in 24 genotype background in a reaction volume of 20 µl given in Table 3.3 for confirmation of diversity analysis. Amplification was carried out in a thermal cycler (Applied Biosystems) as follows cycles given in Table 3.4.

Table 3.4: PCR reaction components for one reaction of ISSR markers

S. No.	Reagent	Stock concentration	Volume (µl)
1.	Nanopure H_2O	-	13.5
2.	PCR buffer with 15 mM $MgCl_2$	10 X	2.0
3.	dNTPs	1mM	1.0
4.	Primer	5pmol	1.0
5.	*Taq* polymerase	1 unit/µl	0.5
6.	DNA template	40ng/µl	2.0

	Total	20

Table 3.5: Thermal profile used for PCR amplification of ISSR markers

Step	Temperature (°C)	Duration	Cycles	Activity
1	95	2 min.	1	Initial denaturation
2	95	30 sec	35	Denaturation
3	48-53	1 min.		Annealing
4	72	90 sec		Extension
5	72	15min.	1	Final Extension
6	4	∞	-	Storage

Table 3.6 Primer sequence of ISSR markers used for diversity analysis in pointed gourd

S. No.	Marker	Primer 5' to 3'	No. of bases	TM (^{0}C)
1	UBC-807	AGAGAGAGAGAGAGAGT	17	42.5
2	UBC-810	GAGAGAGAGAGAGAGAT	17	42.9
3	UBC 812	GAGAGAGAGAGAGAGAA	17	44.3
4	UBC 815	CTCTCTCTCTCTCTCTG	17	44.9

3.13.6 Visualization of amplified products in polyacrylamide gel electrophoresis

Five percent polyacrylamide gels (vertical) were used for better separation and visualization of PCR amplified products, since polyacrylamide gels have better resolution for amplified products. Gels were casted in *CBS-SCIENTIFIC* electrophoresis unit. Glass plates were prepared before making the gel solution.

3.13.7 Assembling and pouring the gel

1. Gasket was fixed to the three sides of the outer plate (without notches). Spacers of 1.5 mm thickness were placed along the sides by just attaching the gasket of outer plate.
2. Later, notch plate was kept on the outer plate so that spacers were between the two plates. Clamps were put on the three sides of plates leaving notch side of unit. It was checked with water to found any leakages.
3. For casting each gel, 65 ml of acrylamide gel (5%) solution was prepared just prior to pouring. For each 65 ml of solution, 70 µl of TEMED (N-NN-N-Tetramethylethylene diamine) and 700 µl of (freshly prepared) ammonium per sulphate (10 %) (APS) were added to initiate the polymerization process.
4. The contents were mixed gently by swirling, but bubbles were avoided. Before pouring, assembly was kept on the bench top so that it made 45 degree angle with bench top.
5. Then gel solution was poured from notch side with maximum care to avoid air bubbles. Comb of 1.5 mm thickness (63 wells) was inserted with tooth side in the gel.
6. Later assembly was kept for polymerization for 20-30 min.

3.13.8 Electrophoresis

1. After polymerization process, gasket was removed and assembly was kept in the electrophoresis unit with electrophoresis unit clamps so that notch side facing inner side of the unit and facing other plate without notch to outer side.
2. TBE (1x) was poured in upper tank in the unit and the rest was poured in bottom chamber.
3. Comb was removed with care so that it does not disturb the wells formed in the gel.
4. At last, 4 µl loading dye (10x) was added to PCR products.
5. Finally, 5 µl of each sample were loaded into the wells for facilitating the sizing of the various alleles. Ladder (50bp) was loaded in the first well.
6. Gel was run at 120 volts till the dye reached bottom of the gel.

7. After electrophoresis, gels were stained with Ethidium bromide (10µl/ 100ml) and visualized in BIORAD Gel Doc XR+.

3.13.9 Scoring of data

Scoring of the bands as separated by gel photograph was done in decreasing order of alleles for each of 10 primers was done in decreasing order of alleles for each of 10 primers of ISSR results were analyzed using NTSYS (Numerical Taxonomy System Biostatistics) PC Ver. 2.02e numerical software package. Only visually scorable and reproducible clear bands were considered for the construction of binary data matrix as one (1) for presence and as zero (0) for absence of band and those not amplified were designated as (NA). The bands which were very faint were not considered for scoring. The scores obtained using all the primers in the ISSR analysis were then pooled to create a binary data matrix and used to construct a dendogram using UPGMA (Unweighted Pair Group Method of Arithmetic Means) algorithm. The pair wise similarity between isolates and polymorphic bands were calculated using the genotypic data thus generated was used for studying molecular diversity analysis Jacquard's coefficient (Jaccard, 1908).

CHAPTER – IV
RESULTS AND DISCUSSION

The present investigation entitled **"Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)"** comprises of two parts of experiments which were conducted at Horticulture Farm, College of Agriculture and Dr. R.H. Richharia Research Laboratory, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Kharif* and *summer* seasons of 2012-13 and 2013-14. The first experiment was aimed to the collection, characterization and evaluation of local genotypes of Pointed Gourd. The second experiment consisted of study of genetic diversity of the pointed gourd genotypes though utilization ISSR molecular markers.

Experiment No. 1: "Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)"

4.1 Characterization of indigenous genotypes of Pointed Gourd
4.2 Analysis of variance and mean performance
4.3 Estimation of genetic variability
4.4 Heritability
4.5 Genetic advance
4.6 Correlation analysis
4.7 Path coefficient analysis
4.8 Genetic divergence (D^2)

Experiment No. II: Study on genetic diversity of the pointed gourd genotypes though utilization ISSR molecular markers

Experiment No. I: "Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)"

The results of characterization and grouping of genotypes for different morphological characters based on characterization data as per IIVR descriptor (unpublished) are presented in Table 4.1 to 4.3

4.1 Characterization of indigenous genotypes of pointed gourd

4.1.1 Stem, leaf and plant characters

4.1.1.1 Stem pubescence

For stem pubescence, 24 genotypes were categorized into two groups that is presence of dense or sparse pubescence on vine stem. Out of 24 genotypes, only five genotypes namely, IPG-1, IPG-3, IPG-4, IPG-6 and Swarna Rekha had dense pubescence and remaining 19 genotypes have sparse pubescence.

4.1.1.2 Stem shape

All the 24 genotypes studied under this investigation had only one shape of the stem that is angular.

4.1.1.3 Leaf colour

All the twenty four genotypes studied were categorized into two groups *viz.*, dark and light for the colour of the leaves. Twelve genotypes namely, IPG-1, IPG-2, IPG-6, IPG-7, IPG-8,IPG-10,IPG-15, IPG-16, IPG-19, IPG-21, IPG-22 and Swarna Alaukik had dark leaves whereas, rest of twelve genotypes had light colour of leaves.

4.1.1.4 Leaf type

All the twenty four genotypes studied were categorized into two groups *viz.*, blunt and pointed for the tip of the leaves. Twelve genotypes namely, IPG-1, IPG-2, IPG-7, IPG-9, IPG-14, IPG-15, IPG-16, IPG-17, IPG-19, IPG-20, IPG-21, and Swarna Alaukik had blunt leaves whereas, rest of twelve genotypes had pointed leaves.

4.1.1.5 Leaf shape

For leaf shape the twenty four genotypes studied were categorized into five groups *viz.*, oblong, cordate, obovate, ovate and orbicular. Three genotypes namely, IPG-1, IPG-2 and IPG-4 had oblong leaves whereas four genotypes, IPG-3,IPG-12,IPG-16 and IPG-21 had oblong leaves. Further, seven genotypes had obovate shape of the leaves which included IPG-5, IPG-7, IPG-8,IPG-9, IPG-10, IPG-14 and IPG-20, IPG-14 and IPG-20.The other two leaf shape *i.e.* ovate and orbicular were recorded for eight genotypes (IPG-6, IPG-11, IPG-13, IPG-15, IPG-

17, IPG-18, IPG-22 and Swarna Rekha) and orbicular for two genotypes (IPG-19 and Swarna Alaukik) respectively.

4.1.1.6 Leaf Pubescence nature

The twenty four genotypes studied were categorized into only one group for leaf pubescence nature. The leaf pubescence nature was recorded to be absent in all the genotypes studied.

4.1.1.7 Leaf margin

According to the nature of the leaf margin the genotypes under investigation were categorized into three groups viz. serrated, entire and undulated. Eleven genotypes namely, IPG-1, IPG-4, IPG-5, IPG-6, IPG-7, IPG-9, IPG-10, IPG-11, IPG-14, IPG-18 and IPG-22 have serrated leaf margins whereas seven genotypes that is IPG-2, IPG-8, IPG-12, IPG-13, IPG-15, IPG-17 and Swarna Rekha had entire leaf margins. Further, six genotypes had undulated margins of the leaves which included IPG-3, IPG-16, IPG-19, IPG-20, IPG-21 and Swarna Alaukik.

4.1.1.8 Number of lobes in leaf blade

For number of lobes in leaf blade genotypes were categorized into two groups *viz.*, with less than five lobes or with five to seven lobes. Expect six genotypes namely, IPG-1, IPG-11, IPG-19, IPG-20, IPG-21 and Swarna Alaukik which had five to seven lobes remaining eighteen genotypes had less than five lobes.

4.1.1.9 Depth of leaf blade lobing

The twenty four genotypes studied were categorized into only one group for depth of leaf blade lobing which was recorded to be shallow in nature in case of all the genotypes.

4.1.1.10 Sex type

The twenty four genotypes studied were categorized into only one group for sex type and all the genotypes were found to be dioecious in nature.

The wide variation in above morphological characters might be due to genetic dissimilarities amongst the genotypes studied. These findings of variability in stem, leaf and plant morphological characteristics are in the conformity of the results as reported by Hazara *et al*. (1998), Dora *et al.* (2002), Srivastava *et al*. (2005), Pariari *et al*. (2005), Bharathi *et al*. (2005), and Dubey *et al*. (2005), Bharathi and Vishalnath (2011).

4.1.2 Fruit characters

4.1.2.1 Fruit shape

The twenty four genotypes studied were categorized into three groups for shape of fruit i.e., oval, spindle or club shape. Thirteen genotypes (IPG-1, IPG-2, IPG-3, IPG-5, IPG-6, IPG-7, IPG-8, IPG-9, IPG-11, IPG-12, IPG-13, IPG-16 and IPG-18) exhibited oval shape and nine genotypes, (IPG-4, IPG-10, IPG-14, IPG-15, IPG-19, IPG-20, IPG-21, Swarna Alaukik and Swarna Rekha) showed spindle shape of the fruits. Only two genotypes namely, IPG-17 and IPG-22 showed club shape of the fruits.

4.1.2.2 Fruit colour (Fruit Skin Primary colour)

The twenty four genotypes studied were categorized into two groups for primary colour of fruit skin which was recorded either green or dark green in colour. Only two genotypes namely, IPG-3 and Swarna Alaukik recorded green and remaining twenty two genotypes had dark green colour.

4.1.2.3 Fruit stripe (Fruit Surface Colour Pattern)

The genotypes studied were categorized into three groups for fruit surface colour pattern i.e., stripped, mottled or uniform in pattern. Only one genotype was noted to be mottled and uniform in pattern namely, IPG-11 and Swarna Alaukik, respectively and rest of twenty two genotypes had stripped fruit surface colour pattern.

4.1.2.4 Fruit glossiness

The twenty four genotypes studied were categorized into only one group for fruit glossiness which was recorded to be glossy in nature in all the genotypes.

Table 4.1: Morphological characterization of genotypes of Pointed Gourd (*Trichosanthes dioca* Roxb) as per descriptor

S. No.	A. Stem, Leaf, and plant characters									
	Genotypes	Stem Pubescence	Stem Shape	Leaf Shape	Leaf Pubescence nature	Leaf Margin	Leaf Blade No. of lobes	Depth of leaf blade lobing	Leaf colour	Leaf Type
1.	IPG-1	Dense	Angular	Oblong	Absent	Serrated	5-7	Shallow	Dark	Blunt
2.	IPG-2	Sparse	Angular	Oblong	Absent	Entire	<5	Shallow	Dark	Blunt
3.	IPG-3	Dense	Angular	Cordate	Absent	Undulated	<5	Shallow	Light	Pointed
4.	IPG-4	Dense	Angular	Oblong	Absent	Serrated	<5	Shallow	Light	Pointed
5.	IPG-5	Sparse	Angular	Obovate	Absent	Serrated	<5	Shallow	Light	Pointed
6.	IPG-6	Dense	Angular	Ovate	Absent	Serrated	<5	Shallow	Dark	Pointed
7.	IPG-7	Sparse	Angular	Obovate	Absent	Serrated	<5	Shallow	Dark	Blunt
8.	IPG-8	Sparse	Angular	Obovate	Absent	Entire	<5	Shallow	Dark	Pointed
9.	IPG-9	Sparse	Angular	Obovate	Absent	Serrated	<5	Shallow	Light	Blunt
10.	IPG-10	Sparse	Angular	Obovate	Absent	Serrated	<5	Shallow	Dark	Pointed
11.	IPG-11	Sparse	Angular	Ovate	Absent	Serrated	5-7	Shallow	Light	Pointed
12.	IPG-12	Sparse	Angular	Cordate	Absent	Entire	<5	Shallow	Light	Pointed
13.	IPG-13	Sparse	Angular	Ovate	Absent	Entire	<5	Shallow	Light	Pointed
14.	IPG-14	Sparse	Angular	Obovate	Absent	Serrated	<5	Shallow	Light	Blunt
15.	IPG-15	Sparse	Angular	Ovate	Absent	Entire	<5	Shallow	Dark	Blunt
16.	IPG-16	Sparse	Angular	Cordate	Absent	Undulated	<5	Shallow	Dark	Blunt
17.	IPG-17	Sparse	Angular	Ovate	Absent	Entire	<5	Shallow	Light	Blunt
18.	IPG-18	Sparse	Angular	Ovate	Absent	Serrated	<5	Shallow	Light	Pointed
19.	IPG-19	Sparse	Angular	Orbicular	Absent	Undulated	5-7	Shallow	Dark	Blunt
20.	IPG-20	Sparse	Angular	Obovate	Absent	Undulated	5-7	Shallow	Light	Blunt
21.	IPG-21	Sparse	Angular	Cordate	Absent	Undulated	5-7	Shallow	Dark	Blunt
22.	IPG-22	Sparse	Angular	Ovate	Absent	Serrated	5-7	Shallow	Dark	Pointed
23.	S. Alaukik	Sparse	Angular	Orbicular	Absent	Undulated	5-7	Shallow	Dark	Blunt
24.	S. Rekha	Dense	Angular	Ovate	Absent	Entire	<5	Shallow	Light	Pointed

Table 4.2: Morphological characterization of genotypes of Pointed Gourd (*Trichosanthes dioca* Roxb) as per descriptor

S. No.	B. Fruit characters											
	Genotypes	Fruit Shape	Fruit Skin primary Colour	Fruit Surface Colour pattern	Fruit Glossiness	Pericarp Hardiness of fruit	Flesh Colour	Blossom End fruit shape	Seedi-ness	Colour of fruit stripe	Fruit Curva-ture	Sex Type
1.	IPG-1	Oval	Dark Green	Stripped	Glossy	Soft	White	Flatten	Present	Light Green	Straight	Dioecious
2.	IPG-2	Oval	Dark Green	Stripped	Glossy	Hard	Creamy	Flatten	Present	Light Green	Straight	Dioecious
3.	IPG-3	Oval	Green	Stripped	Glossy	Soft	White	Flatten	Present	Light Green	Straight	Dioecious
4.	IPG-4	Spindle	Dark Green	Stripped	Glossy	Soft	White	Flatten	Present	Light Green	Straight	Dioecious
5.	IPG-5	Oval	Dark Green	Stripped	Glossy	Soft	Creamy	Flatten	Present	Light Green	Straight	Dioecious
6.	IPG-6	Oval	Dark Green	Stripped	Glossy	Soft	White	Round	Present	Light Green	Straight	Dioecious
7.	IPG-7	Oval	Dark Green	Stripped	Glossy	Hard	White	Round	Present	Light Green	Straight	Dioecious
8.	IPG-8	Oval	Dark Green	Stripped	Glossy	Soft	White	Pointed	Present	Light Green	Straight	Dioecious
9.	IPG-9	Oval	Dark Green	Stripped	Glossy	Soft	White	Flatten	Present	Light Green	Straight	Dioecious
10.	IPG-10	Spindle	Dark Green	Stripped	Glossy	Soft	White	Round	Present	Light Green	Straight	Dioecious
11.	IPG-11	Oval	Dark Green	Mottled	Glossy	Soft	Creamy	Pointed	Present	Light Green	Straight	Dioecious
12.	IPG-12	Oval	Dark Green	Stripped	Glossy	Soft	Creamy	Round	Present	Light Green	Straight	Dioecious
13.	IPG-13	Oval	Dark Green	Stripped	Glossy	Hard	White	Pointed	Present	Light Green	Straight	Dioecious
14.	IPG-14	Spindle	Dark Green	Stripped	Glossy	Soft	White	Pointed	Present	Light Green	Straight	Dioecious
15.	IPG-15	Spindle	Dark Green	Stripped	Glossy	Soft	Creamy	Flatten	Present	Light Green	Straight	Dioecious
16.	IPG-16	Oval	Dark Green	Stripped	Glossy	Soft	White	Round	Present	Light Green	Straight	Dioecious
17.	IPG-17	Club	Dark Green	Stripped	Glossy	Soft	White	Pointed	Present	Light Green	Straight	Dioecious
18.	IPG-18	Oval	Dark Green	Stripped	Glossy	Soft	White	Pointed	Present	Light Green	Straight	Dioecious
19.	IPG-19	Spindle	Dark Green	Stripped	Glossy	Soft	Creamy	Flatten	Present	Light Green	Straight	Dioecious
20.	IPG-20	Spindle	Dark Green	Stripped	Glossy	Soft	White	Round	Present	Light Green	Straight	Dioecious
21.	IPG-21	Spindle	Dark Green	Stripped	Glossy	Soft	White	Pointed	Present	Light Green	Straight	Dioecious
22.	IPG-22	Club	Dark Green	Stripped	Glossy	Soft	Creamy	Flatten	Present	Light Green	Straight	Dioecious
23.	S. Alaukik	Spindle	Green	Uniform	Glossy	Hard	White	Pointed	Present	No Stripe	Straight	Dioecious
24.	S. Rekha	Spindle	Dark Green	Stripped	Glossy	Soft	White	Pointed	Present	Light Green	Straight	Dioecious

4.1.2.5Pericarp hardiness of Fruit

The genotypes studied were categorized into two groups for pericarp hardiness of fruit which was recorded soft or hard in pattern. Four genotypes namely, IPG-2, IPG-7, IPG-13 and Swarna Alaukik noted hard fruit pericarp and all remaining twenty genotypes had soft fruit pericarp.

4.1.2.6 Flesh colour

The genotypes studied were categorized into two groups for flesh colour of fruit which was recorded white or creamy in colour. Seven genotypes namely, IPG-2, IPG-5, IPG-11,IPG-12, IPG-15, IPG-19and IPG-22 noted to be creamy flesh colour of fruit and all remaining seventeen genotypes had white flesh colour of fruit.

4.1.2.7Blossom end fruit shape

The genotypes studied were categorized into three groups for blossom end fruit shape i.e. either flatten, round or pointed in shape. Six genotypes namely,IPG-6, IPG-7, IPG-10, IPG-12, IPG-16 and IPG-20 had round blossom end fruit shape whereas nine genotypes that is IPG-8 ,IPG-11, IPG-13, IPG-14, IPG-17, IPG-18 IPG-21,Swarna Alaukik and Swarna Rekha had pointed blossom end fruit shape. Further, nine genotypes have flatten blossom end fruit shape which included IPG-1, IPG-2, IPG-3, IPG-4, IPG-5, IPG-9, IPG-15, IPG-19, and IPG-22.

4.1.2.8 Seediness

The twenty four genotypes studied were categorized into only one group for fruit seediness i.e. presence of seeds and no genotypes without seeds was noted.

4.1.2.9 Colour of fruit stripe

The twenty four genotypes studied were categorized into two groups for colour of fruit stripe *i.e.* light green or without stripes. Only one genotype namely Swarna Alaukik was noted without stripes and all other genotypes had light green colour of stripes.

4.1.2.10 Fruit curvature

The twenty four genotypes studied were categorized into only one group for fruit curvature *i.e.* straight. All the genotypes showed straight fruit curvature.

