GENETIC VARIABILITY AND DIVERGENCE ANALYSIS IN ASH GOURD [*Benincasa hispidia* (Thumb) Cogn.]

M. Sc. (Ag) Thesis

by

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DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
FACULTI OF AGRICULTURE
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GENETIC VARIABILITY AND DIVERGENCE ANALYSIS IN ASH GOURD [*Benincasa hispidia* (Thumb) Cogn.]

Thesis

Submitted to the

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by

Parmeshwar Kumar Sahu

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AUGUST, 2015

CERTIFICATE – I

This is to certify that the thesis entitled **"Genetic variability and divergence analysis in ash gourd [*Benincasa hispidia* (Thumb) Cogn.]"** submitted in partial fulfillment of the requirements for the degree of **Master of Science** in **Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Parmeshwar Kumar Sahu** under my 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 investigations have been duly acknowledged by him.

Chairman

Date: 13/10/2015

THESIS APPROVED BY THE STUDENTS ADVISORY COMMITTEE

Chairman : Dr. Dhananjay Sharma

Member : Dr. Neeraj Shukla

Member : Dr. Nandan Mehta

Member : Dr. R.R. Saxena

CERTIFICATE - II

This is to certify that the thesis entitled **"Genetic variability and divergence analysis in ash gourd [*Benincasa hispidia* (Thumb) Cogn.]"** submitted by **Parmeshwar Kumar Sahu** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Science** in the **Department of Horticulture** has been approved by the external examiner and Student's Advisory Committee after oral examination.

7.11.2015

Signature External Examiner

(Name: Dr. A. K. Das)

Date: 7. 11. 2015

Major Advisor ______________________

Head of the Department ______________________

Faculty Dean ______________________

Approved/Not approved

Director of Instructions ______________________

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"Education plays vital role in personal and social development and teacher plays a fundamental role in imparting education. Teachers have crucial role in shaping young people not only to face the future with confidence but also to build up it with aim and responsibility. There is no substitute for teacher pupil relationship". I start in the name of God -who has bestowed upon me all the physical and mental attributes that I posses and skill to cut through and heal a fellow human.

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LIST OF ABBREVIATIONS

%	Per cent
^{o}C	Degree Celsius
CD	Critical Difference
cm	Centimeter
CV	Coefficient of variation
SEm	Standard error of mean
DAS	Days after sowing
DAT	Days after transplanting
df	Degree of freedom
et al.	and co-workers/ and others
Fig.	Figure
FYM	Farm yard manures
g	Gram
GA	Genetic advance
GCV	Genotypic coefficient of variation
ha	Hectare
h^2 (b)	Heritability in broad sense
hrs	Hours
i.e.	That is
Kg	Kilogram
m^2	Square meter
MSS	Mean sum of square
No.	Number
NPK	Nitrogen, phosphorus and potassium
NS	Non significant
PCV	Phenotypic coefficient of variation
q	Quintal
q/ha	Quintal per hectare
T	Tonnes
var.	Variety
via.	Through
viz.	For example

THESIS ABSTRACT

a) Title of the Thesis:	Genetic variability and divergence analysis in ash gourd [*Benincasa hispidia* (Thumb) Cogn.]
b) Full Name of the Student	Parmeshwar Kumar Sahu
c) Major Subject:	Horticulture
d) Name and Address of the major advisor:	Dr. Dhananjay Sharma, Scientist Department of Vegetable Science, IGKV, Raipur
e) Degree to be Awarded:	M.Sc. (Ag) Horticulture

Signature of the student

Signature of Major Advisor

Date: 14/10/2015

Signature of Head of the Department

ABSTRACT

The present investigation was conducted during the year 2014-15 at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was comprised of thirty genotypes of ash gourd and laid out in randomized block design (RBD) with three replications. Data were analysed to work out the variability, correlation coefficient, path analysis and genetic divergence for the characters for yield and its component character. The analyses of variance revealed that mean sum of squares due to genotypes were highly significant for all characters. Which indicated that the presence of variability in the genotype. The genotype IAG 10 was found highest yield and earliest flowering was noted in IAG- 12 earliest.

High heritability coupled with high genetic advance was observed for node number of 1st female flower appears, average fruit weight (kg.) and fruit yield per plot (kg.).

Correlation coefficient analysis observed that number of fruits per plant and fruit girth exhibited the significant positive correlation with yield per plot. The path co – efficient analysis stated that number of fruits per plant had highest direct effect followed by fruit girth, average fruit weight, 100 seed weight, node number of first male flower, total soluble solid, duration of crop and number of branches per plant.