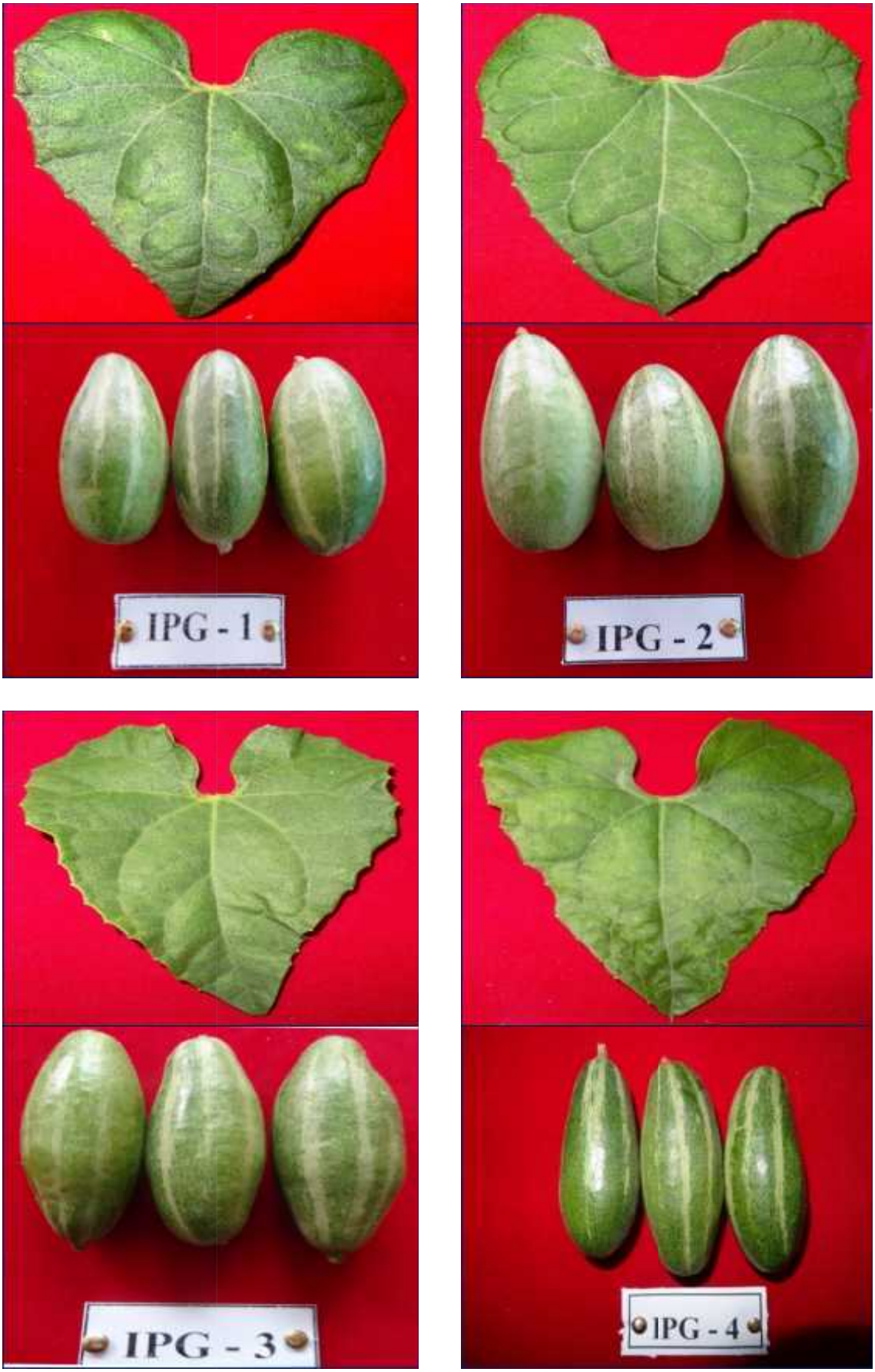


Fig-4.1: Depicting variability for leaf and fruit (IPG-1 to IPG-4)

Fig-4.2 :Depicting variability for leaf and fruit (IPG-5 to IPG-8)

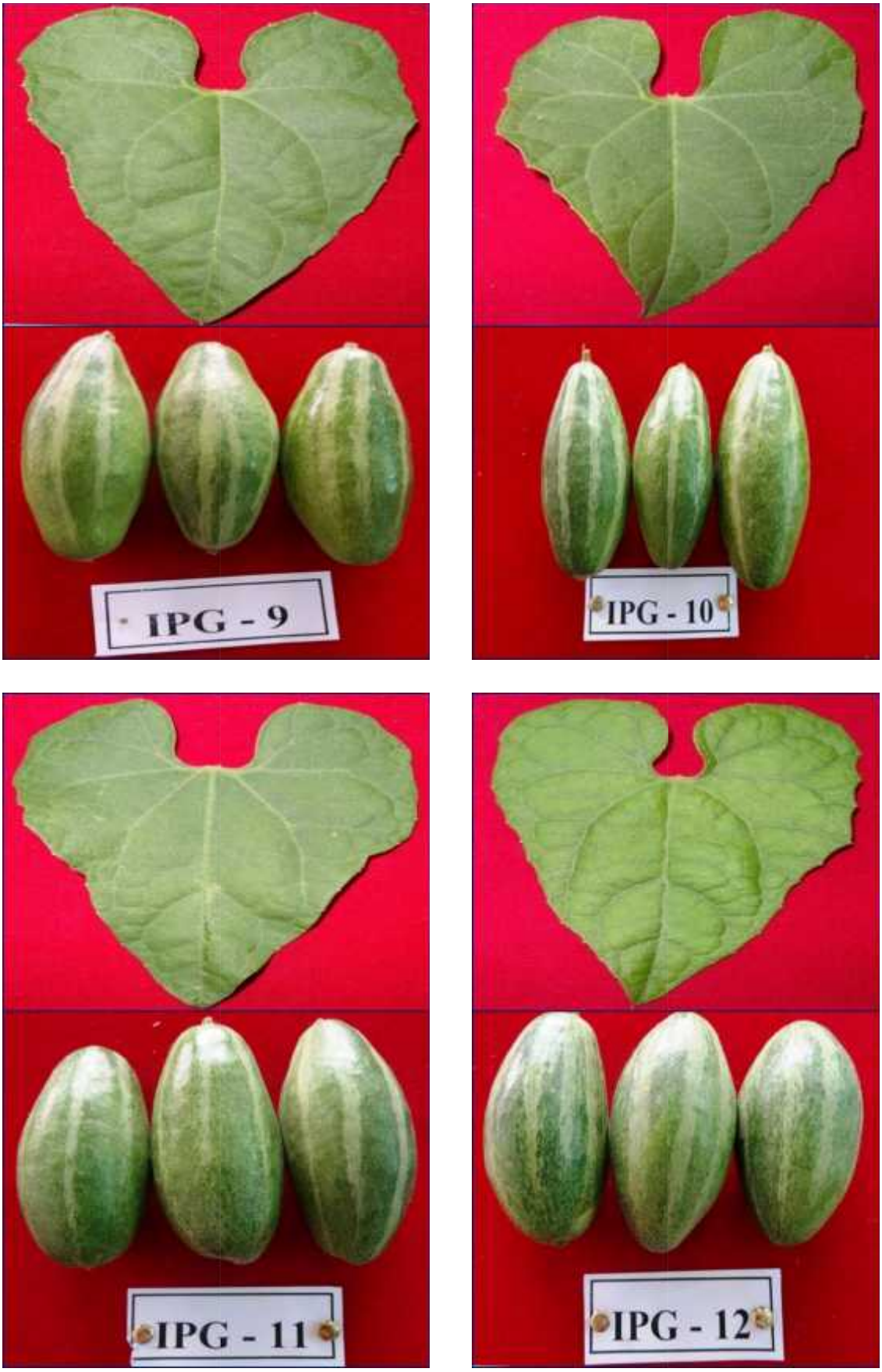


Fig-4.3: Depicting variability for leaf and fruit (IPG-9 to IPG-12)

Fig-4.4: Depicting variability for leaf and fruit (IPG-13 to IPG-16)

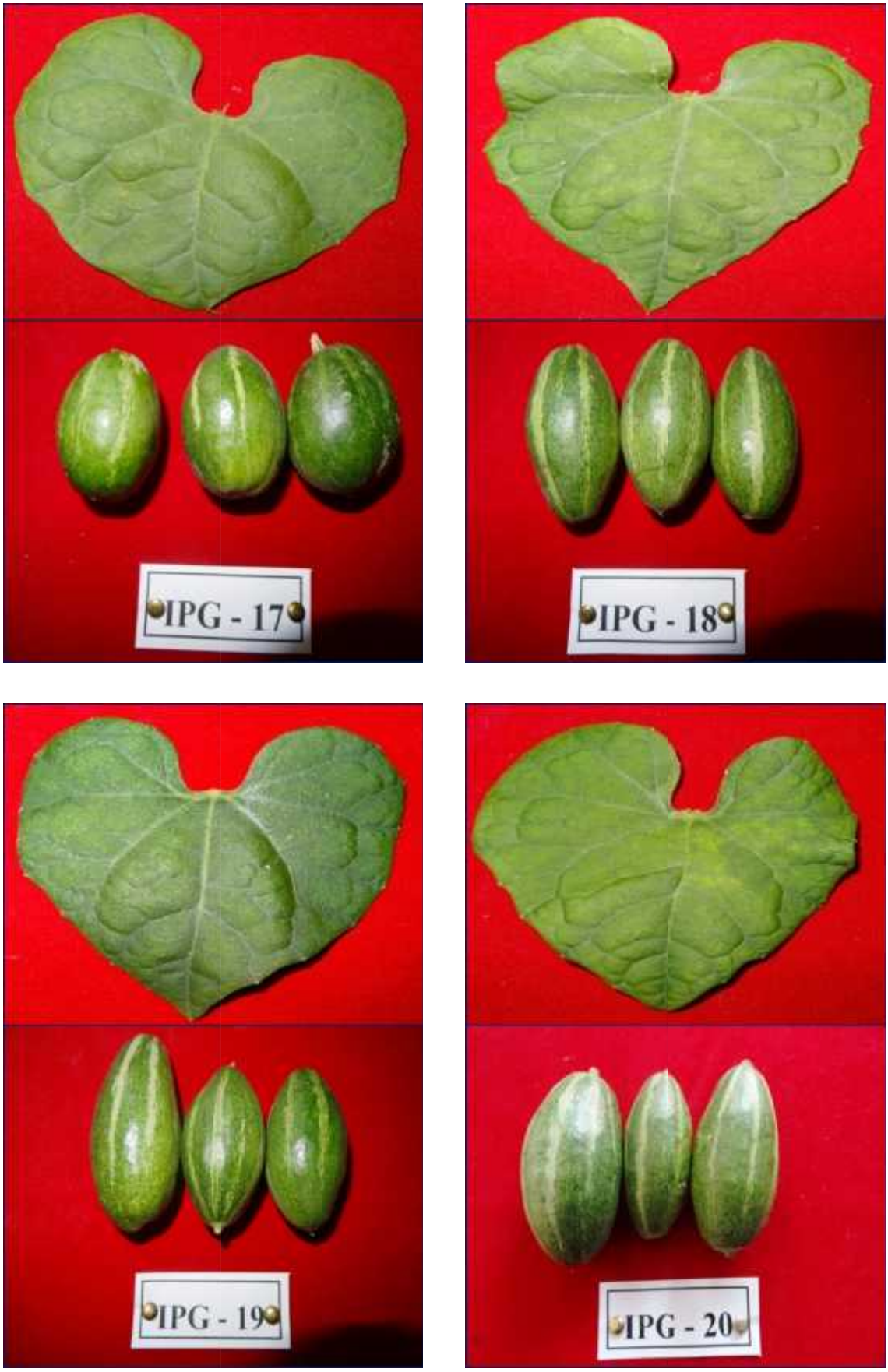


Fig-4.5: Depicting variability for leaf and fruit (IPG-17 to IPG-20)

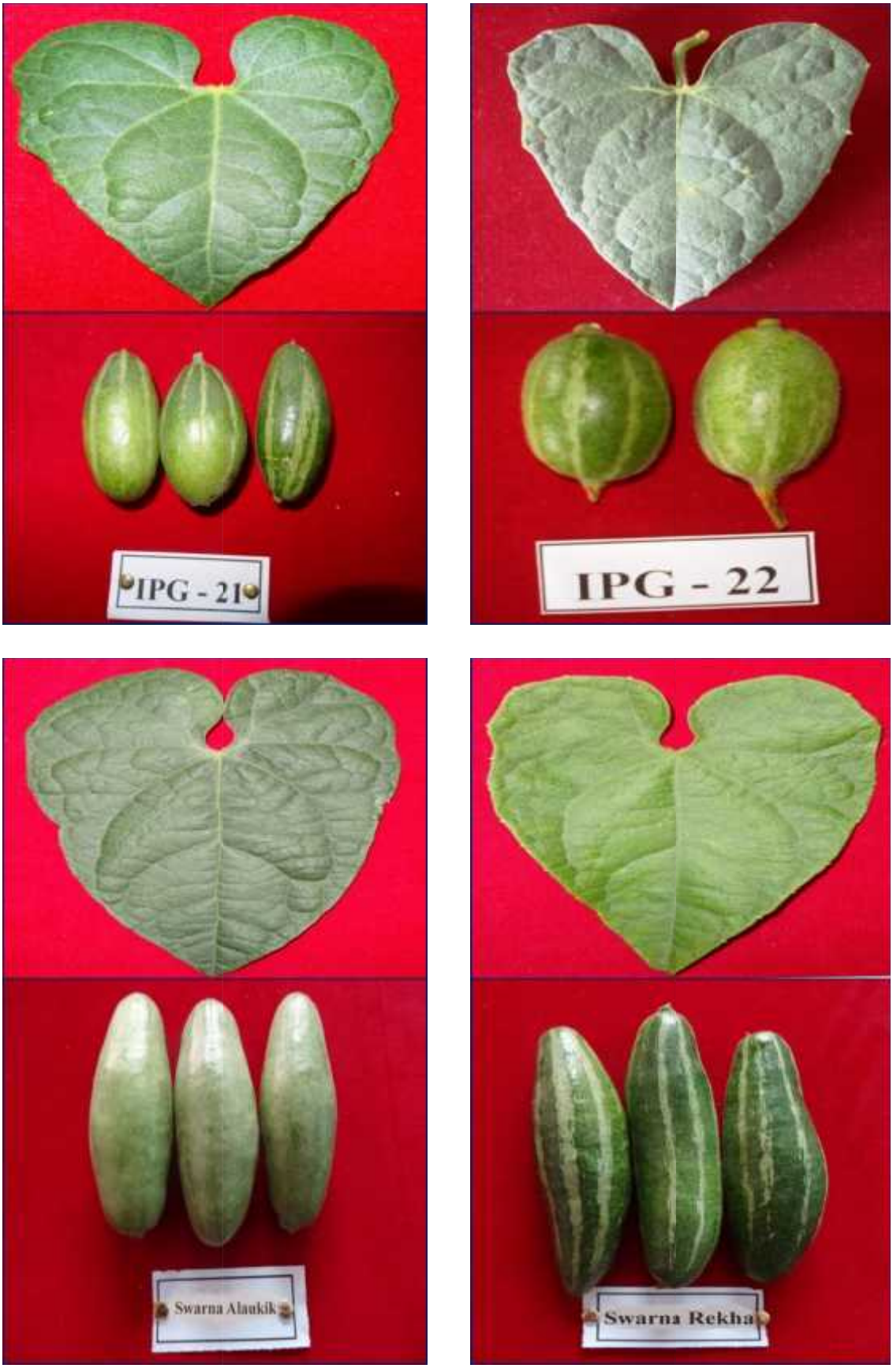


Fig-4.6: Depicting variability for leaf and fruit (IPG-21 to Swarna Rekha)

4.1.3 Quantitative characters

4.1.3.1 Leaf length (cm)

Maximum length of leaves (12.68 cm) was recorded in genotype IPG-14 and minimum was 6.93 cm in genotype IPG-1.

4.1.3.2 Leaf width (cm)

Maximum width of leaves (9.35 cm) was recorded in genotype IPG-14 and minimum was 5.70 cm in genotype IPG-1.

4.1.3.3 Average internodal length (cm)

Maximum average internodal length (10.93 cm) was recorded in genotype IPG-14 and minimum was 5.63 cm in genotype IPG-20.

4.1.3.4 Days taken for appearance of first female flower

Maximum days (58.48) were taken for appearance of first female flower in genotype IPG-12 and minimum 40.95 days was recorded in genotype IPG-8.

4.1.3.5 Petiole length (cm)

Maximum length of petiole for leaves (5.52cm) was recorded in genotype IPG-14 and minimum petiole length of 1.43 cm was noted in genotype IPG-15.

4.1.3.6 Node of the first female flower

Maximum number of node for the appearance first female flower (15.27) was recorded in genotype IPG-10. However, minimum number of nodes (8.47) for the appearance first female flower was noted in Swarna Rekha.

4.1.3.7 Fruit length (cm)

Maximum length of fruits (9.82cm) was recorded in genotype Swarna Rekha and minimum fruit length of 5.41 cm was noted in genotype IPG-17.

4.1.3.8 Fruit diameter (cm)

Maximum diameter of Fruit (3.55cm) was recorded in genotype IPG-7 whereas minimum value of diameter of fruit (2.73cm) was noted in genotype Swarna Alaukik.

Table 4.3: Characterization of pointed gourd genotypes on pooled data basis

Genotypes	Characters													
	Leaf length (cm)	Leaf width (cm)	Average Internodal length (cm)	Days taken for appearance of first female flower	Petiole Length (cm)	Node of the first female flower	Fruit Length (cm)	Fruit diameter (cm)	No. of fruits/Plant	No. of seeds/Fruit	Average fruit weight (g)	Days taken from fruit set to Harvest maturity	Yield per plant(Kg)	Yield ha^{-1} (t)
IPG-1	6.93	5.70	5.73	47.47	2.07	10.17	5.64	3.43	158.58	10.33	27.33	6.63	4.33	19.24
IPG-2	8.03	5.90	7.72	53.35	3.23	15.20	6.73	3.48	153.47	11.80	28.39	7.88	4.27	18.97
IPG-3	10.05	7.82	7.95	51.23	4.08	11.07	6.24	3.40	99.22	16.38	30.88	7.48	2.93	13.02
IPG-4	10.40	8.20	9.23	53.85	4.70	9.28	7.25	3.35	141.04	13.57	35.35	8.81	4.97	22.08
IPG-5	9.97	7.62	8.15	57.87	3.62	14.58	6.23	3.43	125.18	15.85	37.32	8.68	4.62	20.53
IPG-6	9.47	7.98	9.87	48.88	4.40	11.20	7.41	3.15	137.10	12.95	30.95	6.05	3.49	15.51
IPG-7	9.87	7.33	7.95	45.77	3.38	9.03	6.06	3.55	207.70	12.80	32.27	6.72	6.59	29.28
IPG-8	10.68	6.97	7.42	40.95	3.05	8.50	7.56	3.42	200.78	14.90	35.83	5.80	7.61	33.82
IPG-9	11.22	7.83	6.95	51.18	3.65	11.23	7.03	3.30	161.49	15.32	32.48	6.98	5.18	23.08
IPG-10	9.75	7.20	6.15	52.58	2.77	15.27	6.68	3.38	134.09	16.77	35.80	7.37	4.88	21.68
IPG-11	10.68	7.98	7.22	54.47	2.90	13.42	5.70	3.25	119.43	15.33	34.63	7.05	3.92	17.42
IPG-12	9.95	7.53	7.10	58.48	3.43	14.28	6.59	3.35	163.34	12.17	25.91	8.27	3.18	14.13
IPG-13	10.28	6.22	8.58	46.17	2.70	10.32	6.06	2.73	242.79	14.15	47.12	5.95	6.00	26.66
IPG-14	12.68	9.35	10.93	57.47	5.52	11.12	7.33	3.22	267.19	14.23	35.19	7.17	4.91	21.82
IPG-15	7.27	5.73	8.17	48.12	1.43	14.40	6.60	3.28	219.25	11.43	22.01	6.83	5.54	24.62
IPG-16	10.23	8.25	10.03	57.43	3.42	10.85	5.59	3.33	230.12	13.32	19.54	7.07	4.55	20.22
IPG-17	8.55	7.75	8.48	48.58	3.63	8.55	5.41	3.50	179.83	11.10	25.32	5.50	3.96	17.60
IPG-18	9.83	8.12	7.10	56.72	3.12	10.15	6.01	3.13	217.08	13.70	19.53	7.07	5.45	24.22
IPG-19	7.78	7.05	7.38	53.53	2.67	12.47	5.56	3.07	185.67	12.45	24.80	5.77	3.88	17.24
IPG-20	7.45	7.07	5.63	47.53	2.08	11.75	6.10	3.03	221.83	10.75	21.78	7.58	5.05	22.44
IPG-21	7.54	7.22	10.45	57.90	3.52	10.53	5.74	2.93	181.77	11.15	24.51	8.10	4.86	21.60
IPG-22	8.85	6.65	9.75	51.37	3.42	12.78	5.39	3.20	117.12	12.67	24.59	7.85	4.12	18.31
Swarna Alaukik	8.63	6.82	6.58	52.62	1.88	10.27	8.76	3.27	135.22	12.07	29.82	7.08	6.58	29.24
Swarna Rekha	8.08	7.38	7.70	58.32	2.15	8.47	9.82	3.17	149.25	13.78	37.32	7.95	5.73	25.46
General Mean	9.34	7.32	8.01	52.16	3.20	11.45	6.58	3.27	172.85	13.29	29.94	7.13	4.86	21.60

4.1.3.9 Number of fruits per plant

Maximum number of fruits per plant (267.19) was recorded in genotype IPG-14 whereas minimum number of fruits per plant (134.09) was noted in genotype IPG-10.

4.1.3.10 Number of seeds per fruit

Maximum number of seeds per fruit (16.77) was recorded in genotype IPG-10 whereas minimum number of seeds per fruit (10.33) was noted in genotype IPG-1.

4.1.3.11 Average Fruit Weight (grams)

Maximum average weight of individual fruit that is 47.12 grams was recorded in genotype IPG-13 whereas minimum weight of fruits (19.53 grams) was noted in genotype IPG-18.

4.1.3.12 Days taken from fruit set to harvest maturity

Maximum days (8.81) were taken from fruit set to harvest maturity in genotype IPG-4. However, minimum 5.50 days was recorded in genotype IPG-17.

4.1.3.13 Yield per plant (kg)

Maximum yield of fruits per plant (7.61kg) was recorded in genotype IPG-8 whereas minimum yield of the fruits per plant (2.93 kg) was noted in genotype IPG-3.

The variation in genetic constitution of genotypes studied is clearly indicated in the results. Similar variation in the genotypes studied for different perennial cucurbits were also reported by many workers such as by Hazara *et al.*(1998) , Singh *et al.*(2001), Srivastava *et al.* (2005), Pariari *et al.* (2005), in pointed gourd and Sarnaik *et al.* (2002), Nag *et al.* (2012) in ivy gourd and Bharathi *et al.*(2005) in spine gourd.

4.2 Analysis of variance and mean performance

The analysis of variance for each of the 13 characters for 24 genotypes was carried out on pooled basis and separately for the year 2012-13 and 2013-14.

The mean performance of genotypes for yield attributes and its component characters for the year 2012-13, 2013-14 and pooled analysis of both the years (Table 4.7, 4.8 & 4.9) are described below:

Table 4.4: Analysis of variance for growth parameters and yield in pointed gourd (*Trichosanthes dioica* Roxb.) year 2012-13

Observations	df	Mean Sum of Squares		
		Replication	Genotype	Error
		2	23	46
1. Leaf Length (cm)		0.122	12.90**	0.86
2. Leaf width (cm)		0.20	2.87**	0.17
3. Average Internodal length (cm)		0.24	5.77	3.41
4. Days taken for appearance of first female flower		1.19	63.57**	2.63
5. Petiole length (cm)		0.48	2.40**	0.19
6. Node of the first female flower		1.42	10.80	2.29
7. Fruit length (cm)		0.55	2.16**	0.24
8. Fruit Diameter(cm)		0.03	0.27	0.08
9. No. of fruits/ plant		1788.54	8382.09*	2363.89
10. No. of seeds/fruit		0.39	5.55**	0.13
11. Average Fruit Weight		34.10	211.09**	14.87
12. Days taken from fruit set to harvest maturity		0.35	2.10**	0.18
13. Yield per plant(kg)		0.11*	4.57**	0.24

*Significant at 5 % and **Significant at 1% levels.

Table 4.5: Analysis of variance for growth parameters and yield in pointed gourd (*Trichosanthes dioica* Roxb.) year 2013-14

Observations	df	Mean Sum of Squares		
		Replication	Genotype	Error
		2	23	46
1. Leaf Length (cm)		0.23	5.24**	0.67
2. Leaf width (cm)		67.88	65.67	62.90
3. Average Internodal length (cm)		9.74	10.81	3.79
4. Days taken for appearance of first female flower		2.80	74.22**	1.06
5. Petiole length (cm)		0.24	4.06**	0.33

6. Node of the first female flower	0.32	19.73**	0.60
7. Fruit length (cm)	0.14	3.69**	0.31
8. Fruit Diameter(cm)	0.01	0.16	0.06
9. No. of fruits/ plant	241.11	6126.61**	1295.48
10. No. of seeds/fruit	0.84	28.61**	2.94
11. Average Fruit Weight	3.13	109.03*	15.50
12. Days taken from fruit set to harvest maturity	0.11	2.51**	0.09
13. Yield per plant(kg)	0.46*	3.29**	0.11

*Significant at 5 % and **Significant at 1% levels.

Table 4.6: Analysis of variance for growth parameters and yield in pointed gourd (*Trichosanthes dioica* Roxb.)Pooled

Observations	Mean Sum of Squares		
	Replication	Genotype	Error
df	2	23	46
1. Leaf Length (cm)	0.06	6.14**	0.42
2. Leaf width (cm)	18.70	17.38	15.66
3. Average Internodal length (cm)	2.28	6.24*	1.77
4. Days taken for appearance of first female flower	1.88	67.85**	1.00
5. Petiole length (cm)	0.23	2.61**	0.14
6. Node of the first female flower	0.61	13.84**	0.64
7. Fruit length (cm)	0.09	2.18**	0.09
A8. Fruit Diameter(cm)	0.01	0.11	0.03
9. No. of fruits/ plant	746.90	6011.43**	1046.58
10. No. of seeds/fruit	0.59	9.87**	0.79
11. Average Fruit Weight	4.44	136.04**	5.18
12. Days taken from fruit set to harvest maturity	0.02	2.25**	0.05
13. Yield per plant(kg)	0.24**	3.78**	0.04

*Significant at 5 % and **Significant at 1% levels.

4.2.1 Leaf length (cm)

Leaf length ranged from 6.97 cm (IPG-15) to 12.73 cm (IPG-12) in the year 2012-13. During the year 2013-14, it ranged from 5.07 cm (IPG-1) to 10.63 cm (IPG-14). The mean performance for both the years was 9.34 cm.

4.2.2 Leaf width (cm)

Leaf breadth ranged from 5.63 cm (IPG-15) to 10.37 cm (IPG-14) in the year 2012-13 and 4.27 (IPG-1) to 8.43 (IPG-16) in the year 2013-14. The genotype IPG-14 recorded significantly superior leaf width to other genotypes on pooled data basis. The mean performance for both the years was 7.32 cm.

4.2.3 Average internodal length (cm)

Average internodal length ranged from 6.07 cm (IPG-15) to 11.80 cm (IPG-14) in the year 2012-13 and 4.97 (IPG-20) to 11.37 (IPG-21) in the year 2013-14. The genotype IPG-14 recorded significantly superior average internodal length in comparison other genotypes on pooled data basis. The mean performance for both the years was 8.01 cm.

4.2.4 Days taken for appearance of first female flower

Flowering of female flowers in terms of days taken for appearance of first female flower was recorded to be earliest in the genotype IPG-8 (41.23days) whereas, genotype IPG-22 produced first female flower in maximum 58.90 days during the year 2012-13.During the year 2013-14, genotype IPG-8 took minimum (40.67) days for appearance of first female flower, however, maximum days (59.37) taken by Swarna Rekha for this trait. The genotype IPG-8 also recorded significantly earlier appearance of first female flower as compared to other genotypes on pooled data basis. The mean performance for both the years was 52.16 days.

4.2.5 Petiole length (cm)

Petiole length ranged from 1.30cm (IPG-15) to 5.37 cm (IPG-14) in the year 2012-13. During the year 2013-14, it ranged from 1.57 cm (IPG-15) to 5.67 cm (IPG-14). On pooled data basis, similar to the results of both years, genotypes

Table 4.7: Mean Performance of pointed gourd genotypes: Year- 2012-13

Genotypes	Characters													
	Leaf length (cm)	Leaf width (cm)	Average Internodal length (cm)	Days taken for appearance of first female flower	Petiole Length (cm)	Node of the first female flower	Fruit Length (cm)	Fruit diameter (cm)	No. of fruits/Plant	No. of seeds/Fruit	Average fruit weight (g)	Days taken from fruit set to Harvest maturity	Yield per plant(Kg)	Yield ha^{-1} (t)
IPG-1	8.80	7.13	6.30	47.63	2.27	10.40	5.85	3.40	145.61	5.90	28.43	6.63	4.14	18.40
IPG-2	9.53	7.07	9.20	53.33	3.50	14.97	6.78	3.50	169.64	6.67	25.57	7.90	4.25	18.89
IPG-3	10.87	7.90	7.33	51.57	3.17	11.03	6.28	3.30	85.20	8.03	33.83	7.47	2.80	12.44
IPG-4	12.43	8.77	9.07	53.47	4.10	8.93	6.92	3.17	127.37	7.60	36.10	8.17	4.58	20.35
IPG-5	9.67	7.80	8.87	58.30	3.97	13.70	6.13	3.37	88.66	7.50	43.27	8.57	4.30	19.11
IPG-6	10.27	8.63	9.40	49.33	3.83	11.10	7.62	2.80	122.50	6.83	36.90	6.30	3.10	13.77
IPG-7	11.77	8.67	8.73	45.97	2.33	9.00	6.15	3.57	200.90	5.87	33.77	6.53	6.63	29.46
IPG-8	11.80	7.47	8.40	41.23	2.87	8.43	7.33	3.30	185.74	6.50	37.30	5.90	7.83	34.80
IPG-9	12.53	8.77	7.63	50.80	4.67	10.77	6.98	3.27	130.83	7.40	35.27	6.93	4.78	21.24
IPG-10	9.57	7.47	6.57	52.57	3.00	15.30	6.58	3.30	107.09	7.80	37.73	7.40	4.38	19.46
IPG-11	12.23	8.93	7.57	53.63	3.47	13.93	5.63	3.03	114.72	7.60	34.10	7.03	3.48	15.46
IPG-12	12.73	8.33	8.07	58.30	2.97	12.80	6.72	3.27	198.22	6.13	24.93	8.20	2.92	12.97
IPG-13	11.73	7.00	8.87	46.70	3.13	11.40	6.15	2.50	248.25	11.53	49.93	5.77	5.93	26.35
IPG-14	14.73	10.37	11.80	56.33	5.37	10.77	7.29	3.23	249.11	8.73	37.30	7.17	4.84	21.51
IPG-15	6.97	5.63	6.07	47.63	1.30	13.30	6.43	3.07	224.17	6.20	18.92	7.17	5.42	24.08
IPG-16	10.13	8.07	9.07	57.70	3.40	11.63	5.58	3.43	233.28	5.47	20.77	7.07	4.56	20.26
IPG-17	8.70	7.77	8.30	48.33	3.53	9.00	5.49	3.70	194.70	5.67	24.13	5.57	3.84	17.06
IPG-18	9.70	7.87	6.73	55.37	3.13	9.70	6.12	3.17	230.97	6.30	19.78	6.97	5.52	24.53
IPG-19	7.77	7.07	7.47	52.70	2.77	11.57	6.69	3.50	227.83	7.13	24.87	5.73	4.05	18.00
IPG-20	7.10	6.73	6.30	47.53	2.10	12.13	6.17	2.90	210.23	5.77	20.83	7.63	4.71	20.93
IPG-21	7.60	7.27	9.53	58.90	3.47	10.60	5.65	2.60	215.69	6.13	21.30	8.07	5.15	22.80
IPG-22	8.50	6.80	10.30	50.80	3.37	12.13	5.48	3.37	123.46	5.50	21.63	7.53	4.10	18.22
Swarna Alaukik	8.60	7.07	7.33	52.70	2.03	11.57	8.59	3.53	134.10	5.20	24.00	7.03	6.76	30.07
Swarna Rekha	7.70	8.47	8.97	57.27	2.10	9.30	9.88	3.00	136.65	6.67	35.97	7.90	5.78	25.68
General Mean	10.06	7.79	8.24	52.00	3.16	11.39	6.60	3.22	171.04	6.84	30.28	7.11	4.74	21.06
SE m	0.54	0.24	1.07	0.94	0.25	0.87	0.29	0.17	2.80	0.21	2.23	0.25	0.09	0.32
SE d	0.76	0.34	1.51	1.32	0.35	1.24	0.41	0.24	3.97	0.29	3.15	0.35	0.13	0.46
CV (%)	9.23	5.28	22.40	3.12	13.72	13.29	15.82	8.7	2.84	5.27	12.73	5.99	3.25	3.27
CD at 5%	1.53	0.68	3.04	2.66	0.71	2.49	0.82	0.47	7.99	0.59	6.34	0.67	0.25	4.25

Table 4.8: Mean Performance of pointed gourd genotypes: Year- 2013-14

Genotypes	Characters													
	Leaf length (cm)	Leaf width (cm)	Average Internodal length (cm)	Days taken for appearance of first female flower	Petiole Length	Node of the first female flower	Fruit Length (cm)	Fruit diameter (cm)	No. of fruits/Plant	No. of seeds/Fruit	Average fruit weight (g)	Days taken from fruit set to Harvest maturity	Yield per plant(Kg)	Yield ha^{-1} (t)
IPG-1	5.07	4.27	5.17	47.30	1.87	9.93	5.43	3.47	171.54	14.77	26.23	6.63	4.51	20.04
IPG-2	6.53	4.73	6.23	53.37	2.27	15.43	6.67	3.47	137.30	16.93	31.20	7.87	4.28	19.02
IPG-3	9.23	7.73	8.57	50.90	5.00	11.10	6.20	3.50	113.23	24.73	27.93	7.50	3.06	13.60
IPG-4	8.37	7.63	9.40	54.23	5.30	9.63	7.57	3.53	154.70	19.53	34.60	8.20	5.35	23.77
IPG-5	10.27	7.43	7.43	57.43	3.27	15.47	6.30	3.50	161.70	24.20	31.37	8.80	4.93	21.91
IPG-6	8.67	7.33	10.33	48.43	4.97	11.30	7.20	3.50	151.70	19.07	25.00	5.80	3.86	17.15
IPG-7	7.97	6.00	7.17	45.57	4.43	9.07	5.97	3.53	214.49	19.73	30.77	6.90	6.54	29.06
IPG-8	9.57	6.47	6.43	40.67	3.23	8.57	7.80	3.53	215.83	23.30	34.37	5.70	7.39	32.84
IPG-9	9.90	6.90	6.27	51.57	2.63	11.70	7.07	3.33	192.14	23.23	29.70	7.03	5.56	24.71
IPG-10	9.93	6.93	5.73	52.60	2.53	15.23	6.77	3.47	161.07	25.73	33.87	7.33	5.38	23.91
IPG-11	9.13	7.03	6.87	55.30	2.33	12.90	5.78	3.47	124.14	23.07	35.17	7.07	4.35	19.33
IPG-12	7.17	6.73	6.13	58.67	3.90	15.77	6.47	3.43	128.46	18.20	26.88	8.33	3.44	15.28
IPG-13	8.83	5.43	8.30	45.63	2.27	9.23	5.97	2.97	237.33	16.77	44.30	6.13	6.06	26.93
IPG-14	10.63	8.33	10.07	58.60	5.67	11.47	7.37	3.20	258.28	19.73	33.07	7.17	4.98	22.13
IPG-15	7.57	5.83	10.27	48.60	1.57	15.50	6.77	3.50	214.34	16.67	25.10	6.50	5.66	25.15
IPG-16	10.33	8.43	11.00	57.17	3.43	10.07	5.60	3.23	226.94	21.17	18.32	7.07	4.54	20.17
IPG-17	8.40	7.73	8.67	48.83	3.73	8.10	5.33	3.30	164.96	16.53	26.50	5.43	4.07	18.08
IPG-18	9.97	8.37	7.47	58.07	3.10	10.60	5.90	3.10	203.18	21.10	19.27	7.17	5.38	23.91
IPG-19	7.80	7.03	7.30	54.37	2.57	13.37	6.43	2.63	143.51	17.77	24.73	5.80	3.17	14.08
IPG-20	7.80	7.40	4.97	47.53	2.07	11.37	6.03	3.17	233.43	15.73	22.73	7.53	5.38	23.91
IPG-21	7.48	7.17	11.37	56.90	3.57	10.47	5.83	3.27	147.84	16.17	27.72	8.13	4.57	20.31
IPG-22	9.20	6.50	9.20	51.93	3.47	13.43	5.30	3.03	110.77	19.83	27.54	8.17	4.14	18.40
Swarna Alaukik	8.67	6.57	5.83	52.53	1.73	8.97	8.76	3.00	136.32	18.93	35.63	7.13	6.39	28.40
Swarna Rekha	8.47	6.30	6.43	59.37	2.20	7.63	9.75	3.33	161.84	20.90	38.67	8.00	5.68	25.24
General Mean	8.62	6.85	7.78	52.32	3.63	11.51	6.59	3.31	174.67	19.74	29.6	7.14	4.97	22.08
SE m	0.47	4.58	1.12	0.60	0.33	0.45	0.32	0.14	2.07	0.99	2.27	0.17	0.19	0.48
SE d	0.66	6.48	1.59	0.84	0.47	0.63	0.46	0.20	2.93	1.40	3.21	0.24	0.27	0.67
CV (%)	9.44	10.20	25.05	1.97	17.88	6.73	8.23	7.57	2.06	8.69	13.29	4.19	6.63	6.65
CD at 5%	1.34	13.03	3.20	1.70	0.95	1.27	0.92	0.41	5.91	2.82	6.47	0.49	0.54	4.23

Table 4.9: Mean Performance of pointed gourd genotypes on Pooled data basis

Genotypes	Characters													
	Leaf length (cm)	Leaf width (cm)	Average Internodal length (cm)	Days taken for appearance of first female flower	Petiole Length (cm)	Node of the first female flower	Fruit Length (cm)	Fruit diameter (cm)	No. of fruits/Plant	No. of seeds/Fruit	Average fruit weight (g)	Days taken from fruit set to Harvest maturity	Yield per plant(Kg)	Yield ha^{-1} (t)
IPG-1	6.93	5.70	5.73	47.47	2.07	10.17	5.64	3.43	158.58	10.33	27.33	6.63	4.33	19.22
IPG-2	8.03	5.90	7.72	53.35	3.23	15.20	6.73	3.48	153.47	11.80	28.39	7.88	4.27	18.95
IPG-3	10.05	7.82	7.95	51.23	4.08	11.07	6.24	3.40	99.22	16.38	30.88	7.48	2.93	13.02
IPG-4	10.40	8.20	9.23	53.85	4.70	9.28	7.25	3.35	141.04	13.57	35.35	8.81	4.97	22.06
IPG-5	9.97	7.62	8.15	57.87	3.62	14.58	6.23	3.43	125.18	15.85	37.32	8.68	4.62	20.51
IPG-6	9.47	7.98	9.87	48.88	4.40	11.20	7.41	3.15	137.10	12.95	30.95	6.05	3.49	15.46
IPG-7	9.87	7.33	7.95	45.77	3.38	9.03	6.06	3.55	207.70	12.80	32.27	6.72	6.59	29.26
IPG-8	10.68	6.97	7.42	40.95	3.05	8.50	7.56	3.42	200.78	14.90	35.83	5.80	7.61	33.82
IPG-9	11.22	7.83	6.95	51.18	3.65	11.23	7.03	3.30	161.49	15.32	32.48	6.98	5.18	22.97
IPG-10	9.75	7.20	6.15	52.58	2.77	15.27	6.68	3.38	134.09	16.77	35.80	7.37	4.88	21.68
IPG-11	10.68	7.98	7.22	54.47	2.90	13.42	5.70	3.25	119.43	15.33	34.63	7.05	3.92	17.39
IPG-12	9.95	7.53	7.10	58.48	3.43	14.28	6.59	3.35	163.34	12.17	25.91	8.27	3.18	14.12
IPG-13	10.28	6.22	8.58	46.17	2.70	10.32	6.06	2.73	242.79	14.15	47.12	5.95	6.00	26.64
IPG-14	12.68	9.35	10.93	57.47	5.52	11.12	7.33	3.22	267.19	14.23	35.19	7.17	4.91	21.82
IPG-15	7.27	5.73	8.17	48.12	1.43	14.40	6.60	3.28	219.25	11.43	22.01	6.83	5.54	24.61
IPG-16	10.23	8.25	10.03	57.43	3.42	10.85	5.59	3.33	230.12	13.32	19.54	7.07	4.55	20.21
IPG-17	8.55	7.75	8.48	48.58	3.63	8.55	5.41	3.50	179.83	11.10	25.32	5.50	3.96	17.57
IPG-18	9.83	8.12	7.10	56.72	3.12	10.15	6.01	3.13	217.08	13.70	19.53	7.07	5.45	24.22
IPG-19	7.78	7.05	7.38	53.53	2.67	12.47	5.56	3.07	185.67	12.45	24.80	5.77	3.88	16.04
IPG-20	7.45	7.07	5.63	47.53	2.08	11.75	6.10	3.03	221.83	10.75	21.78	7.58	5.05	22.42
IPG-21	7.54	7.22	10.45	57.90	3.52	10.53	5.74	2.93	181.77	11.15	24.51	8.10	4.86	21.55
IPG-22	8.85	6.65	9.75	51.37	3.42	12.78	5.39	3.20	117.12	12.67	24.59	7.85	4.12	18.31
Swarna Alaukik	8.63	6.82	6.58	52.62	1.88	10.27	8.76	3.27	135.22	12.07	29.82	7.08	6.58	29.35
Swarna Rekha	8.08	7.38	7.70	58.32	2.15	8.47	9.82	3.17	149.25	13.78	37.32	7.95	5.73	25.46
General Mean	9.34	7.32	8.01	52.16	3.20	11.45	6.58	3.27	172.85	13.29	29.94	7.13	4.86	23.57
SE m	0.37	2.29	0.77	0.58	0.21	0.46	0.16	0.10	1.86	0.51	1.31	0.14	0.11	0.44
SE d	0.53	3.23	1.09	0.82	0.30	0.65	0.25	0.15	2.64	0.73	1.86	0.19	0.16	0.52
CV (%)	6.92	5.09	16.61	1.92	11.48	6.96	6.14	5.52	1.87	6.69	7.60	3.31	4.01	4.66
CD at 5%	1.06	6.50	2.19	1.65	0.60	1.31	0.50	0.30	5.31	1.46	3.74	0.39	0.31	4.51

IPG-15 and IPG- 14 were noted with minimum (1.43cm) and maximum (5.52cm) length of petioles. The mean performance for both the years was 3.20 cm.

4.2.6 Node of the first female flower

The number of node for the appearance of first female flower ranged from 8.43 (IPG-8) to 15.30 cm (IPG-10) in the year 2012-13. During the year 2013-14, it ranged from 7.63 (Swarna Rekha) to 15.77 (IPG-12). On pooled data basis, genotypes Swarna Rekha and IPG-10 recorded minimum (8.47) and maximum (15.27) number of node for the appearance of first female flower respectively. The mean performance for both the years was 11.45 in respect of number of nodes for this character.

4.2.7 Fruit length (cm)

Fruit length ranged from 5.48 cm (IPG-22) to 9.88 cm (Swarna Rekha) in the year 2012-13. During the year 2013-14, it ranged from 5.30 cm (IPG-22) to 9.75 cm (Swarna Rekha). On pooled data basis, similar to the results of both years, genotypes IPG-22 and Swarna Rekha recorded minimum (5.39 cm) and maximum (9.82 cm) average length of fruits. The mean performance for both the years was 4.95 cm.

4.2.8 Fruit Diameter (cm)

Fruit diameter ranged from 2.50 cm (IPG-13) to 3.70 cm (IPG-17) in the year 2012-13. During the year 2013-14, it ranged from 2.63 cm (IPG-19) to 3.53 cm (IPG-8). The mean performance for both the years was 3.27 cm.

4.2.9 Number of fruits per plant

The number of fruits per plant ranged from 85.2 (IPG-3) to 249.11 (IPG-14) in the year 2012-13. During the year 2013-14, it ranged from 110.77 (IPG-22) to 258.28 (IPG-14). On pooled data basis, genotypes IPG-3 and IPG-14 recorded minimum (99.22) and maximum (267.19) number of fruits per plant, respectively. The mean performance for both the years was 172.85 fruits per plant.

4.2.10 Number of seeds per fruit

Minimum number seeds **(**5.20) were recorded in Swarna Alaukik and it ranged from 11.53 in IPG-12 in the year 2012-13. During the year 2013-14, it ranged from 14.77 in IPG-1 to 25.73 in IPG-10. The mean performance for both the years was 13.29 seeds per fruit.