The divergence analysis revealed the presence of appreciable amount of genetic diversity among the genotypes under investigation. Thirty genotypes were grouped into five clusters. The cluster No II had highest number of genotypes (IAG 11, IAG1 8, IAG 21, IAG 22, IAG 23, IAG 25, IAG 26, IAG 27, IAG 28, IAG 30), cluster V had IAG-1, IAG-3, IAG-5, IAG-7, IAG-13, IAG-15, IAG-16, cluster I had IAG-2, IAG-4, IAG-8, IAG-9, IAG-17, IAG-20, cluster IV had IAG-6, IAG-12, IAG-14, IAG-19, IAG-24, IAG-29, and cluster III had lowest number of genotypes (IAG-10). Maximum intra – cluster distance was recorded for cluster IV where as highest intra – cluster distance in between cluster III and cluster IV. Node number to first female flower contributed maximum towards genetic divergence in Ash gourd.

सारांश

वर्तमान परीक्षण अखिल भारतीय समन्वित सब्जी अनुसंधान परियोजना के अंतर्गत, अनुसंधान एवं शैक्षणिक अध्ययन, प्रक्षेत्र इं गां. कृ. वि. रायपुर में वर्ष 2014–15 में किया गया। परिक्षण में रखिया के तीस जीन प्ररूपों को तीन पुनरावृतियों में यादृच्छिक खण्ड योजना में लगाया गया। विभिन्न लक्षणों से प्राप्त आंकड़ों से विभिन्नता, संह–संबंध गुणांक विश्लेषण एंव आनुवांशिक विविधता का सांख्यिकी विश्लेषण किया गया।

सभी लक्षणों के विचरण विश्लेषण से प्राप्त वर्गो के योग के औसत उच्च सार्थक पाये गए। एनोवा से प्राप्त उच्च सार्थक योग के औसतों से जीन प्ररूपो में विभिन्नता प्रमाणित होता है। जीन प्ररूप आई ए जी 10 सर्वाधिक ऊपज देने वाली एवं आई ए जी 12 एक अगेती जीन प्ररूप के रूप मे पाये गए।

सह–संबंध गुणांक विश्लेषण के अध्ययन से स्पष्ट है कि फलों की संख्या प्रति पौंध एवं प्रथम मादा पुष्प के आसंधि की संख्या का ऊपज के साथ धनात्मक एवं सार्थक सह–संबध है। प्रसरण गुणांक विश्लेषण में पाया गया कि ऊपज मे मादा पुष्पों की संख्या, प्रथम फल में परिवर्तित होने वाले दिन, फल की लम्बाई, फल की मोटाई, फल का वजन, फलों की संख्या प्रति पौंध, कुल विलेय ठोस एवं फसल की अवधि का सीधे उच्च धनात्मक प्रभाव पाया गया।

आनुवंशिक विविधता के विष्लेषण से ज्ञात होता है कि सभी जीन प्ररूपों में सार्थक रूप से आनुवांशिक विविधता पाई गई है। तीस जीन प्ररूपों को पाँच समूहों में विभाजित किया गया है। समूह द्वितीय के जीन प्ररूपों आई ए जी 11, आई ए जी 8, आई ए जी 21, आई ए जी 22, आई ए जी 23, आई ए जी 25, आई ए जी 26, आई ए जी 27, आई ए जी 28, एवं आई ए जी 30 के उपयोग संकरण हेतु किया जा सकता है। आनुवांशिक विविधता में प्रथम मादा पुष्प के आसंधि की संख्या का सर्वाधिक योगदान पाया गया।

CHAPTER – I

INTRODUCTION

Ash gourd [*Benincasa hispida* (Thumb) Cogn.] popularly known as Wax gourd, or White pumpkin is important cucurbitaceous vegetable grown thought mainly India in rainy season. It belongs to family cucurbitaceae having chromosome number 2n=24. It is believed to have originates in India. Among the cucurbits, ash gourd is considered a prized vegetable because of its high nutritional value, long storage life and good transport qualities, besides its medicinal properties. The young leaves, flowers and both immature and mature fruits are consumed. The mature fleshy fruit is either eaten raw or cooked as vegetable marrow or 'candied' as sweetmeat popularly known as 'petha'. It is a good source of carbohydrate, vitamin A, vitamin C and minerals like iron and zinc (Randhawa *et al.,* 1983 and Sureja *et al.*, 2006). An enzyme extracted from ash gourd juice can be used in place of calf rennet for producing cheddar cheese (Gupta and Eskin, 1977). It is also used to treat a variety of elements in ayurvedic and naturopathy systems of medicine. Fruit contains 0.4 per cent protein, 1.9 per cent carbohydrate, 0.3 per cent minerals and traces of vitamin A, B and D per 100 g of edible portion (Aykroyd, 1963).

Ash gourd is grown throughout India and found in both cultivated and non cultivated lands and genetic variability is present for fruit shape, size, days to flowering, wax deposition and other vegetative characters. Chhattisgarh state has good genetic diversity for various character and no exploration has been taken to trap the diversity. Genetic variability is present especially for fruit characters, days to flowering and days to maturity.

In spite of being in cultivation science ancient times and the presence of the wide germplasm had created wide genetic variability for various characters conscious evaluation and exploitation of germplasm has not been given much emphasis till date.

At present there is urgent need to develop early maturing high yielding variety possessing desirable processing traits. The genetic improvement of any crop depends upon the available genetic variability for quantitative traits and its judicious exploitation through efficient breeding methods (Chandra *et al*. 2012).

Ash gourd is generally a monoecious herb having climbing or trailing habit (Rashid., 1993). Andromonoecious and hermaphrodite flowers are also observed in ash gourd (Randhawa *et al.,* 1982., Rahman, 1996). Two botanical forms of ash gourd have been recognized in Japan, one is called typical, which is characterized by velvety testa and a marginal band around the seeds, while this characteristic is absent in the other form Though it is a very common crop, it may be mentioned that until to-date there is lack of released variety of ash gourd with high yield potential and better quality. Further, very limited attempt had been made for genetic improvement of this crop because of its high cross-pollination; hardly any genetically pure strain is available to the growers. Lacks of high yielding, disease and pest tolerant variety are the main constraints towards its production.

An understanding of the nature and magnitude of variability or genetic diversity among the genetic stocks is of prime importance to the breeder to overcome these production problems. A good knowledge of genetic diversity helps to Yield is a complex character controlled by a large number of contributing characters and their interactions. A study of correlation between different quantitative characters provides an idea of association that could be effectively exploited to formulate selection strategies for improving yield components. For any effective selection programme, it would be desirable to consider the relative magnitude of association of various characters with yield. The path coefficient technique developed by Wright (1921) helps in estimating direct and indirect contribution of various components in building up the total correlation towards yield. On the basis of these studies the quantum importance of individual character is marked to facilitate the selection programme for better gains.

The genetic improvement of any crop depends upon the available genetic variability for quantitative traits and its judicious exploitation through efficient breeding methods (Yadav and Kumar, 2012). The information about the nature and magnitude of genetic divergence is essential for selection of diverse parents for hybridization programme.. Evaluations of available germplasm immense importance in this regard and is necessary. At present, there is urgent need to develop early maturing high yielding region specific varieties to address local problems and also varieties with wider adoptability. It is the touchstone to a breeder to develop high yielding varieties through selection, either from the existing genotypes or from the segregates of a cross. Hence, information on variability in respect of yield and its contributing characters required to be properly assessed for its improvement. Therefore, the present investigation entitled "Genetic variability and divergence analysis in ash gourd [*Benincasa hispida* (Thumb) Cogn.]" will be undertaken with the following objectives:" will be undertaken with the following objectives:

1. To find out suitable genotypes for Chhattisgarh plains.
2. To work out genetic divergence for fruit yield and its component characters.
3. To work out parameters of genetic variability for fruit yield and its component characters.
4. To find out association (correlation and path analysis) in between fruit yield and yield components in ash gourd.

CHAPTER-II
REVIEW OF LITERATURE

An attempt has been made to collect and review the available literature on genetic variability and divergence in ash gourd for fruit yield and its component characters. Literatures on above aspects of the present study are reviewed in this chapter under the following heads.

2.1 Performance of genotypes/varieties

2.2 Genetic variability

2.3 Correlation studies and path coefficient analysis

2.4 Genetic divergence

2.1 Performance of genotypes/varieties

Sharma and Dhankar (1989) studied eighteen accessions of bottle gourd for traits like fruit shape and colour, number of days to production of the first female flower, male/female sex ratio, number of nodes per plant, internode length, number of fruits/plant and yield per plant and concluded that the accessions HBG3 (round-fruited), HBG2, HBG4 (both bell-shaped), HBG13, HBG14 and HBG18 (all long-fruited) would be best for use in breeding programmes to produce the desired high-yielding type.