4.2.11 Average fruit weight

The average weight of individual fruit ranged from 18.92 gram (IPG-15) to 49.93gram (IPG-13) in the year 2012-13. During the year 2013-14, it ranged from 18.32 gram (IPG-16) to 44.30 gram (IPG-13). On pooled data basis, genotypes IPG-18 and IPG-13 recorded minimum (19.53 gram) and maximum (47.12 gram) average weight of individual fruit, respectively. The mean performance for both the years was 29.94 gram average fruit weight.

4.2.12 Days taken from fruit set to harvest maturity

Harvest maturity in terms of days taken from fruit set was recorded to be earliest in the genotype IPG-17 (5.57 days) whereas, genotype IPG-5 took maximum days (8.57) for harvest maturity during the year 2012-13. During the year 2013-14, genotype IPG-17 took minimum days (5.43) for harvest maturity, however, maximum days (8.80) taken by IPG-5 for this trait. The genotype IPG-17 also recorded significantly earlier harvest maturity (5.50 days) as compared to other genotypes on pooled data basis. The mean performance for both the years was 7.12 days.

4.2.13 Yield per plant (kg)

The pointed gourd fruits yield per plant ranged from 2.80 kg (IPG-3) to 7.83 kg (IPG-8) in the year 2012-13. In the year 2013-14, it ranged from 3.06kg (IPG-3) to 7.39kg (IPG-8). Similarly, on pooled data basis, genotypes IPG-3 and IPG-8 produced minimum (2.93kg) and maximum (7.61kg) yield of fruits per plant, respectively. The mean performance for both the years was 4.66 kg fruits per plant.

4.2.14 Yield (t/ha)

The pointed gourd fruits yield per hectare ranged from 12.44 tonnes (IPG-3) to 34.80 tonnes (IPG-8) in the year 2012-13. During the year 2013-14 it ranged

from 13.60 tonnes (IPG-3) to 32.84 tonnes (IPG-8). Similarly, on pooled data basis, genotypes IPG-3 and IPG-8 produced minimum (13.02 tonnes) and maximum (33.32 tonnes) yield of fruits per hectare, respectively.

The variation in genetic constitution of genotypes studied is clearly indicated in the results. Similar variation in the genotypes studied for different perennial cucurbits were also reported by many workers such as by Hazara *et al.*(1998) , Singh *et al.*(2001), Srivastava *et al.* (2005), Pariari *et al.* (2005), in pointed gourd and Sarnaik *et al.* (2002), Nag *et al.* (2012) in ivy gourd and Bharathi *et al.*(2005) in spine gourd.

4.3 Estimation of genetic variability

Phenotypic variance was higher than the genotypic and environmental variances. In the pooled analysis (4.12**)**, the highest value of genotypic coefficient of variation was recorded for petiole length (28.38) followed by number of fruits per plant (23.53), yield per plant (22.96), average fruit weight (22.05), node of the first female flower (18.31), fruit length (16.83), average internodal length (15.24) and leaf length (14.78), whereas fruit diameter had the lowest genotypic coefficient of variation (4.95). The highest value of phenotypic coefficient of variation was recorded for petiole length (30.62) followed by number of fruits per plant (30.07), average fruit weight (23.33), yield per plant (23.31),average internodal length (22.54), node of the first female flower (19.59), fruit length (17.91)and leaf length (16.32), whereas fruit diameter had the lowest genotypic coefficient of variation (4.95). These result has been correlated with Dora *et al.* (2003), Khan *et al.* (2009) in pointed gourd, Maharana *et al.*(1995), Bharathi *et al.* (2006), Panchbhai *et al.* (2006), Bharathi *et al.* (2010) in spine gourd and Celine *et al.* (2010) and Rajkumar and Karuppaiah (2007) in snake gourd.

Results showed in Table- 4.10 for the year 2012-13, the highest value of genotypic coefficient of variation was recorded for petiole length (27.20) followed by average weight of fruit (26.71), number of fruits per plant (26.19), yield per plant (25.94), fruit length (25.47), leaf length (19.91) and number of seeds per fruit (19.66), whereas fruit diameter had the lowest genotypic coefficient of variation

(7.68). The highest value of phenotypic coefficient of variation was recorded for number of fruits per plant (38.65), followed by petiole length (30.47), fruit length (29.98), average fruit weight (29.59), yield per plant (26.14), average internodal length (24.85), leaf length (21.95) and number of seeds per fruit (20.35). The lowest phenotypic coefficient of variation had recorded for days taken from fruit set to harvest maturity (9.21).

It is the evident from Table- 4.11 that in the year 2013-14 the highest value of genotypic coefficient of variation was recorded for petiole length (27.18) followed by number of fruits per plant (22.97), node of the first female flower (21.93), yield per plant (20.73), average internodal length (19.67), average fruit weight (18.86), fruit length (15.67) and number of seeds per fruit (14.82), whereas fruit diameter had the lowest genotypic coefficient of variation (5.49). The highest value of phenotypic coefficient of variation was recorded petiole length (96.47) followed by average internodal length (31.85), number of fruits per plant (30.86), average fruit weight (23.07), node of the first female flower (22.94), yield per plant (21.77), fruit length (17.70) and leaf length (17.16). The lowest phenotypic coefficient of variation was recorded for fruit diameter (9.35).

4.4 Heritability

Heritability in broad sense was calculated for all the 13 characters. In the pooled analysis (Table- 4.12) the magnitude of heritability ranged from 44.6% to 97.0%. The yield per plant had the high heritability estimate (97%) followed by days taken for appearance of first female flower (95.7%), days taken from fruit set to harvest maturity (92.9%), average fruit weight node (89.4%), fruit length (88.3%), node of the first female flower (87.4%), petiole length (85.9%), leaf width (84.5%) leaf length (82.0%) and number of seeds per fruit (79.3%). The moderate heritability was recorded in number of fruit per plant (61.3%).The characters showed low heritability *viz.*, average internodal length (45.7%) and fruit diameter (44.6%). These findings are in accordance with the results obtained by Dora *et al.* (2003), Srivastava *et al.* (2005) in pointed gourd and Rajkumar and Karuppaiah (2007), Narayanankutty *et al.* (2006) in snake gourd.

Table 4.10: Mean, Range, Variability, Heritability and Genetic advance for growth and yield components in pointed gourd for year 2012-13

S. No.	Characters	Mean	Range		GCV (%)	PCV (%)	h^2 (Broad Sense)	Expected genetic advance	Genetic advance in % of mean
			Min.	Max.					
1.	Leaf length (cm)	10.06	6.97	12.73	19.91	21.95	82.3	3.74	37.17
2.	Leaf width (cm)	7.79	5.63	10.37	12.19	13.28	84.2	1.79	22.97
3.	Average Internodal length	8.24	6.07	11.80	10.75	24.85	18.7	0.79	9.58
4.	Days taken for appearance of first female flower	52.00	41.23	58.90	8.67	9.21	88.5	8.74	16.80
5.	Petiole Length	3.16	1.30	5.37	27.20	30.47	79.7	1.58	50.00
6.	Node of the first female flower	11.39	8.43	15.30	14.77	19.87	55.3	2.58	22.65
7.	Fruit Length	3.14	2.10	5.17	25.47	29.98	72.2	1.40	44.58
8.	Fruit diameter (cm)	3.22	2.50	3.70	7.68	11.80	42.3	0.33	10.24
9.	No. of fruit/Plant	171.04	85.20	248.25	26.19	38.65	45.9	62.51	36.54
10.	No. of seeds/Fruit	6.84	5.20	11.53	19.66	20.35	93.3	2.67	39.04
11.	Average fruit weight (g)	30.28	19.78	49.93	26.71	29.59	81.5	15.04	49.66
12.	Days taken from fruit set to Harvest maturity	7.11	5.57	8.57	11.24	12.74	77.9	1.45	20.39
13.	Yield per plant(Kg)	4.74	2.80	7.83	25.94	26.14	98.5	2.52	53.16

Table 4.11: Mean, Range, Variability, Heritability and Genetic advance for growth and yield components in pointed gourd for year 2013-14

S. No.	Characters	Mean	Range		GCV (%)	PCV (%)	h^2 (Broad Sense)	Expected genetic advance	Genetic advance in % of mean
			Min.	Max.					
1.	Leaf length (cm)	8.62	5.07	10.63	14.33	17.16	69.8	2.13	24.70
2.	Leaf width (cm)	6.85	4.27	8.43	14.76	16.81	77.1	1.83	26.71
3.	Average Internodal length	7.76	4.97	11.37	19.67	31.85	38.1	1.95	25.12
4.	Days taken for appearance of first female flower	52.32	40.67	59.37	9.44	9.64	95.8	9.96	19.03
5.	Petiole Length	3.63	1.57	5.67	27.18	96.47	7.9	0.57	15.70
6.	Node of the first female flower	11.51	7.63	15.77	21.93	22.94	91.4	4.97	43.17
7.	Fruit Length	6.77	5.33	9.37	15.67	17.70	78.4	1.94	28.65
8.	Fruit diameter (cm)	3.31	2.63	3.53	5.49	9.35	34.4	0.22	6.64
9.	No. of fruit/Plant	174.67	110.77	237.33	22.97	30.86	55.4	61.54	35.23
10.	No. of seeds/Fruit	19.74	14.77	25.73	14.82	17.18	74.4	5.20	26.34
11.	Average fruit weight (g)	29.61	19.27	38.67	18.86	23.07	66.8	9.40	31.74
12.	Days taken from fruit set to Harvest maturity	7.14	5.43	8.80	12.59	13.27	90.0	1.76	24.64
13.	Yield per plant(Kg)	4.97	3.06	7.39	20.73	21.77	90.7	2.02	40.64

Table 4.12: Mean, Range, Variability, Heritability and Genetic advance for growth and yield components in pointed gourd for year pooled

S. No.	Characters	Mean	Range		GCV (%)	PCV (%)	h^2 (Broad Sense)	Expected genetic advance	Genetic advance in % of mean
			Min.	Max.					
1.	Leaf length (cm)	9.34	6.93	12.68	14.78	16.32	82.0	2.58	27.62
2.	Leaf width (cm)	7.32	5.70	9.35	11.56	12.57	84.5	1.60	21.85
3.	Average Internodal length	8.01	5.63	10.93	15.24	22.54	45.7	1.70	21.22
4.	Days taken for appearance of first female flower	52.16	40.95	58.48	9.05	9.25	95.7	9.51	18.23
5.	Petiole Length	3.20	1.43	5.52	28.38	30.62	85.9	1.73	54.06
6.	Node of the first female flower	11.45	8.47	15.27	18.31	19.59	87.4	4.04	35.28
7.	Fruit Length	4.95	3.83	7.27	16.83	17.91	88.3	1.61	32.52
8.	Fruit diameter (cm)	3.27	2.73	3.55	4.95	7.41	44.6	0.22	6.72
9.	No. of fruit/Plant	172.85	134.09	267.19	23.53	30.07	61.3	65.59	37.94
10.	No. of seeds/Fruit	13.29	10.33	16.77	13.09	14.70	79.3	3.19	24.00
11.	Average fruit weight (g)	29.94	19.53	47.12	22.05	23.33	89.4	12.86	42.95
12.	Days taken from fruit set to Harvest maturity	7.12	5.50	8.81	12.02	12.46	92.9	1.70	23.87
13.	Yield per plant(Kg)	4.86	2.93	7.61	22.96	23.31	97.0	2.26	46.50

It is observed from the Table- 4.10, that in the year 2012-13 the heritability ranged from 18.7% to 98.5%. The yield per plant had the high heritability (98.5%) followed by number of seeds per fruit(93.3%), days taken for appearance of first female flower (88.5%), leaf width (84.2),leaf length (82.3%), average fruit weight (81.5%), petiole length (79.7%), days taken from fruit set to harvest maturity (77.9%) and fruit length (72.2%).

The moderate heritability was recorded only by node of the first female flower (55.3 %), whereas low heritability was recorded for number of fruits per plant (45.9%), fruit diameter (42.3%) and average internodal length (18.7%).

Result showed that in the year 2013-14 (Table- 4.11), the heritability ranged from 7.9% to 95.8%. The days taken for appearance of first female flower had the highest heritability (95.8%) followed by node of the first female flower (91.4%), yield per plant (90.7%), days taken from fruit set to harvest maturity (90.0%), fruit length (78.4%), leaf width (77.1%) and number of seeds per fruit (74.4%). The character leaf length showed moderate heritability (69.8 %) followed by average fruit weight (66.8%) and number of fruit per plant (55.4%). The low heritability was revealed by the character average internodal length (38.1%) followed by fruit diameter (34.4%) and petiole length (7.9%).

These findings are similar with the results obtained by Dora *et al.* (2003), Srivastava *et al.* (2005) in pointed gourd and Rajkumar and Karuppaiah (2007), Narayanankutty *et al.* (2006) in snake gourd.

4.5 Genetic advance as per cent of mean

In the pooled analysis, the magnitude of genetic advance as per cent of mean ranged from 6.72% to 54.06% (Table- 4.12).The most of the attributes showed high range of genetic advance as per cent of mean. The petiole length recorded highest value of genetic advance as per cent of mean (54.06%) followed by yield per plant (46.50%), average fruit weight (42.95%), number of fruits per plant (37.94 %), node of the first female flower (35.28%), fruit length (32.52%), leaf length (27.62%), number of seeds per fruit (24.00%), days taken from fruit set to harvest maturity (23.87%), leaf width (21.85%) and average internodal

length(21.22%). The character days taken for appearance of first female flower showed moderate magnitude of genetic advance as per cent of mean (18.23%) whereas fruit diameter recorded low range (6.72%) of this parameter.

During the year 2012-13, the genetic advance as per cent of mean ranged from 9.58% to 53.16 % (Table-4.10). The most of the attributes showed high range of genetic advance as per cent of mean. The yield per plant recorded highest value of genetic advance as per cent of mean (53.16%) followed by petiole length (50.00%), average fruit weight (49.66%), fruit length (44.58%), leaf length (37.17%), number of seeds per fruit (39.04%), number of fruits per plant (36.54%), leaf width (22.97%), node of the first female flower(22.65%) and days taken from fruit set to harvest maturity (20.39%).The characters days taken for appearance of first female flower showed moderate magnitude of genetic advance as per cent of mean(16.80%) followed by fruit diameter (10.24%).Whereas average internodal length recorded low range (9.58%) of this parameter.

During the year 2013-14, the genetic advance as per cent of mean ranged from 6.64% to 43.17 % (Table- 4.11). The most of the attributes showed high range of genetic advance as per cent of mean. The node of the first female flower recorded highest value of genetic advance as per cent of mean (43.17%) followed by yield per plant (40.64%), number of fruits per plant (35.23%), average fruit weight (31.74%), fruit length (28.65%), leaf width (26.71%), number of seeds per fruit (26.34%), average internodal length (25.12%), leaf length (24.70%) and days taken from fruit set to harvest maturity (24.64%). The characters days taken for appearance of first female flower showed moderate magnitude of genetic advance as per cent of mean (19.03%) followed by petiole length (15.70%).Whereas fruit diameter recorded low range (6.64%) of this parameter. These findings are in agreement with Dora *et al.* (2003), Srivastava *et al.* (2005) in pointed gourd and Narayanankutty *et al.* (2006) in snake gourd.

Hence, on the basis of genetic parameters of variation, it could be concluded that the characters like, days taken for appearance of first female flower, yield per plant (kg), days taken from fruit set to harvest maturity, fruit length, leaf width, leaf length, petiole length, node of the first female flower, fruit diameter and

average fruit weight had high heritability coupled with genetic advance as percentage of mean. According to Panse (1957) such associations are attributing to additive gene effects and consequently a high genetic gain from selection would be anticipated.

The practical applicability of these findings would be profitably realized in selection programmes in the segregating populations. High heritability estimates of traits reflects the fixable components of the genotype which may show transgressed variation and at the same time, there would be no need to select very large number of single plants, only a few would be sufficient to give the expected genetic gain in the next generation of selection for these traits. The same characters also showed maximum variation on the basis of genetic parameters estimated. Direct selection for this two attributes in the available genotypes or germplasm collection can be utilized to gain immediate improvement of the population.

4.6 Correlation analysis

4.6.1 Correlation studies in pointed gourd genotypes

Association between two or more than two variables is expressed as correlation. It measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement of dependent characters. Galton (1988) was the first to suggest the use of correlation index to describe the degree of association also affects the effectiveness of selection process. Correlation may be true or spurious. Genetic causes of true correlation are mostly due to linkage, pleiotropy and physiological associations necessitated by developmental biochemical pathways. Linkage is responsible for realizing transient correlation. The degree of correlation arising from pleiotropy expresses the extent to which the characters are influenced by the same gene. Correlation coefficients between any two metric traits results from genetic and environmental causes. Environmental correlation is of little interest to breeders but it provides information on the extent of environmental influences on the two characters irrespective of their genetic differences and therefore genetic correlation usually reflects correlation of breeding values.

The estimation of genetic correlation along with phenotypic ones will give a clear picture of the extent of inherent associations and also indicate as to how much of the phenotypic correlation coefficient is influenced by the environment. If two characters show high magnitude of positive correlation coefficient at genotypic level, it will reflect strong linkage at the genetic level but if the correlation values are high at phenotypic level only, it may show weak associations and may be broken up with the change in the said environment of the two correlation values for a pair of threads are high at environmental level, it would indicate that such association are found in that particular environment only and that there will be no such associations if that environment changes. The same principle is applicable to negative correlation values. It the pair of characters possesses low heritability then phenotypic correlation is deterred by the environmental correlation. If they have high heritability genetic correlation is more important.

Correlation coefficient have been worked out in all possible combination and presented in Table- 4.13, 4.14 and 4.15.

During the year 2012-13 (Table 4.13) leaf length had highly significant and positive association with leaf width (0.797, 0.712), petiole length (0.698, 0.569), fruit length (0.689, 0.563) and number of seeds per fruit (0.507, 0.458) at genotypic and phenotypic levels. Leaf length also had significant and positive correlation with average internodal length (0.607) and average fruit weight (0.503) only at genotypic level.

Leaf width had significant and positive correlation with petiole length (0.711, 0.653), fruit length (0.705, 0.650) at genotypic and phenotypic levels whereas average internodal length (0.767) and average fruit weight (0.451) had significant and positive correlation only at genotypic level.

Average internodal length had highly significant and positive correlation with days taken for appearance of first female flower (0.486), and fruit length (0.921) at genotypic level and petiole length (0.965, 0.418) at genotypic and phenotypic level, it also showed positive correlation of number of seeds per fruit (0.337), average fruit weight (0.399), days taken from fruit set to harvest maturity

(0.309) at genotypic levels. Node of first female flower (-0.417) showed significant and negative correlated.

Days taken for appearance of first female flower showed significant and positive correlation with days taken from fruit set to harvest maturity (0.307) both at genotypic and phenotypic levels.

Petiole length had highly significant and positive correlation with fruit length (0.997, 0.972, and 0.892) at genotypic, phenotypic and environmental levels and it also exhibited positive and significant correlation of average fruit weight (0.406), number of seeds per fruit (0.423) and average fruit weight at genotypic levels (0.406).

Node of the first female flower had negative and significant correlation with yield per plant (-0.470) at genotypic level and significant positive correlated with days taken from fruit set to harvest maturity (0.479) at genotypic levels and fruit length (0.414) at environment level.

Fruit length had positive and significant correlation with number of seeds per fruit (0.438) and average fruit weight (0.414) at genotypic levels.

Fruit diameter had highly significant and negative correlation with number of seeds per fruit (-0.577) at genotypic levels and also showed negative correlation of number of fruit per plant (-0.260,) and average fruit weight (-0.298) at genotypic levels.

Number of fruit per plant showed significant and negative correlation with days taken from fruit set to harvest maturity (-0.430), positive correlate with yield per plant (0.385, 0.277).

Highly significant and positive correlation of number of seeds per fruit with average fruit weight (0.811, 0.732) at genotypic and phenotypic levels and days taken from fruit set to harvest maturity (0.451) at genotypic level.

Average fruit weight also had positive correlation with yield per plant (0.104) at genotypic level whereas days taken from fruit set to harvest maturity had

negative correlation with yield per plant (-0.246, -0.225, 0.162) at genotypic level, phenotypic and environmental levels.

During the year 2013-14 (Table 16) leaf length had highly significant and positive correlation with leaf width (0.719, 0.689, 0.615) at genotypic, phenotypic, environment levels and number of seeds per fruit (0.840, 0.610), fruit length (0.587, 0.418) at genotypic and phenotypic levels.

Leaf width had significant and positive correlation with average internodal length (0.533) at genotypic levels and it showed significant and positive correlation with days taken for the appearance of first female flower (0.462, 0.405) both at genotypic and phenotypic levels and number of seeds per fruit (0.433) at genotypic and phenotypic levels.

Average internodal length had significant and positive correlation with petiole length (0.438) at genotypic level. Whereas days taken for appearance of first female flower had highly significant and positive correlation with days taken from fruit set to harvest maturity (0.633, 0.598) both at genotypic and phenotypic levels and yield per plant (0.420) at genotypic level.

Petiole length had significant and positive correlation with node of the first female flower (0.458), fruit diameter (0.545) and significant and negative correlation with yield per plant (-0.625) at genotypic level. Node of the first female flower significant negative correlate with yield per plant (-0.413) at genotypic level. Whereas, fruit length had significant and positive correlation with number of seeds per fruit (0.552, 0.497), average fruit weight (0.508, 0.415) both at genotypic and phenotypic levels.

Fruit diameter showed significant and positive correlation with number of seeds per fruit (0.434) at genotypic level. Highly significant and positive correlation of number of fruit per plant was recorded with yield per plant (0.576, 0.503, 0.464) both at genotypic, phenotypic and environment levels.