Sharma and Dhankar (1990) evaluated thirty five genotypes of bottle gourd and reported that Hisar Local-3, a round-fruited genotype, was the earliest and highest yielding (4.71 kg/plant). Amongst the long-fruited types, Pusa Summer Prolific Long was most promising for earliness and yield.

Lovely *et al*. (2004) at Vellyani India, work out divergence analysis using 25 genotypes of ash gourd collected from various agro climatic regions. Following the Mahalahobis D^2 statistics, the 25 genotypes were grouped into 4 clusters. Seeds per fruit contributed maximum to the total divergence followed by fruit yield per plant, mean fruit weight, fruits per plant and flesh thickness. Clustering pattern was not related to the geographical similarities as each cluster contained genotypes from various localities.

Ram *et al.* (2007) evaluated some winter fruited bottle gourd and observed a large genetic variation for characters like days to germination, flowering, edible maturity, number of branches per plant, fruit size (length x width), number of nodes on main vine, vine length, number of fruits per plant, individual fruit weight and yield per plant. Genotypes WVR-7, WVR-15, WVR-10 and WVR-19 were found promising for earliness, fruit size, individual fruit weight and yield.

Yadav *et al.* (2007) conducted an experiment with twenty diverse genotypes (VRBG-1, VRBG-2, VRBG-8, VRBG-14, VRBG-18, VRBG-33, VRBG-36, VRBG-37, VRBG-40, VRBG-44, VRBG-48, VRBG-101, VRBG-110, NDBG-56, Pusa-Naveen, Pusa Summer Prolific Long (PSPL), PBOG-61, IC-42345, DVBG-2 and NDBG-58) of bottle gourd in randomized block design with three replications. Among all the genotypes, VRBG-110, NDBG-56, VRBG-44, PBOG-61,

Xie *et al.* (2008) at China evaluated the quality of 24 genotypes of ash gourd for quality characters. Data were recorded for soluble solids content, acidity, flesh density, water content, fruit skin colour and shape. The flesh density and ratio of sugar to acid were the most important factors for quality evaluation. A set of quality comprehensive evaluation was developed based on the opinion of producers and consumers.

Mahto *et al.* (2010) evaluated fifteen lines of bottle gourd for different morphological characters, yield components and fruit yield. The genotypes varied in fruit colour (whitish to deep green with or without patches), shape (globular to elongated) and size. A good amount of variation was noticed in fruit length (10.42-42.33 cm). The inbreds, BCBG-17, BCBG-15, BCBG-33, BCBG-3 and BCBG-6 have emerged as highly promising for developing good quality hybrids.

Kumar and Prasad (2011) evaluated five hybrids and one open pollinated variety of bottle gourd. Among all the hybrids, Vikrant was found to be superior to the others in terms of fruit length, diameter, weight, yield, maximum net return per hectare and cost benefit ratio.

2.2 Genetic variability

Genetic variability is the raw material on which selection acts to evolve superior genotypes or varieties in plant breeding programme. The genetic variability for various characters available in the breeding populations or materials is systematically subjected to selection to change the genetic architecture of plant characters and consequently of the plant as a whole to develop improved genotype having higher economic yield. The variability exploited in breeding programme is derived from the naturally occurring variants and the wild relative of crops as well as artificially developed strains and genetic stocks by human-efforts. The reservoir of variability for different characters of a plant species resulting from available natural or artificially synthesized variants or strains constitutes its germplasm. Thus, germplasm may include improved strains, primitive cultivars, wild relatives, obsolete cultures, special genetic stocks, seeds pollen and vegetative parts etc. Most of the germplasm collections are inadequately evaluated or screened for assessment of genetic variability.

Variability in respect of different characters of ash gourd and allied crops is reviewed below. Moreover literatures related to the efficient multivariate techniques for diversity analysis are also reviewed.

Tyagi (1972) found wide range (13.1-21.9) of variability for fruits per plant in bottle gourd. He observed moderate heritability (56.52%) coupled with moderate genetic advance (31.95) for seeds per fruit and moderate heritability (58.9%) as well as moderate genetic advance (20.74) for seed length in bottle gourd.

Chhonkar (1977) found narrow range of variability for 100 seed weight in watermelon.