Table 4.13: Correlation coefficient analysis (phenotypic, genotypic and environmental) among total fruit yield and its components of pointed gourd: Year- 2012-13

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13
Leaf length (cm)	G	1.000	0.797**	0.607*	0.033	0.698**	-0.178	0.689**	0.054	-0.014	0.507*	0.593*	-0.044	-0.041
	P	1.000	0.712**	0.312	0.007	0.569**	-0.105	0.563**	-0.014	-0.006	0.458	0.495*	-0.051	-0.035
	E	1.000	0.293	0.193	-0.150	0.017	0.054	0.144	-0.145	0.008	0.123	0.052	-0.082	0.041
Leaf width (cm)	G		1.000	0.767**	0.358	0.711**	-0.341	0.705**	0.074	-0.121	0.257	0.451	0.097	-0.168
	P		1.000	0.391	0.296	0.653**	-0.228	0.650**	0.014	-0.100	0.218	0.385	0.049	-0.158
	E		1.000	0.243	-0.095	0.394	0.018	0.478	-0.098	-0.085	-0.090	0.067	-0.156	-0.102
Average Internodal length	G			1.000	0.486**	0.965**	-0.417	0.921**	0.002	0.214	0.337	0.399	0.307	0.035
	P			1.000	0.188	0.418	-0.056	0.435	-0.131	0.053	0.128	0.219	0.001	-0.017
	E			1.000	-0.034	0.046	0.130	0.080	-0.193	-0.014	-0.053	0.164	-0.275	-0.287
Days taken for appearance of first female flower	G				1.000	0.349	0.305	0.377	-0.034	-0.085	-0.033	-0.147	0.701**	-0.375
	P				1.000	0.325	0.248	0.336	-0.060	-0.042	-0.032	-0.150	0.592*	-0.356
	E				1.000	0.210	0.152	0.194	-0.152	0.049	-0.027	-0.168	0.062	0.128
Petiole Length	G					1.000	-0108	0.997**	0.000	-0.118	0.423	0.406	0.109	-0.336
	P					1.000	0.059	0.972**	-0.030	-0.080	0.345	0.321	0.081	-0.302
	E					1.000	0.435	0.892**	-0.087	-0.025	-0.171	-0.036	-0.025	-0.078
Node of the first female flower	G						1.000	-0.115	-0.021	-0.192	0.141	-0.064	0.479*	-0.470*
	P						1.000	0.074	-0.009	-0.258	0.092	-0.039	0.245	-0.337
	E						1.000	0.414	0.002	-0.329	-0.053	0.015	-0.222	0.120
Fruit Length	G							1.000	-0.016	-0.130	0.438	0.414	0.137	-0.366
	P							1.000	-0.032	-0.087	0.330	0.317	0.094	-0.317
	E							1.000	-0.057	-0.031	0.216	-0.003	-0.034	-0.123
Fruit diameter (cm)	G								1.000	-0.260	-0.577*	-0.298	-0.141	-0.056
	P								1.000	-0.090	-0.358	-0.227	-0.074	-0.024
	E								1.000	0.043	0.026	-0.160	0.020	0.133
No. of fruit/Plant	G									1.000	0.049	-0.378	-0.430	0.385
	P									1.000	0.019	-0.256	-0.276	0.277
	E									1.000	-0.068	-0.077	-0.054	0.206
No. of seeds/Fruits	G										1.000	0.811**	0.451	-0.050
	P										1.000	0.732**	-0.133	-0.044
	E										1.000	0.219	-0.072	0.144
Average fruit weight (g)	G											1.000	-0.105	0.104
	P											1.000	-0.110	0.096
	E											1.000	-0.130	0.055
Days taken from fruit set to Harvest maturity	G												1.000	-0.246
	P												1.000	-0.225
	E												1.000	-0.162
Yield per plant(Kg)	G													1.000
	P													1.000
	E													1.000

*significant at 0.05% and ** significant at 0.01% level

Table 4.14: Correlation coefficient analysis (phenotypic, genotypic and environmental) among total fruit yield and its components of pointed gourd: Year- 2013-14

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13
Leaf length (cm)	G	1.000	0.719**	0.356	0.253	-0.384	-0.057	0.587*	-0.181	0.303	0.840**	0.096	0.029	0.211
	P	1.000	0.689**	0.170	0.204	-0.055	-0.034	0.418	-0.011	0.258	0.610*	0.090	0.043	0.181
	E	1.000	0.615*	-0.031	-0.022	0.066	0.071	-0.064	0.174	0.190	0.018	0.076	0.118	0.076
Leaf width (cm)	G		1.000	0.533*	0.462	-0.163	-0.106	0.268	-0.192	0.155	0.433	-0.435	0.079	-0.207
	P		1.000	0.322	0.405	-0.094	-0.080	0.204	-0.095	0.125	0.351	-0.257	0.088	-0.194
	E		1.000	0.087	0.077	-0.116	0.063	-0.020	0.011	0.073	0.094	0.202	0.144	-0.145
Average Internodal	G			1.000	0.268	0.438	-0.082	0.172	-0.046	0.236	-0.119	-0.301	-0.059	-0.258
length	P			1.000	0.091	0.022	-0.063	0.082	-0.010	0.042	-0.083	-0.153	-0.055	-0.240
	E			1.000	-0.441	-0.071	-0.066	-0.034	0.010	-0.127	-0.049	-0.003	-0.084	-0.368
Days taken for	G				1.000	0.240	0.291	0.033	-0.187	-0.252	0.193	-0.131	0.633*	0.420*
appearance of first	P				1.000	0.085	0.276	0.015	0.152	-0.172	0.144	-0.124	0.598*	-0.383
female flower	E				1.000	0.094	0.070	0.151	-0.270	0.089	-0.187	-0.165	0.150	0.140
Petiole Length	G					1.000	0.458	0.132	0.545*	-0.295	-0.151	-0.064	0.371	-0.625*
	P					1.000	0.163	0.086	0.198	-0.096	-0.039	0.035	0.181	-0.179
	E					1.000	0.142	0.119	0.139	-0.054	-0.005	0.089	0.271	-0.038
Node of the first female flower	G						1.000	0.207	0.154	-0.312	0.130	-0.226	0.368	-0.413*
	P						1.000	0.201	0.077	-0.224	0.137	-0.151	0.353	-0.386
	E						1.000	0.190	-0.041	-0.007	0.199	0.151	0.214	-0.112
Fruit Length	G							1.000	0.330	0.294	0.552**	0.508*	0.025	0.084
	P							1.000	0.183	0.151	0.497*	0.415	0.034	0.046
	E							1.000	0.032	-0.139	0.317	0.176	0.089	-0.171
Fruit diameter (cm)	G								1.000	-0.104	0.434	0.058	0.272	0.067
	P								1.000	-0.062	0.174	0.103	0.130	0.057
	E								1.000	-0.031	-0.111	0.161	-0.085	0.078
No. of fruit/Plant	G									1.000	-0.143	0.032	-0.367	0.576*
	P									1.000	-0.122	-0.067	-0.234	0.503*
	E									1.000	0.088	-0.223	0.188	0.464
No. of seeds/Fruits	G										1.000	0.204	0.228	0.127
	P										1.000	0.155	0.152	0.073
	E										1.000	0.038	-0.213	-0.201
Average fruit weight (g)	G											1.000	0.065	0.474*
	P											1.000	0.066	0.384
	E											1.000	0.084	0.086
Days taken from fruit set	G												1.000	-0.158
to Harvest maturity	P												1..000	-0.163
	E												1.000	-0.203
Yield per plant(Kg)	G													1.000
	P													1.000
	E													1.000

*significant at 0.05% and ** significant at 0.01% level

Table 4.15: Correlation coefficient analysis (phenotypic, genotypic and environmental) among total fruit yield and its components of pointed gourd: Pooled

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13
	G	1.000	0.715**	0.355	0.134	0.723**	-0.087	0.836**	0.112	0.126	0.773**	0.516*	-0.012	0.091
Leaf length (cm)	P	1.000	0.704**	0.268	0.112	0.609*	-0.079	0.717**	0.110	0.131	0.618*	0.411	0.002	0.078
	E	1.000	0.652**	0.160	-0.075	-0.013	-0.036	0.040	0.132	0.156	-0.032	-0.223	-0.107	-0.043
	G		1.000	0.484*	0.487*	0.769**	-0.240	0.620*	0.039	0.074	0.476*	0.067	0.110	-0.204
Leaf width (cm)	P		1.000	0.344	0.427	0.696**	-0.214	0.565*	0.068	0.086	0.372	0.041	0.110	-0.187
	E		1.000	0.150	-0.132	0.271	0.058	0.224	0.149	0.135	0.101	-0.140	0.123	-0.033
	G			1.000	0.358	0.790**	0.188	0.507*	-0.288	0.309	0.026	0.032	0.117	-0.150
Average Internodal length	P			1.000	0.176	0.510*	-0.121	0.327	-0.118	0.104	-0.018	0.028	-0.014	-0.139
	E			1.000	-0.396	0.054	-0.009	0.018	0.022	-0.129	-0.102	0.031	-0.457	-0.309
Days taken for	G				1.000	0.270	0.291	0.199	-0.105	-0.160	0.138	-0.158	0.663**	-0.402
appearance	P				1.000	0.251	0.285	0.183	-0.093	-0.132	0.121	-0.164	0.624*	-0.385
of first female flower	E				1.000	0.071	0.248	0.014	-0.158	-0.071	0.002	-0.256	-0.023	0.053
	G					1.000	-0.138	0.779**	0.162	-0.029	0.359	0.205	0.131	-0.342
Petiole Length	P					1.000	-0.091	0.729**	0.134	0.002	0.288	0.165	0.132	-0.311
	E					1.000	0.211	0.392	0.121	0.100	-0.050	-0.123	0.141	0.015
	G						1.000	0.135	0.115	-0.264	0.150	-0.155	0.418	-0.452
Node of the first female flower	P						1.000	0.137	0.049	-0.248	0.142	-0.114	0.348	-0.408
	E						1.000	0.147	-0.089	-0.247	0.109	-0.106	-0.309	0.133
	G							1.000	-0.035	-0.023	0.713**	0.603*	0.095	-0.175
Fruit Length	P							1.000	-0.024	-0.013	0.621*	0.513*	0.120	-0.161
	E							1.000	-0.011	0.016	0.161	-0.040	0.380	0.006
	G								1.000	-0.445	0.139	-0.121	0.116	-0.086
Fruit diameter (cm)	P								1.000	-0.221	0.083	-0.061	0.071	-0.052
	E								1.000	0.024	0.000	0.062	0.016	0.034
	G									1.000	-0.310	-0.154	0.417	0.452*
No. of fruit/Plant	P									1.000	-0.238	-0.107	-0.284	0.385
	E									1.000	-0.079	0.035	0.181	0.336
	G										1.000	0.653**	0.119	0.046
No. of seeds/Fruits	P										1.000	0.506*	0.116	0.020
	E										1.000	-0.192	0.115	-0.256
	G											1.000	-0.037	0.293
Average fruit weight (g)	P											1.000	-0.034	0.287
	E											1.000	0.001	0.253
	G												1.000	-0.200
Days taken from fruit set to Harvest maturity	P												1.000	-0.198
	E												1.000	-0.170
Yield per plant(Kg)	G													1.000
	P													1.000
	E													1.000

*significant at 0.05% and ** significant at 0.01% level

None of the traits had significant correlation with number of seeds per fruit. Average fruit weight had significant and positive correlation with yield per plant (0.474) at genotypic levels. None of the traits had significant correlation with days taken from fruit set to harvest maturity.

In the pooled analysis (Table 4.15), leaf length had positive and significant correlation with leaf width (0.715, 0.704, 0.652) at genotypic, phenotypic and environment levels and significant and positive correlation was noticed in petiole length (0.723, 0.609), fruit length (0.836, 0.717) and number of seeds per fruit (0.773, 0.618) and average fruit weight (0.516, 0.411) both at genotypic and phenotypic levels.

Leaf width showed highly significant and positive correlation with days taken for first female flower appearance (0.487, 0.427), petiole length (0.769, 0.696) fruit length (0.620, 0.565) at genotypic and phenotypic levels and it also exhibited positive correlation with average internodal length (0.484) and number of seeds per fruit (0.476) at genotypic level.

Average internodal length showed highly significant and positive correlation with petiole length (0.790, 0.510) both at genotypic and phenotypic level and it also exhibited positive correlation of fruit length (0.507) at genotypic level only.

Days taken for the appearance of first female flower also showed positive correlation with days taken from fruit set to harvest maturity (0.663, 0.624) except petiole length (0.270, 0.251), node of the first female flower (0.291, 0.285), fruit length (0.199, 0.183), fruit diameter (-0.105, 0.093), number of fruit per plant (-0.160, -0.132), number of seeds per fruit (0.138, 0.121) and average fruit weight (-0.158, -0.164).

Petiole length showed highly significant and positive correlation with fruit length (0.779, 0.729) both at genotypic and phenotypic level. None of the traits had significant correlation with node of the first female flower.

Fruit length showed highly significant and positive correlation with number of seeds per fruit (0.713, 0.621) and average fruit weight (0.603, 0.513) at genotypic and phenotypic level, while fruit diameter had significant and negative correlate with number of fruit per plant (-0.445) at genotypic level. And number of fruit per plant had significant positive correlation with days taken from fruit set to harvest maturity (0.417), yield per plant (0.452) at genotypic level.

Number of seeds per fruit had significant and positive correlation with average fruit weight (0.653, 0.506) at genotypic and phenotypic level only while, none of the traits had significant and positive correlation with average fruit weight and days taken from fruit set to harvest maturity. Similar correlations were also obtained by Prasad and Singh (1990), Sarkar (1999), Hazra *et al.* (2003), Dora *et al.* (2003), Srivastava *et al.* (2005) and Singh *et al.* (2002) in pointed gourd, Sarnaik *et al.* (2002) in ivy gourd and Narayanankutty *et al.* (2006), Kumaresan *et al.* (2006) in snake gourd. Similar correlations were also obtained by Prasad and Singh (1990), Sarkar (1999), Hazra *et al*. (2003), Dora *et al.* (2003), Srivastava *et al.* (2005) and Singh *et al.* (2002) in pointed gourd, Sarnaik *et al.* (2002) in ivy gourd and Narayanankutty *et al.* (2006), Kumaresan *et al.* (2006) in snake gourd.

4.7 Path coefficient analysis

The observed correlation coefficient of yield and its components was further partitioned into direct and indirect effects. The path coefficient analysis representing the effect of the component of the fruit yield per plant has been presented in the Table- 4.16, 4.17 and 4.18.

In the year 2012-13, genotypic and phenotypic path coefficient recorded direct and indirect effects of different growth characters and fruit yield per plant (kg) is given in Table 4.16.

Genotypic path coefficients showing direct effect on fruit yield per plant are given in Table 4.16. Number of seeds per fruits (0.444) had maximum positive direct effect on fruit yield per plant followed by average fruit weight (0.376), node

of the first female flower (0.364), fruit length (0.252), average internodal length (0.247), leaf length (0.175), days taken for appearance of first female flower (0.139), fruit diameter (0.120) and number of fruits per plant (0.111). Days taken from fruit set to harvest maturity (-0.118), leaf width (-0.233) and petiole length (-0.252) showed direct negative effect on fruit yield per plant.

Leaf length had indirect positive effect on average fruit weight (0.768), fruit length (0.263), average internodal length (0.15), days taken from fruit set to harvest maturity (0.052) and days taken for appearance of first female flower (0.046) while rest of characters showed indirect negative values.

The positive indirect effect of leaf width was recorded on days taken for appearance of first female flower (0.499), leaf width (0.223), and average internodal length (0.19) whereas rest of the characters exhibited indirect negative effects on this attribute.

The positive indirect effect of average Internodal length was recorded through days taken for appearance of first female flower (0.678), average fruit weight (0.501), fruit length (0.281), number of fruits per plant (0.237) and leaf length (0.035), while rest of the characters showed indirect negative values.

Days taken for appearance of first female flower had positive indirect effect on fruit Length (0.949), number of seeds per fruit (0.146), average internodal length (0.12), node of the first female flower (0.111), leaf length (0.058) and fruit diameter (0.04) whereas, rest of the all characters recorded indirect negative values.

The positive indirect effect of petiole length was observed on days taken for appearance of first female flower (0.487), fruit length (0.473), average fruit weight (0.472), average internodal length (0.256) and fruit diameter (0.012) and rest of the all the characters exhibited indirect negative values.

The positive indirect effect of node of the first female flower was recorded through leaf width (0.796), days taken for appearance of first female flower (0.426), petiole length (0.272) and fruit diameter (0.025), while remaining all characters recorded with indirect negative values.

Fruit Length had positive indirect effect on average internodal length (0.791), average fruit weight (0.443), average internodal length (0.267), days taken for appearance of first female flower (0.252) and fruit diameter (0.019) whereas, rest of the characters recorded indirect negative values.

The positive indirect effect of fruit diameter was observed through number of seeds per fruit (0.438), days taken from fruit set to harvest maturity (0.166), leaf length (0.095), average internodal length (0.011) and petiole length (0.001) while rest of the characters showed indirect negative effect on total fruit yield.

Number of fruits per plant showed positive indirect effect on days taken from fruit set to harvest maturity (0.509), fruit diameter (0.313), petiole length (0.298), leaf width (0.283) and leaf length (0.053), while rest of the characters exhibited indirect negative values.

The positive indirect effect of number of seeds per fruit on total fruit yield was recorded through average fruit weight (0.949), leaf length (0.889), fruit diameter (0.696), days taken from fruit set to harvest maturity (0.172), petiole length (0.001), and node of the first female flower (0.051), while rest of the characters showed indirect negative values.

Average fruit weight had positive indirect effect on fruit diameter (0.359), days taken from fruit set to harvest maturity (0.124), average internodal length (0.099), leaf length (0.059) and petiole length (0.001) whereas, rest of the characters showed indirect negative values.

The positive indirect effect of days taken from fruit set to harvest maturity was observed through days taken for appearance of first female flower (0.978),

number of seeds per fruit (0.645), fruit length (0.344), leaf width (0.226), node of the first female flower (0.174), fruit diameter (0.169) and average internodal length (0.076) while rest of the characters showed indirect negative effect on total fruit yield.

During the year 2013-14, genotypic and phenotypic path coefficient recorded the direct and indirect effects of different growth characters and fruit yield per plant (kg) which is presented in Table- 4.17. Genotypic path coefficients showing direct effect on fruit yield per plant are given in Table- 4.17. Leaf length had maximum positive direct effect on yield per plant (0.794) followed by average fruit weight (0.785), days taken from fruit set to harvest maturity (0.737), average internodal length (0.609), days taken for appearance of first female flower (0.509), fruit diameter (0.348), fruit length (0.182) and number of seeds per fruit (0.049) whereas, petiole length (-0.161), node of the first female flower (-0.117), leaf width (-0.272) and number of fruit per plant (-0.341) showed direct negative effect.

Phenotypic path coefficients showing direct effect on fruit yield per plant are given in Table- 4.17. Number of fruit per plant had maximum positive direct effect on yield per plant (0.492) followed by average fruit weight (0.317), leaf length (0361), number of seeds per fruit (0.155), days taken from fruit set to harvest maturity (0.145) and fruit diameter (0.029)

Table 4.16: Genotypic and Phenotypic path coefficient showing direct and indirect effects of different pointed gourd characters on total fruit yield: Year- 2012-13

Characters	Path	Leaf length (cm)	Leaf width (cm)	Average Internodal length	Days taken for appearance of first female flower	Petiole Length	Node of the first female flower	Fruit length	fruit diameter (cm)	No. of fruit/Plant	No. of seeds/Fruits	Average fruit weight (g)	Days taken from fruit set to Harvest maturity
Leaf length (cm)	G	**0.175**	-0.759	0.15	0.046	-0.659	-0.065	0.263	-0.066	-0.015	-0.149	0.768	0.052
	P	**0.122**	-0.141	0.021	-0.001	0.068	0.021	-0.205	0.001	-0.002	-0.14	0.225	-0.002
Leaf width (cm)	G	-0.298	**-0.233**	0.19	0.499	-0.208	-0.124	0.223	-0.089	-0.134	-0.505	-0.695	-0.115
	P	0.087	**-0.198**	0.026	-0.037	0.078	0.045	-0.236	0.001	-0.031	0.067	0.174	0.002
Average Internodal length	G	0.035	-0.211	**0.247**	0.678	-0.391	-0.152	0.281	-0.002	0.237	-0.505	0.501	-0.363
	P	0.038	-0.078	**0.067**	-0.024	0.05	0.011	-0.158	0.001	0.016	-0.039	0.099	0.001
Days taken for appearance of first female flower	G	0.058	-0.836	0.12	**0.139**	-0.88	0.111	0.949	0.04	-0.094	0.146	-0.555	-0.83
	P	0.001	-0.059	0.013	**-0.126**	0.039	-0.049	-0.122	0.001	-0.013	0.01	-0.068	0.019
Petiole Length	G	-0.124	-0.341	0.256	0.487	**-0.252**	-0.039	0.473	0.012	-0.131	-0.121	0.472	-0.13
	P	0.069	-0.129	0.028	-0.041	**0.119**	-0.012	-0.353	0.013	-0.024	-0.106	0.145	0.003
Node of the first female flower	G	-0.312	0.796	-0.103	0.426	0.272	**0.364**	-0.289	0.025	-0.213	-0.627	-0.242	-0.567
	P	-0.013	0.045	-0.004	-0.031	0.007	**-0.197**	-0.027	0.001	-0.079	-0.028	-0.018	0.008
Fruit Length	G	0.791	-0.355	0.267	0.252	-0.472	-0.042	**0.252**	0.019	-0.144	-0.056	0.443	-0.162
	P	0.069	-0.129	0.029	-0.042	0.116	-0.015	**-0.363**	0.001	-0.027	0.101	0.144	0.003
Fruit diameter (cm)	G	0.095	-0.173	0.011	-0.047	0.001	-0.007	-0.04	**0.120**	-0.288	0.438	-0.879	0.166
	P	-0.002	-0.003	-0.009	0.008	-0.004	0.002	0.011	**0.004**	-0.028	0.112	-0.103	-0.002
No. of fruit/Plant	G	-0.024	0.283	0.053	-0.188	0.298	-0.07	-0.327	0.313	**0.111**	-0.216	-0.577	0.509
	P	-0.001	0.02	0.004	0.005	-0.009	0.051	0.032	0.012	**0.306**	-0.006	-0.116	-0.009
No. of seeds/Fruits	G	0.889	-0.599	0.083	-0.046	0.001	0.051	-0.104	0.696	0.054	**0.444**	0.949	0.172
	P	0.056	-0.43	0.009	0.004	0.041	-0.018	-0.12	0.001	0.006	**-0.307**	0.332	-0.004
Average fruit weight (g)	G	0.059	-0.048	0.099	-0.206	0.001	-0.23	-0.043	0.359	-0.419	-0.401	**0.376**	0.124
	P	0.06	-0.076	0.015	0.019	0.038	0.008	-0.115	0.001	-0.078	-0.224	**0.453**	-0.003
Days taken from fruit set to Harvest maturity	G	-0.076	0.226	0.076	0.978	-0.276	0.174	0.344	0.169	-0.476	0.645	-0.394	-0.118
	P	-0.006	-0.01	0.001	-0.075	0.01	-0.048	-0.034	0.001	-0.084	0.041	-0.05	**0.031**

Residual effect= 0.0321 (G); Residual effect= 0.0614 (P)

Table 4.17: Genotypic and Phenotypic path coefficient showing direct and indirect effects of different pointed gourd characters on total fruit yield: Year-2013-14

Characters	Path	Leaf length (cm)	Leaf width (cm)	Average Internodal length (cm)	Days taken for appearance of first female flower	Petiole Length (cm)	Node of the first female flower	Fruit length (cm)	fruit diameter (cm)	No. of fruit/Plant	No. of seeds/Fruits	Average fruit weight (g)	Days taken from fruit set to Harvest maturity
Leaf length (cm)	G	**0.794**	-0.047	0.217	0.128	0.618	0.066	0.93	-0.063	-0.103	-0.413	-0.171	0.021
	P	**0.261**	-0.179	-0.02	-0.048	0.006	0.007	-0.101	0.101	0.127	0.095	0.028	0.006
Leaf width (cm)	G	0.571	**-0.272**	0.325	0.253	0.262	0.124	0.489	-0.067	0.053	-0.213	0.777	0.059
	P	0.18	**-0.259**	-0.039	-0.095	0.01	0.015	-0.049	-0.003	0.061	0.054	-0.082	0.013
Average Internodal length	G	0.283	0.552	**0.609**	0.136	-0.704	0.095	0.314	-0.016	-0.08	0.059	0.053	-0.044
	P	0.044	-0.083	**-0.12**	0.022	-0.002	0.012	-0.02	0.001	0.02	-0.013	-0.049	-0.008
Days taken for appearance of first female flower	G	0.201	-0.745	0.164	**0.509**	-0.387	-0.339	0.061	-0.65	0.086	-0.095	0.234	0.467
	P	0.053	-0.105	-0.011	**-0.236**	-0.009	-0.053	-0.004	-0.004	-0.084	0.022	-0.039	0.087
Petiole Length	G	-0.305	0.443	0.267	0.122	**-0.161**	-0.535	0.24	0.19	0.001	0.074	0.114	0.274
	P	-0.014	0.024	-0.003	-0.02	**-0.104**	-0.031	-0.021	0.006	-0.047	0.006	0.011	0.026
Node of the first female flower	G	-0.045	0.289	-0.05	0.148	-0.738	**-0.117**	0.377	0.054	0.106	0.064	0.404	0.271
	P	-0.009	0.021	0.008	-0.65	-0.017	**-0.192**	-0.049	0.002	-0.11	0.021	-0.048	0.051
Fruit Length(cm)	G	0.466	-0.729	0.105	0.017	-0.212	-0.241	**0.182**	0.115	-0.1	-0.272	-0.907	0.019
	P	0.109	-0.053	-0.01	-0.003	-0.009	-0.039	**-0.242**	0.005	0.074	0.077	0.132	0.005
Fruit diameter (cm)	G	-0.144	0.522	0.028	-0.095	-0.877	-0.18	0.601	**0.348**	0.035	-0.214	-0.103	0.2
	P	-0.003	0.025	0.001	0.036	-0.021	-0.015	-0.044	**0.029**	-0.303	0.027	0.033	0.019
No. of fruit/Plant	G	0.241	-0.421	0.044	-0.128	0.475	0.364	0.536	-0.036	**-0.341**	0.07	-0.057	-0.27
	P	0.067	-0.032	-0.005	0.04	0.01	0.043	0.036	-0.002	**0.492**	0.019	-0.021	-0.034
No. of seeds/Fruits	G	0.667	-0.825	0.073	0.098	0.242	-0.151	0.093	0.151	0.040	**0.049**	-0.364	0.168
	P	0.0159	-0.091	0.01	-0.034	0.004	-0.026	-0.12	0.005	-0.06	**0.155**	0.049	0.022
Average fruit weight (g)	G	0.076	0.817	0.183	-0.067	0.103	0.264	0.927	0.02	-0.011	-0.1	**0.785**	0.048
	P	0.023	0.067	0.018	0.029	-0.004	0.029	0.001	0.003	-0.033	0.024	**0.317**	0.01
Days taken from fruit set to harvest maturity	G	0.023	-0.216	-0.036	0.322	-0.597	-0.429	0.046	0.095	0.125	0.112	-0.117	**0.737**
	P	0.011	0.023	0.007	-0.141	-0.019	-0.068	-0.008	0.004	-0.115	0.024	0.021	**0.145**

Residual effect= 0. 0412 (G); Residual effect= 0.0614 (P)

Table 4.18: Genotypic and Phenotypic path coefficient showing direct and indirect effects of different pointed gourd characters on total fruit yield: Pooled Data

Characters	Path	Leaf length (cm)	Leaf width (cm)	Average Internodal length (cm)	Days taken for appearance of first female flower	Petiole Length (cm)	Node of the first female flower	Fruit length (cm)	fruit diameter (cm)	No. of fruit/Plant	No. of seeds/Fruits	Average fruit weight (g)	Days taken from fruit set to Harvest maturity
Leaf length (cm)	G	**0.374**	-0.377	-0.033	0.013	-0.054	0.059	-0.067	0.035	0.127	0.68	0.074	-0.006
	P	**0.029**	-0.113	0.101	-0.023	-0.234	0.028	-0.103	0.005	0.048	0.071	0.095	0.001
Leaf width (cm)	G	-0.267	**-0.471**	-0.045	-0.047	-0.057	0.164	-0.05	0.012	0.074	0.418	0.01	0.056
	P	0.205	**-0.16**	0.013	-0.086	-0.267	0.076	-0.081	0.003	0.032	0.043	0.009	0.026
Average internodal length(cm)	G	-0.133	-0.228	**-0.093**	-0.035	-0.059	0.129	-0.014	-0.089	0.311	0.023	0.005	0.059
	P	0.078	-0.055	**0.039**	-0.035	-0.196	0.043	-0.047	-0.006	0.039	-0.002	0.006	-0.003
Days taken for appearance of first female flower	G	-0.133	-0.228	-0.093	**-0.035**	-0.059	0.129	-0.041	-0.089	0.311	0.023	0.005	0.059
	P	0.033	-0.068	0.007	**-0.201**	-0.096	-0.101	-0.026	-0.004	-0.049	0.014	-0.038	0.0145
Petiole Length(cm)	G	-0.27	-0.0363	-0.073	-0.026	**-0.074**	0.094	-0.063	0.05	-0.029	0.316	0.029	0.067
	P	0.177	-0.111	0.02	-0.05	**-0.384**	0.032	-0.104	0.006	0.001	0.033	0.038	0.031
Node of the first female flower	G	0.032	0.113	0.017	-0.028	0.01	**-0.684**	-0.011	0.036	-0.266	0.132	-0.017	0.213
	P	-0.023	0.034	-0.005	-0.057	0.035	**-0.354**	-0.02	0.002	-0.092	0.016	-0.026	0.081
Fruit Length(cm)	G	-0.312	-0.092	-0.047	-0.019	-0.058	-0.093	**0.081**	-0.011	-0.023	0.626	0.086	0.048
	P	0.209	-0.09	0.013	-0.037	-0.28	-0.048	**-0.143**	-0.001	-0.005	0.072	0.123	0.028
fruit diameter (cm)	G	-0.042	-0.018	0.027	0.01	-0.012	-0.079	0.003	**0.309**	-0.447	0.122	-0.017	0.059
	P	0.032	-0.011	-0.005	0.019	-0.052	-0.017	0.004	**0.048**	-0.082	0.01	-0.014	0.017
No. of fruit/Plant	G	-0.047	-0.035	-0.029	0.016	0.002	0.181	0.003	-0.137	**0.101**	0.272	-0.022	-0.213
	P	0.038	-0.014	0.004	0.027	-0.001	0.088	0.002	-0.011	**0.071**	-0.027	-0.025	-0.066
No. of seeds/Fruits	G	-0.289	-0.224	-0.002	-0.013	-0.027	-0.102	-0.057	0.043	-0.043	**-0.312**	0.879	0.091
	P	0.18	-0.059	-0.001	-0.024	-0.11	-0.05	-0.089	0.004	-0.088	**0.115**	0.117	0.027
Average fruit weight (g)	G	-0.193	-0.032	-0.003	0.015	-0.015	0.079	-0.049	-0.037	-0.155	0.558	**0.143**	-0.019
	P	0.12	-0.007	0.001	0.033	-0.063	0.04	-0.076	-0.003	-0.039	0.058	**0.231**	-0.008
Days taken from fruit set to Harvest maturity	G	0.004	-0.052	-0.011	-0.065	-0.01	-0.286	-0.008	0.036	-0.419	0.105	-0.005	**0.510**
	P	0.001	-0.018	-0.001	-0.126	-0.05	-0.123	-0.017	0.003	-0.105	0.013	-0.008	**0.232**

Residual effect= 0.0423 (G); Residual effect= 0.0632 (P)

Whereas leaf length (-0.259), fruit length (-0.242), days taken for appearance of first female flower (-0.236), node of the first female flower (-0.192), petiole length (-0.104) and average internodal length (-0.12) recorded with direct negative effect on fruit yield per plant.

The positive indirect effect of leaf length was observed through fruit length (0.930), petiole length (0.618), average internodal length (0.217), days taken for appearance of first female flower (0.128), node of the first female flower (0.066), days taken from fruit set to harvest maturity (0.021) and rest of the characters exhibited indirect negative values.

Leaf width had positive indirect effect through average fruit weight (0.777), leaf length (0.571), fruit length (0.489), average internodal length (0.325), petiole length (0.262), days taken for appearance of first female flower (0.253), fruit length (0.124), fruit diameter (0.059) and number of fruit per plant (0.053) while rest of the characters recorded indirect negative values.

Average internodal length had positive indirect effect via leaf width (0.552), fruit length (0.314), leaf length (0.283), days taken for appearance of first female flower (0.136), node of the first female flower (0.095), number of seeds per fruit (0.059) and average fruit weight (0.053) while rest of the characters showed indirect negative values.

Days taken for appearance of first female flower had positive indirect effect via days taken from fruit set to harvest maturity (0.467), average fruit weight (0.234), leaf length (0.201), average internodal length (0.164), number of fruits per plant (0.086) and fruit length (0.061) while rest of the characters exhibited indirect negative values.

Petiole length exhibited positive indirect effect via leaf width (0.443), days taken from fruit set to harvest maturity (0.274), average internodal length (0.267), fruit length (0.240), fruit diameter (0.190), days taken for appearance of first female flower (0.122), average fruit weight (0.114), number of seeds per fruit

(0.074) and number of fruit per plant (0.001) while rest of the character exhibited low positive indirect effect and negative values.

Node of the first female flower had positive indirect effect on average fruit weight (0.404), fruit length (0.377), leaf width (0.289), days taken from fruit set to harvest maturity (0.271), days taken for appearance of first female flower (0.148), number of fruit per plant (0.106), number of seeds per fruit (0.064) and fruit diameter (0.054) while, rest of the characters exhibited indirect negative values.

Fruit length had positive indirect effect on total fruit yield via leaf length (0.466), fruit diameter (0.115), average internodal length (0.105), days taken from fruit set to harvest maturity (0.019), and days taken for appearance of first female flower (0.017) while rest of the characters recorded indirect negative values.

Fruit diameter had positive indirect effect on total fruit yield through fruit length (0.601), leaf width (0.522), days taken from fruit set to harvest maturity (0.200), number of fruits per plant (0.035), average internodal length (0.028) while rest of the characters showed indirect negative values.

Number of fruit per plant had positive indirect effect on total fruit yield via fruit length (0.536), petiole length (0.475), node of the first female flower (0.364), leaf length (0.241), number of seeds per fruit (0.07) and average internodal length (0.044) while rest of the characters exhibited indirect negative values.

Number of seeds per fruit had positive indirect effect on total fruit yield via leaf length (0.667), petiole length (0.242), days taken from fruit set to harvest maturity (0.168), fruit diameter (0.151), days taken for appearance of first female flower (0.098), fruit length (0.093), average internodal length (0.073), number of fruits per plant (0.040) while rest of the characters recorded indirect negative values.

Average fruit weight had positive indirect effect on total fruit yield through fruit length (0.927), leaf width (0.817), node of the first female flower (0.264),

average internodal length (0.183), petiole length (0.103), leaf length (0.076), days taken from fruit set to harvest maturity (0.048), fruit diameter (0.020) while rest of the characters recorded indirect negative values.

The positive indirect effect on days taken from fruit set to harvest maturity was noted to be highest under days taken for appearance of first female flower (0.322), number of fruits per plant (0.125), number of seeds per fruit (0.112), fruit diameter (0.095), fruit length (0.046) while rest of the characters exhibited indirect negative values.

On the basis of the pooled data of both years of the investigation, genotypic and phenotypic path correlation coefficients of fruit yield per plant along with its components were partitioned into direct and indirect effect which has been presented in Table 4.18.

Genotypic path coefficients showing direct effect on fruit yield per plant are given in Table 4.18. Days taken from fruit set to harvest maturity (0.510) had maximum positive direct effect on followed by leaf length (0.374), fruit diameter (0.309), average fruit weight (0.143), number of fruits per plant (0.101), fruit length (0.081). Among the direct negative effect, days taken for appearance of first female flower showed highest negative direct effect (-0.035) on fruit yield per plant followed by petiole length (-0.074), average internodal length (-0.093), number of seeds per fruit (-0.312), leaf width (-0.471) and node of the first female flower (-0.684).

Leaf length recorded positive indirect effect via number of seeds per fruit (0.680), number of fruits per plant (0.127), average fruit weight (0.074), node of the first female flower (0.059), fruit diameter (0.035), days taken for appearance of first female flower (0.013) while, rest of the characters exhibited indirect negative values.

Leaf width exhibited positive indirect effect via number of seeds per fruit (0.418), node of the first female flower (0.164), days taken from fruit set to harvest

maturity (0.056), fruit diameter (0.012), average fruit weight (0.010) while, rest of the characters recorded indirect negative values.

Average internodal length exhibited positive indirect effect via number of fruits per plant (0.311), node of the first female flower (0.129), days taken from fruit set to harvest maturity (0.059), number of seeds per fruit (0.023), average fruit weight(0.005) while, rest of the characters showed indirect negative values.

Days taken for appearance of first female flower recorded positive indirect effect via number of fruits per plant (0.311), node of the first female flower (0.129), days taken from fruit set to harvest maturity (0.059), number of seeds per fruit (0.023), average fruit weight (0.005) while, rest of the characters showed indirect negative values.

Petiole length observed positive indirect effect via number of seeds per fruit (0.316), node of the first female flower (0.094), days taken from fruit set to harvest maturity (0.067), fruit diameter (0.050), average fruit weight (0.029) while, rest of the characters exhibited negative indirect values.

Node of the first female flower had positive indirect effect via days taken from fruit set to harvest maturity (0.213), number of seeds per fruit (0.132), leaf width (0.113), fruit diameter (0.036), leaf length (0.032), average internodal length (0.017), petiole length (0.010) while, rest of the characters showed indirect negative values.

Fruit length recorded positive indirect effect via number of seeds per fruit (0.626), average fruit weight (0.086), days taken from fruit set to harvest maturity (0.048) while, rest of the characters exhibited indirect negative values.

Fruit diameter exhibited positive indirect effect via number of seeds per fruit (0.122), days taken from fruit set to harvest maturity (0.059), average internodal length (0.027), days taken for appearance of first female flower (0.010),

fruit length (0.003) whereas, rest of the characters exhibited low positive indirect effect and indirect negative values.

Number of fruits per plant observed positive indirect effect via number of seeds per fruit (0.272), node of the first female flower (0.181), days taken for appearance of first female flower (0.016), petiole length (0.002), fruit length (0.003) while, rest of the characters observed indirect negative values.

The positive indirect effect of number of seeds per fruit on total fruit yield per plant was observed highest via average fruit weight (0.879), days taken from fruit set to harvest maturity (0.091), fruit diameter (0.043) while, rest of the characters exhibited indirect negative values.

Average fruit weight had positive indirect effect through number of seeds per fruit (0.558), node of the first female flower (0.079), average internodal length (0.015) while, rest of the characters showed indirect negative values.

Days taken from fruit set to harvest maturity had positive indirect effect through number of seeds per fruit (0.105), fruit diameter (0.036), leaf length (0.004) while, rest of characters exhibited indirect negative values for total fruit yield per plant. The findings are supported by studies carried out by Sarkar (1999), Malek *et al.* (2007) Khan *et al.* (2009) in pointed gourd, Kumaresan *et al.* (2006) in snake gourd and Bharti *et al.* (2008) in ivy gourd.

4.8 Genetic divergence (D^2)

The results of D^2 analysis revealed that as per studies during the year 2012-13, the twenty four genotypes were grouped into four clusters. The inter and intra cluster D^2 Values are presented in Table 4.19.

4.8.1 Intra cluster distance (2012-13)

Cluster III had the highest intra cluster distance of 2.975 followed by cluster IV (2.821), cluster I (2.498) and cluster II (2.183).

The inter cluster distance was observed highest in between cluster II and III (4.990). The inter cluster D^2 values were also high between cluster I and IV (4.653), I and III (4.439), cluster I and II (3.359), Cluster II and IV (3.235), Cluster III and IV (4.099). The lowest inter cluster D^2 value was found between Cluster II and IV (3.235)

Table 4.19: Composition of clusters for fruit yield per plant (kg) and its components in pointed gourd genotypes (2012-13)

Cluster	No. of genotypes included	Name of genotypes
I	11	IPG-1, IPG-15, IPG-16, IPG-17, IPG-18, IPG-19, IPG-20, IPG-21, IPG-22, IPG-23, IPG-24
II	3	IPG-7, IPG-8, IPG-13
III	6	IPG-2, IPG-3, IPG-5, IPG-10, IPG-11, IPG-12
IV	4	IPG-4, IPG-6 ,IPG-9, IPG-14

Table 4.20: Intra and inter cluster average D^2 values (2012-13)

Cluster	Cluster I	Cluster II	Cluster III	Cluster IV
Cluster I	**2.498**	3.359	4.439	4.653
Cluster II		**2.183**	4.990	3.235
Cluster III			**2.975**	4.099
Cluster IV				**2.821**

Composition of clusters for fruit yield per plant (kg) and its components in pointed gourd genotypes during the year 2012-13 are presented in Table 4.19. Cluster number I had the highest 11 genotypes followed by cluster number III (6 genotypes), cluster number IV (4 genotypes) and lowest number of genotypes were in cluster number II (3 genotypes).

4.8.2 Intra cluster means (2012-13)

The intra cluster means for thirteen characters given in Table 4.21 revealed marked difference between the four clusters in respect of cluster means for different characters.

The cluster mean for leaf length was the highest for cluster IV (12.49 cm) followed by cluster II (11.77 cm) and cluster III (10.77 cm). The lowest cluster mean for leaf length showed by cluster I (8.32 cm).

In case of character, leaf width the highest cluster mean was obtained for cluster IV (9.13 cm) followed by cluster III (7.92cm), cluster II (7.71 cm) and cluster I (7.26 cm) showed the lowest cluster mean value.

The highest cluster mean for average internodal length was observed for cluster IV (9.48 cm) followed by cluster II (8.67 cm) and cluster III (7.93 cm). The lowest cluster mean for average internodal length was observed in cluster I (7.85 cm).

Cluster III (54.62) showed the highest cluster mean for days taken for appearance of first female flower followed by cluster IV (52.48) and cluster I (52.42 cm). The lowest cluster mean was observed in cluster II (44.63).

The highest cluster mean value for petiole length was observed for cluster IV (4.49 cm) followed by cluster III (3.34 cm) and cluster II (2.78 cm). The lowest cluster mean was observed for cluster I (2.68 cm).

Cluster III had the highest treatment mean for the node of the first female flower (13.62) followed by cluster I (11.03) and cluster IV (10.39). The lowest cluster mean was observed for cluster II (9.61).

Cluster IV had the highest treatment mean for fruit length (4.34 cm) followed by cluster III (3.36 cm) and cluster II (2.78 cm). The lowest cluster mean was observed for cluster I (2.68 cm).

Table 4.21: Mean value for fruit yield per plant and its components in various clusters (Year: 2012-13)

S. No.	Observations	Cluster Number				Mean	Range	
		I	II	III	IV		Min.	Max.
1.	Leaf length (cm)	8.32	11.77	10.77	12.49	10.84	8.32	12.49
2.	Leaf width (cm)	7.26	7.71	7.92	9.13	8.01	7.26	9.13
3.	Average Internodal length(cm)	7.85	8.67	7.93	9.48	8.48	7.85	9.48
4.	Days taken for appearance of first female flower	52.42	44.63	54.62	52.48	51.04	44.63	54.62
5.	Petiole Length(cm)	2.68	2.78	3.34	4.49	3.32	2.68	4.49
6.	Node of the first female flower	11.03	9.61	13.62	10.39	11.16	9.61	13.62
7.	Fruit Length(cm)	2.68	2.78	3.36	4.34	3.29	2.68	4.34
8.	Fruit diameter (cm)	3.24	3.12	3.29	3.11	3.19	3.12	3.29
9.	No. of fruits/plant	188.79	211.63	127.25	157.45	171.28	211.63	211.63
10.	No. of seeds/fruit	5.99	7.97	7.29	7.64	7.22	5.99	7.97
11.	Average fruit weight (g)	23.69	40.33	33.24	36.39	33.41	23.69	40.33
12.	Days taken from fruit set to Harvest maturity	7.03	6.07	7.76	7.14	7.00	6.07	7.76
13.	Yield per plant(kg)	4.91	6.80	3.69	4.32	4.93	3.69	6.80

The highest cluster mean for fruit diameter was observed for cluster III (3.29 cm) followed by cluster I (3.24 cm) and cluster II (3.12 cm). The lowest cluster mean fruit diameter was observed for the cluster IV (3.11 cm).

Cluster II (211.63) had the highest treatment mean for the number of fruits per plant followed by cluster I (188.79) and cluster IV (157.45). The lowest cluster mean for the number of fruits per plant was noted for cluster III (127.25).

Cluster III had the highest treatment mean for number of seeds per fruit II (7.97) followed by cluster III (7.29) and cluster IV (7.64). The lowest cluster treatment mean for number of seeds per fruit was found for cluster I (5.99).

Cluster II had the highest treatment mean for average fruit weight (40.33) followed by cluster IV (36.39) and cluster III (33.24). The lowest cluster mean for average fruit weight was showed by cluster I (23.69).

The highest cluster mean for days taken from fruit set to harvest maturity was observed for cluster III (7.76) followed by cluster IV (7.14) and cluster I (7.03). The lowest cluster mean for this attribute was noted by cluster II (6.07).

The highest cluster mean for yield per plant (kg) was recorded for cluster II (6.80 kg) followed by cluster I (4.91 kg), cluster IV (4.32 kg). The lowest cluster mean for yield per plant was found for cluster III (3.69 kg).

4.8.3 Intra cluster distance (2013-14)

The analysis of the results of the year 2012-13 grouped twenty four genotypes studied in to four clusters. The inter and intra cluster D^2 Values are presented in Table 4.22.

Cluster IV had the highest intra cluster distance of 3.039 followed by cluster II (2.858), cluster III (2.680) and cluster II (2.471).

The inter cluster distance was observed highest in between cluster III and IV (4.735). The inter cluster D^2 values were also high between cluster I and IV (4.666), cluster I and III (3.542), cluster II and IV (3.928) and cluster II and III

(3.549). The lowest inter cluster D^2 value was found between cluster I and II (3.196).

Composition of clusters for fruit yield per plant (kg) and its components in pointed gourd genotypes (2013-14) are presented in Table 4.23.

Cluster number III had the highest 9 genotypes followed by cluster number IV (7 genotypes), cluster number II (5 genotypes) and lowest genotypes were grouped in cluster number I (3 genotypes).

Table 4.22: Intra and inter cluster average D^2 values (2013-14)

Cluster S. No.	Cluster I	Cluster II	Cluster III	Cluster IV
Cluster I	**2.471**	3.196	3.542	4.666
Cluster II		**2.858**	3.549	3.928
Cluster III			**2.680**	4.735
Cluster IV				**3.039**

Table 4.23: Composition of clusters for fruit yield per plant (kg) and its components in pointed gourd genotypes (2013-14)

Cluster S. No.	No. of genotypes included	Name of genotypes
I	3	IPG-1, IPG-2, IPG-12
II	5	IPG-7, IPG-8, IPG-13 ,IPG-23, IPG-24
III	9	IPG-6, IPG-15, IPG-16, IPG-17, IPG-18, IPG-19, IPG-20, IPG-21, IPG-22,
IV	7	IPG-3, IPG-4, IPG-5, IPG-9, IPG-10, IPG-11, IPG-14

4.8.4 Intra cluster means (2013-14)

The intra cluster means for thirteen characters given in Table 4.24 revealed marked differences between the four clusters in respect of cluster means for different characters.

The cluster mean for leaf length was the highest for cluster IV (9.64 cm) followed by cluster II (8.70 cm) and cluster III (8.58 cm). The lowest cluster mean for leaf length showed by cluster I (6.26 cm).

In case of character, leaf width the highest cluster mean was obtained for cluster IV (7.43 cm) followed by cluster III (7.31cm), cluster II (6.15 cm) and cluster I (5.24 cm) showed the lowest cluster mean value.

The highest cluster mean for average internodal length was observed for cluster III (8.95 cm) followed by cluster IV (7.76 cm) and cluster II (6.83 cm). The lowest cluster mean for average internodal length was observed in cluster I (5.84 cm).

Cluster IV (54.38) showed the highest cluster mean for days taken for appearance of first female flower followed by cluster I (53.11) and cluster III (52.43 cm). The lowest cluster mean for days taken for appearance of first female flower was observed in cluster II (48.75).

The highest cluster mean value for petiole length was observed for cluster I (6.01 cm) followed by cluster IV (3.82 cm) and cluster III (3.16 cm), whereas lowest cluster mean for this attribute was observed for cluster I (2.77 cm).

Cluster I has the highest treatment mean for node of the first female flower (13.71) followed by cluster IV (12.50) and cluster III (11.58). The lowest cluster mean for node of the first female flower was observed for cluster II (8.69).

Cluster IV had the highest treatment mean for fruit length (8.00 cm) followed by cluster II (6.73 cm) and cluster III (6.10 cm). The lowest cluster mean for fruit length was observed for cluster I (5.99 cm).

Table 4.24: Mean value for fruit yield per plant and its components in various clusters (Year: 2013-14)

S. No.	Observations	Cluster Number				Mean	Range	
		I	II	III	IV		Min.	Max.
1.	Leaf length (cm)	6.26	8.70	8.58	9.64	8.30	6.26	9.64
2.	Leaf width (cm)	5.24	6.15	7.31	7.43	6.53	5.24	7.43
3.	Average Internodal length(cm)	5.84	6.83	8.95	7.76	7.35	5.84	8.95
4.	Days taken for appearance of first female flower	53.11	48.75	52.43	54.38	52.17	48.75	54.38
5.	Petiole Length(cm)	6.01	2.77	3.16	3.82	3.94	2.77	6.01
6.	Node of the first female flower	13.71	8.69	11.58	12.50	11.62	8.69	13.71
7.	Fruit Length(cm)	5.99	6.73	6.10	8.00	6.71	5.99	8.00
8.	Fruit diameter (cm)	3.46	3.27	3.19	3.43	3.34	3.19	3.46
9.	Number of fruits/plant	145.77	193.16	177.41	170.32	171.67	145.77	193.16
10.	No. of seeds/fruits	16.63	19.93	18.23	22.89	19.42	16.63	22.89
11.	Average fruit weight (g)	28.10	36.75	24.10	32.24	30.30	24.10	36.75
12.	Days taken from fruit set to Harvest maturity	7.61	6.77	6.84	7.59	7.20	6.77	7.59
13.	Yield per plant(kg)	4.07	6.41	4.59	4.80	4.97	4.07	6.41

The highest cluster mean for fruit diameter was observed for cluster I (3.46cm) followed by cluster IV (3.43 cm) and cluster II (3.27 cm). The lowest cluster mean for fruit diameter was observed by the cluster III (3.19 cm).

Cluster II (193.16) had the highest treatment mean for number of fruits per plant followed by cluster III (177.41) and cluster IV (170.32). The lowest cluster mean for number of fruits per plant was showed by cluster I (145.77).

Cluster III had the highest treatment mean for number of seeds per fruit (22.89) followed by cluster II (19.93) and cluster III (18.23). The lowest cluster treatment mean for number of seeds per fruit was showed by cluster I (16.63).

Cluster II had the highest treatment mean for average fruit weight (36.75) followed by cluster IV (32.24) and cluster I (28.10), whereas the lowest cluster mean for this attribute was showed by cluster III (24.10).

The highest cluster mean for days taken from fruit set to harvest maturity was observed for cluster I (7.61) followed by cluster IV (7.59) and cluster III (6.84). The lowest cluster mean for days taken from fruit set to harvest maturity was showed by cluster II (6.77).

The highest cluster mean for the yield per plant (kg) was recorded for cluster II (6.41 kg) followed by cluster IV (4.80 kg), cluster III (4.59 kg). The lowest cluster mean for the yield per plant was showed by cluster I (4.07 kg).

4.8.5 Intra and inter cluster distance (Pooled data)

On the basis of pooled data of two years study, the twenty four genotypes were grouped into four clusters. The inter and intra cluster D^2 Values are presented in Table 4.25.

Cluster I had the highest intra cluster distance of 2.761 followed by cluster IV (2.610), cluster III (2.598) and cluster II (2.522).

Table 4.25: Intra and inter cluster average D^2 values (pooled)

Cluster S. No.	Cluster I	Cluster II	Cluster III	Cluster IV
Cluster I	**2.761**	3.120	4.373	4.554
Cluster II		**2.522**	4.616	2.843
Cluster III			**2.598**	4.180
Cluster IV				**2.610**

Table 4.26: Composition of clusters for fruit yield per plant (kg) and its components in pointed gourd genotypes (Pooled data basis)

Cluster S. No.	No. of genotypes included	Name of genotypes
I	7	IPG-1, IPG-2, IPG-15, IPG-17, IPG-19, IPG-20, IPG-23
II	3	IPG-7, IPG-8, IPG-13
III	6	IPG-12, IPG-16, IPG-18, IPG-21, IPG-22, IPG-24
IV	8	IPG-3, IPG-4, IPG-5, IPG-6, IPG-9, IPG-10, IPG-11, IPG-14

Composition of clusters for fruit yield per plant (kg) and its components in pointed gourd genotypes on the basis of pooled data are presented in Table 4.26.

Cluster number IV had the highest 8 genotypes followed by cluster number I (7 genotypes), cluster number III (6 genotypes) and lowest was in cluster number II (3 genotypes).

The inter cluster distance was observed highest in between cluster I and IV (4.554). The inter cluster D^2 values were also high between cluster I and III (4.373)

cluster I and II (3.120), cluster II and III (4.616), Cluster III and IV (4.180). The lowest inter cluster D^2 value was found between cluster II and IV (2.843).

4.8.6 Intra cluster means (pooled data basis)

The intra cluster means on the basis of pooled data for thirteen characters is given in Table 4.27 revealed marked differences between the four clusters in respect of cluster means for different characters.

The cluster mean for leaf length was the highest for cluster IV (10.53 cm) followed by cluster II (10.28 cm) and cluster III (9.08 cm). The lowest cluster mean for leaf length was showed by cluster I (7.81 cm).

In case of character, leaf width the highest cluster mean was obtained for cluster IV (8.00 cm) followed by cluster III (7.53 cm), cluster II (6.84 cm) and cluster I (6.57 cm) showed the lowest cluster mean value.

The highest cluster mean for average internodal length was observed for cluster III (8.69 cm) followed by cluster IV (8.31 cm) and cluster II (7.98 cm). The lowest cluster mean for average internodal length was observed in cluster I (7.10 cm).

Cluster III (56.70) showed the highest cluster mean for days taken for appearance of first female flower followed by cluster IV (53.44) and cluster I (50.17 cm), whereas the lowest cluster mean for this attribute was observed in cluster II (44.29).

The highest cluster mean value for petiole length was observed for cluster IV (3.95 cm) followed by cluster III (3.17 cm) and cluster II (3.04 cm). The lowest cluster mean for petiole length was observed for cluster I (2.43).

Cluster IV has the highest treatment mean for node of the first female flower (12.15) followed by cluster I (11.83) and cluster III (11.18). The lowest cluster mean for node of the first female flower was observed for cluster II (9.28).

Table 4.27: Mean value for fruit yield per plant and its components in various clusters (pooled data basis)

S. No.	Observations	Cluster Number				Mean	Range	
		I	II	III	IV		Min.	Max.
1.	Leaf length (cm)	7.81	10.28	9.08	10.53	9.43	7.81	10.53
2.	Leaf width (cm)	6.57	6.84	7.53	8.00	7.24	6.57	8.00
3.	Average Internodal length	7.10	7.98	8.69	8.31	8.02	7.10	8.69
4.	Days taken for appearance of first female flower	50.17	44.29	56.70	53.44	51.15	44.29	56.70
5.	Petiole Length(cm)	2.43	3.04	3.17	3.95	3.15	2.43	3.95
6.	Node of the first female flower	11.83	9.28	11.18	12.15	11.11	9.28	12.15
7.	Fruit Length (cm)	4.23	5.01	4.51	5.90	4.91	4.23	5.90
8.	Fruit diameter (cm)	3.30	3.23	3.19	3.31	3.26	3.19	3.31
9.	No. of fruits/plant	179.12	217.09	176.44	148.09	180.19	148.09	217.09
10.	No. of seeds/fruit	11.42	13.95	12.80	15.05	13.31	11.42	15.05
11.	Average fruit weight (g)	25.64	38.41	25.23	34.08	30.84	25.23	34.08
12.	Days taken from fruit set to Harvest maturity	6.75	6.16	7.72	7.37	7.00	6.16	7.72
13.	Yield per plant(kg)	4.80	6.73	4.65	4.36	5.14	4.36	6.73

Cluster IV had the highest treatment mean for fruit length (5.90 cm) followed by cluster II (5.01 cm) and cluster III (4.51 cm). The lowest cluster mean for fruit length was observed for cluster I (4.23 cm).

The highest cluster mean for fruit diameter was observed for cluster IV (3.31 cm) followed by cluster I (3.30 cm) and Cluster II (3.23 cm), whereas the lowest cluster mean for this attribute was observed by the cluster III (3.19 cm).

Cluster II (217.09) had the highest treatment mean for number of fruits per plant followed by cluster I (179.12) and cluster III (176.44). The lowest cluster mean for number of fruits per plant was showed by cluster IV (148.09).

Cluster IV had the highest treatment mean for number of seeds per fruit (15.05) followed by cluster II (13.95) and cluster III (12.80). The lowest cluster treatment mean for number of seeds per fruit was showed by cluster I (11.42).

Cluster II had the highest treatment mean for average fruit weight (34.08) followed by cluster IV (34.08) and cluster I (25.64). The lowest cluster mean for average fruit weight was showed by cluster III (25.23).

The highest cluster mean for days taken from fruit set to harvest maturity was observed for cluster IV (7.37) followed by cluster III (7.72) and cluster I (6.75). The lowest cluster mean for days taken from fruit set to harvest maturity was showed by cluster II (6.16).

The highest cluster mean for the yield per plant (kg) was recorded for cluster II (6.73 kg) followed by cluster I (4.80 kg), cluster III (4.65 kg). The lowest cluster mean for the yield per plant was showed by cluster IV (4.36 kg).

4.9 Genetic diversity based on molecular markers in selected pointed gourd genotypes

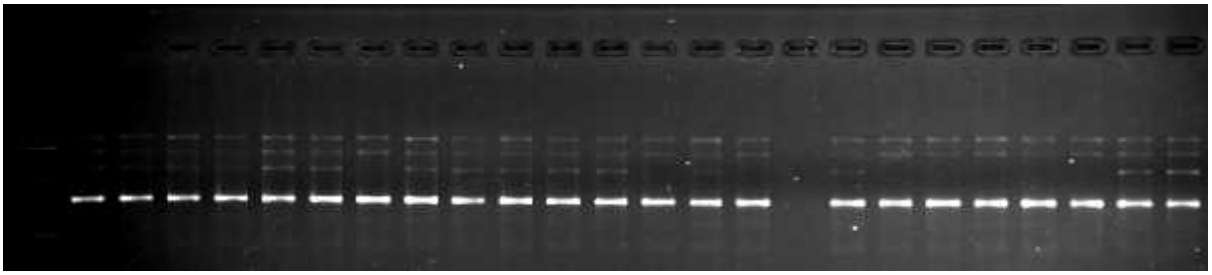
ISSR results were analyzed using NTSYS (Numerical Taxonomy System Biostatistics) PC Ver. 2.02e numerical software package. Out of 12, 10 ISSR primers (Fig. 4.7 shows typical examples of ISSR amplification patterns) generated a total of 426 bands which were scored as present (1) or absent (0) for determining the genetic relationship among the genotypes. Similarity matrices were calculated

using NTSYS (Numerical Taxonomy System Biostatistics) computer programme. Cluster analysis was done within the SAHN program by using UPGMA (Unweighted pair-group method with arithmetic averages) method.

The similarity coefficient ranged from 0.78 to 0.95. The dendrogram indicated that all genotypes are grouped into 2 major clusters namely; A and B. Major cluster 'A' consisting of only 23 genotypes whereas major cluster 'B' consisting of only 1 genotype that is G16 variety having 0.80 similarities coefficient with cluster 'A' (Fig. 4.8).

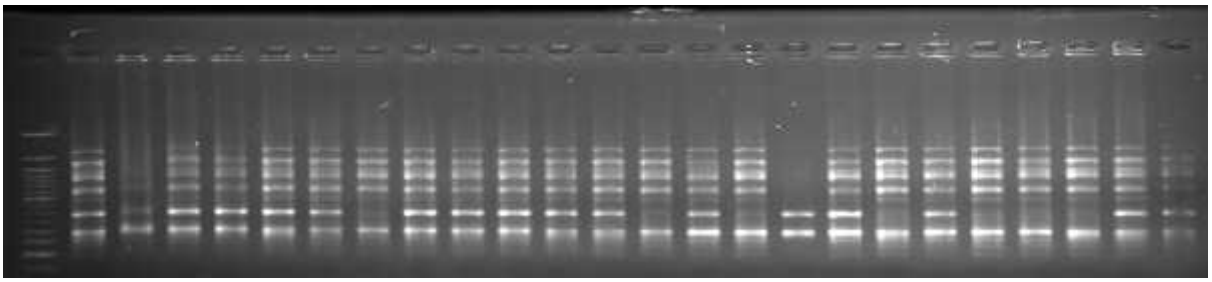
Major cluster 'A' showed 2 sub clusters as 'A_1' and 'A_2' near the 0.75 similarity level which consist 22 and 1 genotype respectively. Sub-cluster 'A1' showed further sub-clustering near the 0.68 similarity level as A_1 (a) and A_1 (b) which consisted 14 and 8 genotypes respectively. Sub-cluster A_1 (a) have 14 genotypes; whereas sub-cluster A_1 (b) showed further sub-clustering near the similarity level 0.70 as A1 (b1) and A1 (b2) which have 7 and 1 genotype(s) respectively.

Genetic diversity analysis based on molecular markers in pointed gourd genotypes results showed that there is higher similarity at genetic level amongst the genotypes of point gourd. Only one genotype IPG-16 showed genetic diversity as compared to other twenty three genotypes.

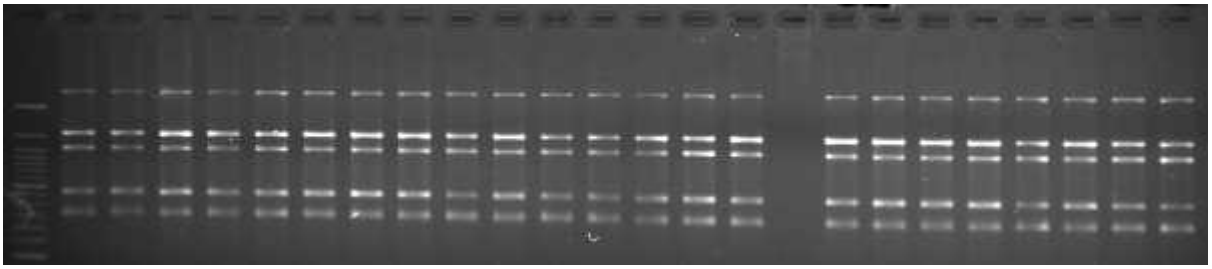


Pointed gourd (UBC 807)

Pointed gourd (UBC 810)



Pointed gourd (UBC 812)



Pointed gourd (UBC 815)

Fig 4.7 ISSR Profile generated by UBC 807, UBC 810, UBC 812, and UBC 815 primer of twenty four pointed gourd genotypes

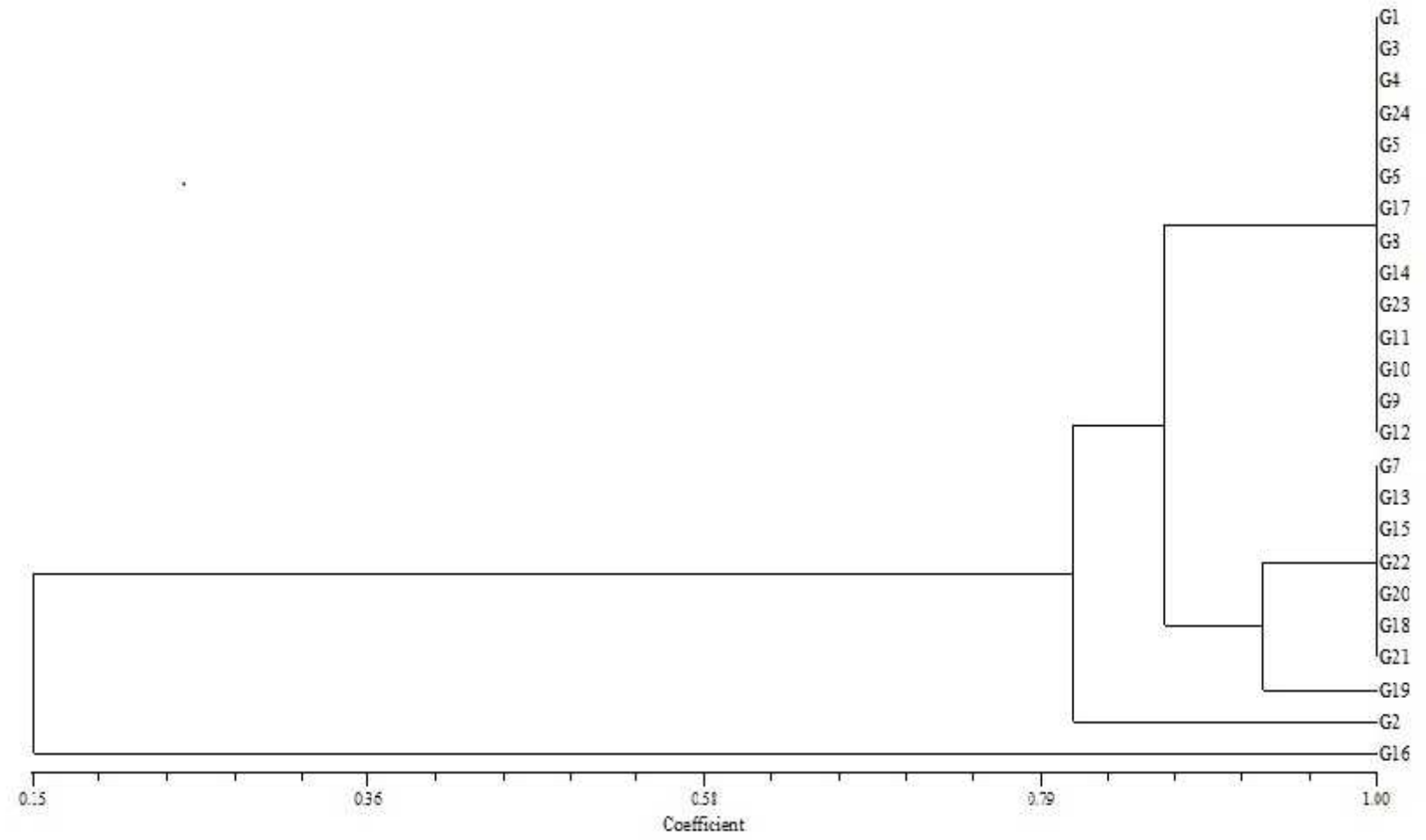


Fig 4.8 Dendrogram constructed using UPGMA based on Jaccard's coefficient of 24 pointed gourd genotypes (ISSR Markers)

CHAPTER-V
SUMMARYAND CONCLUSIONS

SUMMARY

The present investigation entitled “Evaluation, characterization and diversity analysis of local genotypes of Pointed Gourd (*Trichosanthes dioica* Roxb.)” was undertaken to study the characterization of collected genotypes, mean performance of genotypes, genetic variability heritability, genetic advance, correlation, path coefficient and genetic divergence analysis of diverse genotypes to identify suitable pointed gourd genotypes with higher fruit yield. The second part of the experiment was aimed for the use of molecular markers based on DNA sequence polymorphism in independent of environmental conditions.

The experimental material comprised of twenty two indigenous genotypes of pointed gourd collected from different districts of Chhattisgarh and two released varieties. On the basis of high fruit yield and other attributes best genotypes were selected. The collected genotype was used for further molecular marker study.

The present investigation was carried out at Horticulture Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Kharif* and Summer seasons of 2012-13 and 2013-14 and second experiment on molecular marker study was conducted in Dr. R.H. Richharia Research Laboratory, Indira Gandhi Krishi Vishwavidyalaya, Raipur during subsequent winter season of 2013-14. The first part of experiment comprised of twenty two genotypes of pointed gourd along with two standard checks grown in three replications in a Randomized Complete Block Design.

The observations were recorded on leaf length, leaf width, average internodal length, days taken for appearance of first female flower, petiole length, node of the first female flower, fruit length, fruit diameter, number of fruits per plant, number of seeds per fruit, average fruit weight, days taken from fruit set to harvest maturity, yield per plant and total fruit yield.

The morphological characterization of genotypes was also done as per IIVR unpublished descriptor of Pointed Gourd (*Trichosanthes dioica* Roxb.).

The analysis of variance found highly significant for most of the characters studied. Therefore it is evident that sufficient variability exists among the genotypes for carrying out various analyses. The mean squares due to genotypes were found to be significant for almost all the characters, indicating the existence of substantial variability for different characters under study of pointed gourd.

The genotype IPG-14 found superior in respect of leaf width, internodal length, length of petioles and maximum number of fruits per plant. Genotype IPG-8 has first of appearance female flower and maximum yield of fruit per plant. Swarna Rekha has maximum number of node for the appearance of first female flower and average length of fruit. For maximum fruit diameter was recorded in (IPG-17) and IPG-12 has recorded for maximum number of seeds per fruit. However, IPG-13 recorded maximum average weight of individual fruit. Further, genotype IPG-17 recorded earliest harvest maturity.

A wide range of genotypic coefficient of variation was observed in most of the plant characters, namely petiole length followed by number of fruits per plant, yield per plant, average fruit weight, node of the first female flower, fruit length, average internodal length and leaf length, whereas fruit diameter had the lowest genotypic coefficient of variation. The highest value of phenotypic coefficient of variation was recorded for petiole length followed by number of fruits per plant, average fruit weight, yield per plant, average internodal length, node of the first female flower, fruit length and leaf length, whereas fruit diameter had the lowest genotypic coefficient of variation.

Heritability estimates were high for most of the characters studied. The yield per plant followed by days taken for appearance of first female flower, days taken from fruit set to harvest maturity, average fruit weight node, fruit length, node of the first female flower, petiole length, leaf width leaf length and number of seeds per fruit. The moderate heritability was recorded in number of fruits per

plant. The characters showed low heritability includes average internodal length and fruit diameter.

Genetic advance as per cent of mean showed high range for the most of the attributes studied. The petiole length followed by yield per plant, average fruit weight, number of fruits per plant, node of the first female flower, fruit length, leaf length, number of seeds per fruit, days taken from fruit set to harvest maturity, leaf width and average internodal length. The character days taken for appearance of first female flower showed moderate magnitude of genetic advance as per cent of mean whereas fruit diameter recorded low range of this parameter.

Some of the associations had positive association with yield per plant such as leaf width, leaf width, average internodal length, days taken for appearance of first female flower, node of the first female flower, petiole length, fruit length, fruit diameter, number of fruits per plant, number of seeds per fruit, average fruit weight, days taken from fruit set to harvest maturity. The improvement of yield per plant can be possible by practicing individual selection for number of fruits per plant and average fruit weight.

Path coefficient analysis revealed that the growth characters leaf length had maximum positive direct effect. Petiole length, average internodal length, leaf width and node of the first female flower had exhibited direct negative effect.

Path coefficient analysis raveled that the days taken from fruit set to harvest maturity had maximum positive direct effect on yield per plant followed by fruit diameter, average fruit weight, number of fruits per plant, fruit length whereas number of seeds per fruit showed highest negative direct effect on fruit yield per plant.

The twenty four genotypes were grouped into four clusters. Cluster number IV had the highest 8 genotypes followed by cluster number I (7 genotypes), cluster number III (6 genotypes) and lowest was in cluster number II (3 genotypes). Cluster I had the highest intra cluster distance of 2.761 followed by cluster IV (2.610), cluster III (2.598) and cluster II (2.522). The inter cluster distance was observed highest in between cluster I and IV (4.554). The inter cluster D^2 values

were also high between cluster I and III (4.373) cluster I and II (3.120), cluster II and III (4.616), Cluster III and IV (4.180). The lowest inter cluster D^2 value was found between cluster II and IV (2.843).

Genetic diversity analysis based on molecular markers in pointed gourd genotypes results showed that there is higher similarity at genetic level amongst the genotypes of point gourd. Only one genotype IPG-16 showed genetic diversity as compared to other twenty three genotypes.

CONCLUSIONS

Based on the results, the following conclusions are drawn from the present investigation.

1. Characterization of genotypes provided the information on morphological agronomic and molecular aspects of the material that is essential for further improvement programme.
2. Analysis of variance found highly significant for most of the characters studied. Therefore, it is evident that sufficient variability exists among the genotypes studied.
3. The genotypes observed the highest mean performance under yield attributing characters of fruits per plant *viz.* IPG-10 and IPG-14 and for average weight of fruit IPG-18 and Swarna Rekha had maximum number of node for the appearance of first female flower and average length of fruit.
4. Considerable genetic variation has been exhibited by genotypes involved in present investigation. Petiole length followed by number of fruits per plant, yield per plant, average fruit weight, node of the first female flower, fruit length, average internodal length and leaf length.
5. Occurrence of high heritability coupled with high genetic advance as per cent of mean were noted for the characters *viz.,* days taken for appearance of first female flower, yield per plant, days taken from fruit set to harvest maturity, fruit length, leaf width, leaf length, petiole length, node of the first female flower, fruit diameter and average fruit weight which can be improved by direct selection.

6. The correlation coefficients were influenced by environmental factors. However, some of the characters exhibited some extent of association and not much affected by environment. The improvement of total fruit yield per plant can be possible by practicing individual selection for leaf width, leaf width, average internodal length, days taken for appearance of first female flower, node of the first female flower, petiole length, fruit length, fruit diameter, number of fruits per plant, number of seeds per fruit, average fruit weight, days taken from fruit set to harvest maturity. The improvement of yield per plant can be possible by practicing individual selection for number of fruit per plant and average fruit weight. Hence these characters must be given importance for further improvement of the population.
7. Path coefficient analysis for different growth characters on fruit yield per plant revealed that the leaf length had maximum positive direct effect. Petiole length, average internodal length, leaf width and node of the first female flower had exhibited direct negative effect.
8. On the basis of D^2 studies, highest inter cluster distance between cluster I and IV (4.554). The inter cluster D^2 values were also high between cluster I and III (4.373) cluster I and II (3.120), cluster II and III (4.616), Cluster III and IV (4.180). This suggested that the hybridization programme involving parents from these clusters are expected to give higher frequency of better segregates or desirable combination for development of useful genetic stocks or varieties.
9. Genetic diversity analysis based on molecular markers in pointed gourd genotypes results showed that there is higher similarity at genetic level amongst the genotypes of point gourd. Only one genotype IPG-16 showed genetic diversity as compared to other twenty three genotypes.

Suggestions for future work

1. An ideotype of pointed gourd may be developed on the basis of number of fruits per plant, average fruit weight and fruit yield per plant.
2. Characters *viz.*, petiole length followed by number of fruits per plant, yield per plant, average fruit weight, node of the first female flower, fruit length, average internodal length and leaf length, petiole length, yield per plant,

average fruit weight, node of the first female flower, fruit length, average internodal length and leaf length had high genotypic coefficient of variation, phenotypic coefficient of variations and genetic advance in the present investigation. These findings suggest a possibility of achieving desirable genetic gain through direct selection of aforesaid characters in pointed gourd crop.

3. The experiment should be repeated further to confirm the consistency of clustering pattern in the D^2 analysis.
4. Some of the best genetically diverse lines possessing desirable features can be evaluated in multi-location trials and stable genotype may be released as variety for commercial cultivation by the farmers.
5. Large number of genotypes should be collected and evaluated to find out the actual genetic variability available in pointed gourd.
6. There is need to screen the genotypes against biotic and abiotic stresses.
7. The genotypes IPG-3 and IPG-8 identified as the best genotypes for higher fruit yield per plant can be evaluated under multilocation trials across Chhattisgarh.
8. The bio-chemical analysis of fruit should be undertaken in further evaluation programme of the genotypes.
9. More number of genotypes should be included to study the genetic diversity based on molecular markers.

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Appendix – A: Weekly meteorological data during crop growth period (2012)

Wk No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Rain-fall (mm)	Relative Humidity (%)		Vapour Pressure (mm of Hg)		Wind Velocity (Kmph)	Sun Shine (hours)
					I	II	I	II		
1	**Jan 01-07**	26.3	18.7	34.1	96	72	16.2	17.6	0.7	0.9
2	**08-14**	24.2	11.0	20.6	94	39	10.3	8.3	0.6	6.7
3	**15-21**	26.9	10.5	0.0	86	31	9.1	18.7	1.5	9.0
4	**22-28**	25.7	12.5	0.0	86	42	10.2	10.4	0.6	5.2
5	**29-04**	25.4	13.1	5.4	87	47	10.7	10.9	1.0	4.5
6	**Feb 05-11**	29.7	12.4	0.0	78	27	9.1	7.9	0.7	9.1
7	**12-18**	30.1	16.2	0.0	85	44	12.8	14.6	2.4	7.9
8	**19-25**	33.2	14.9	0.0	78	25	10.9	9.2	2.2	9.3
9	**26-04**	33.5	15.2	0.0	77	23	11.2	8.8	2.6	8.4
10	**Mar 05-11**	33.6	15.9	0.0	71	19	10.6	7.1	3.6	8.8
11	**12-18**	34.6	17.5	0.0	70	21	11.9	8.6	3.8	8.0
12	**19-25**	37.9	17.4	0.0	68	19	11.5	9.1	2.5	8.4
13	**26-01**	38.5	20.1	0.0	57	16	11.7	8.1	2.7	8.1
14	**Apr 02-08**	39.2	23.5	0.0	57	21	13.5	10.6	5.6	8.3
15	**09-15**	39.6	23.9	9.2	57	20	15.1	10.3	6.3	8.5
16	**16-22**	40.2	24.8	0.0	48	16	13.3	8.7	3.6	9.4
17	**23-29**	39.1	25.2	6.6	68	25	18.7	12.9	5.6	8.5
18	**30-06**	40.9	25.5	0.0	59	14	17.0	7.5	5.9	10.4
19	**May 07-13**	41.1	27.4	0.0	43	19	13.6	11.0	4.6	8.1
20	**14-20**	43.3	27.6	0.0	43	13	14.4	8.4	4.5	9.4
21	**21-27**	44.6	28.5	0.0	34	11	12.3	7.7	3.7	8.0
22	**28-03**	45.8	28.4	2.2	29	13	11.8	8.1	5.2	7.8
23	**Jun 04-10**	43.4	30.8	0.0	43	22	16.0	13.2	8.7	9.0
24	**11-17**	38.3	26.6	103.6	74	48	21.4	19.9	9.5	3.9
25	**18-24**	31.0	24.2	124.2	89	69	21.5	22.2	9.1	1.5
26	**25-01**	37.0	26.3	21.8	78	49	21.3	20.0	8.3	7.7
27	**Jul 02-08**	30.3	25.0	72.9	91	81	22.9	24.5	7.5	2.3
28	**09-15**	31.7	25.5	73.6	91	69	23.4	23.7	6.0	4.0
29	**16-22**	29.9	24.5	341.4	93	83	22.7	24.1	5.9	1.1
30	**23-29**	27.6	24.1	60.3	92	88	21.6	23.1	9.3	0.7
31	**30-05**	25.8	23.2	271.1	95	91	21.1	22.5	11.1	0.0
32	**Aug 06-12**	28.8	24.8	106.8	93	79	22.6	22.6	8.7	1.3
33	**13-19**	30.2	25.3	33.2	90	78	22.7	22.4	6.4	3.5
34	**20-26**	29.6	24.5	127.6	93	78	22.6	23.0	5.6	3.1
35	**27-02**	31.1	25.8	55.6	92	74	24.1	24.3	2.9	4.7
36	**Sep 03-09**	30.3	25.1	74.4	93	75	23.9	23.4	3.4	2.5
37	**10-16**	30.4	24.7	42.6	93	74	22.8	22.8	6.8	4.0
38	**17-23**	31.4	24.6	84.4	95	73	23.0	23.0	3.3	4.3
39	**24-30**	32.2	24.4	2.8	90	54	22.4	19.0	1.9	8.3
40	**Oct 01-07**	31.9	23.9	9.2	91	56	21.8	19.1	2.3	7.6
41	**08-14**	31.0	20.2	0.0	89	45	17.6	14.4	1.3	8.0
42	**15-21**	31.9	19.5	0.0	88	37	16.9	12.6	1.4	8.6
43	**22-28**	31.6	18.4	0.0	85	38	15.4	12.8	2.3	6.9
44	**29-04**	28.9	18.4	27.3	92	59	16.2	15.8	2.3	4.9
45	**Nov 05-11**	28.5	17.3	5.6	95	45	15.2	21.5	0.8	6.6
46	**12-18**	28.4	12.7	0.0	90	33	11.1	9.2	1.4	9.1
47	**19-25**	29.6	16.4	0.0	84	43	12.9	13.0	1.6	7.3
48	**26-02**	30.1	14.3	0.0	89	35	12.1	10.7	0.8	8.4
49	**Dec 03-09**	30.3	13.6	0.0	88	31	11.1	9.7	0.7	7.7
50	**10-16**	30.0	18.1	0.2	91	50	15.0	15.0	3.4	6.4
51	**17-23**	28.3	11.0	0.0	90	29	9.9	8.0	1.1	7.9
52	**24-31**	25.6	8.3	0.0	88	30	8.1	7.6	1.1	9.0
	Mean/Total	**32.7**	**20.6**	**1716.7**	**79**	**44**	**16.1**	**14.8**	**3.9**	**6.4**

Appendix – B: Weekly meteorological data during crop growth period (2013)

Wk No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Rain-fall (mm)	Relative Humidity (%)		Vapour Pressure (mm of Hg)		Wind Velocity (Kmph)	Sun Shine (hours)
					I	II	I	II		
1	Jan 01-07	28.0	16.0	1.2	86	57	12.4	15.0	1.5	3.3
2	08-14	26.3	9.1	0.0	86	24	8.0	6.3	1.3	8.1
3	15-21	30.7	14.6	0.0	81	39	10.8	11.6	1.2	8.8
4	22-28	27.0	12.2	0.0	81	36	9.3	8.9	1.1	6.1
5	29-04	28.8	11.4	0.0	84	31	9.1	8.7	1.1	7.9
6	Feb 05-11	30.0	16.8	0.2	86	44	13.0	12.6	1.3	6.7
7	12-18	29.7	16.4	11.6	87	47	13.2	13.0	2.5	6.7
8	19-25	29.8	14.6	0.8	84	36	11.5	11.0	2.1	9.9
9	26-04	32.3	13.8	0.0	79	22	11.0	7.9	2.1	10.0
10	Mar 05-11	34.3	14.8	0.0	71	19	10.1	7.5	1.8	9.6
11	12-18	33.8	20.4	0.0	70	31	13.4	11.5	3.3	6.1
12	19-25	36.4	20.2	0.0	66	22	13.4	9.9	1.9	8.3
13	26-01	38.1	22.7	0.0	62	21	14.1	10.0	2.1	7.8
14	Apr 02-08	38.7	21.5	0.0	58	17	13.4	8.1	2.7	9.0
15	09-15	39.9	24.7	8.6	57	28	14.9	12.9	3.5	7.8
16	16-22	38.0	21.9	26.0	63	28	14.2	10.9	6.5	9.6
17	23-29	38.1	24.4	0.0	64	29	17.6	14.7	3.4	9.5
18	30-06	43.1	27.6	0.0	51	21	16.6	13.1	6.8	10.9
19	May 07-13	43.6	27.2	1.0	48	17	16.0	10.5	8.2	9.4
20	14-20	43.3	27.9	0.0	44	15	15.0	9.9	5.1	8.8
21	21-27	46.0	29.0	3.6	34	16	13.2	11.0	7.8	8.6
22	28-03	41.7	28.0	2.2	58	24	19.2	13.9	8.1	7.5
23	Jun 04-10	37.8	26.1	55.3	80	49	21.9	21.0	8.8	6.5
24	11-17	32.4	25.0	105.2	87	67	22.8	22.6	7.5	2.6
25	18-24	34.4	25.8	46.4	83	67	22.7	22.0	7.5	5.6
26	25-01	30.4	24.9	41.0	88	73	22.6	22.8	11.8	1.4
27	Jul 02-08	31.3	24.5	73.5	90	70	22.4	22.8	6.7	4.4
28	09-15	31.2	24.3	144.4	93	78	22.7	23.6	7.7	3.9
29	16-22	30.5	25.3	44.6	95	74	23.5	24.6	6.4	2.3
30	23-29	28.4	24.7	88.2	92	83	22.2	22.6	9.0	0.7
31	30-05	28.3	23.9	255.8	95	84	22.1	23.0	7.4	1.3
32	Aug 06-12	31.1	24.7	87.4	93	76	23.2	23.2	5.2	3.3
33	13-19	31.3	24.3	177.0	95	80	23.0	24.1	3.2	3.3
34	20-26	27.9	23.8	60.5	92	84	21.0	22.3	9.3	1.5
35	27-02	29.3	24.5	120.8	95	80	23.0	23.9	5.8	3.1
36	Sep 03-09	31.1	24.8	54.8	93	76	23.5	24.2	3.0	4.2
37	10-16	31.9	25.2	11.6	92	73	24.2	23.6	2.0	6.2
38	17-23	29.9	24.1	92.6	93	77	22.4	22.9	3.7	2.5
39	24-30	32.0	24.9	28.6	93	68	23.3	22.2	2.7	6.3
40	Oct 01-07	30.1	24.1	45.2	95	75	22.3	22.7	3.6	4.2
41	08-14	30.2	23.3	8.6	89	71	20.4	20.8	4.6	3.5
42	15-21	30.7	21.4	0.0	91	56	18.9	18.0	2.0	8.6
43	22-28	28.8	22.6	32.6	96	73	20.5	20.4	3.9	2.1
44	29-04	30.5	17.3	0.0	92	38	15.5	12.1	0.7	8.9
45	Nov 05-11	30.0	16.7	0.0	91	37	14.4	11.2	0.6	8.2
46	12-18	27.5	13.2	0.0	91	36	11.6	9.6	1.0	7.6
47	19-25	30.3	16.7	0.0	87	40	13.0	12.4	1.5	7.3
48	26-02	30.0	15.6	0.0	83	35	12	10.8	1.6	8.4
49	Dec 03-09	28.1	11.8	0.0	91	31	10.4	8.3	1.3	8.5
50	10-16	27.7	9.8	0.0	90	27	8.9	7.3	1.3	9.0
51	17-23	28.1	11.7	0.0	90	34	10.1	9.2	1.6	8.0
52	24-31	28.3	12.7	0.0	93	40	10.8	10.9	0.9	6.5
	Mean/Total	32.4	20.6	1629.3	81	48	16.6	15.5	4.0	6.4

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Signature