Mangal *et al.* (1981) observed significant differences among 21 bitter gourd genotypes for the traits leaf length and leaf width and found low genotypic and phenotypic variances for leaf length (1.83-1.99) and breadth (3.74-4.17). They also reported high heritability as well as high genetic advance for leaf length (91.96% and 41.33) and breadth (89.69% and 42.55) and variability for fruits per plant among the genotypes (6.0-17.5) and low value of genotypic and phenotypic variances for fruits per plant in bitter gourd (9.02 and 10.45). Significant variation for fruit length and diameter were also reported in bitter gourd. They observed genotypic and phenotypic variances for seeds per fruit in bitter gourd were 2.49 and 29.70, respectively.

Randhawa *et al.* (1982) observed the ratio of staminate to distillate flowers of ash gourd was 34:1.

Arora *et al.* (1983) observed a wide range of variability for fruits per plant among the genotypes of sponge gourd (0.3-12.0). They found significant variation for fruit length and diameter in this crop.

Vashishtha *et al.* (1983) found low range of variation (1.37-2.09) for fruits per plant in watermelon. They reported high heritability (76.7%) and considerable genetic advance (21.8) for seeds per fruit in water melon.

Swamy *et al.* (1984) conducted a field experiment on muskmelon and reported genetic diversity for vine length of this crop. They also found a wide range of variability among the genotypes for seed weight per fruit in muskmelon.

Rana *et al.* (1986) reported the genetic diversity for main vine length in pumpkin. Fruit weight of pumpkin also varied widely.

Hamid *et al.* (1989) studied nine local ash gourd genotypes for two years and observed that the first male flower opened within 41 to 50 and 50 to 66 days and the first female flower opened within 51 to 70 and 60 to 75 days in the 1st and 2nd year, respectively. They reported that the first male flower appeared within the node order of 10 to 13 (1st year) and 9 to 15 (2nd year) in some ash gourd genotypes but for the remaining test lines of the study, the node order was 22 to 28 in the 1st year and 23 to 31 in the 2nd year.

Rahman *et al.* (1996) Studied the flower biology of ash gourd and found that exotic materials (Chiquas, MKI and HF) produced higher number of female flowers (range 6-13) than those of local ones although the number of fruit setting depends upon the number of female flowers, the lowest percentage of fruit set (13%) was observed in the "Bisexual" which produced the highest number of hermaphrodite flowers. Maximum number of fruits per plant (7.8) as well as the highest percentage of fruit set (74.29%) was found in the exotic genotype “Chiqua-90-1 0”. All the exotic monoecious materials showed 51-75% fruit setting without hand pollination. However, in the local genotypes 50% of the female flowers produced fruit. hi also observed that weight of edible and mature fruits ranged from 0.94-1.72 kg and 1.59-2.92 kg, and local genotypes the weight of edible and mature fruits ranged from 1.28-1.59 kg and 3.10-1.08 kg, respectively. he also observed a wide range of variability for fruits per plant among the genotypes of bottle gourd (2.25-8.2) and significant variation for fruit length and diameter both in ribbed gourd and bottle gourd.

Hawlader *et al.* (1999) studied genetic variability in thirteen cultivars of bottle gourd for eight quantitative characters. A wide range of variability was recorded for most of the characters. Heritability was very high for all the eight characters. Number of male flowers, number of female flowers and fruit yield per plant exhibited high heritability coupled with high genetic advance.

Mathew *et al.* (2000) evaluated twenty eight bottle gourd genotypes for their qualitative and quantitative characters and observed significant difference in accession for quantitative characters, *viz.,* vine length, number of primary branches, days to first female flower opening, nodes to first female flower, sex ratio, number of fruits per plant, length of fruit, girth of fruit, 100 seed weight and number of seeds per fruit Maximum rang of variation was observed for number of seeds per fruit followed by fruit set percent. The highest genotypic and phenotypic coefficient of variation was recorded for number of fruits per plant and the lowest for inter node length.

Singh and Kumar (2002) studied genetic variability in bottle gourd and reported that the phenotypic coefficient of variation was higher than the genotypic coefficient of variation. Fruit yield per plant, fruit diameter, fruit length, fruit weight;

number of nodes to first male flower and vine length were characterized by high genetic variation. High estimates of heritability were recorded for fruit yield per plant, vine length, number of days to first harvest, number of nodes to first male and female flowers, number of primary branches per plant, and fruit length, weight and diameter. High heritability and high genetic advance were recorded for fruit yield per plant, vine length, fruit diameter, fruit length, fruit weight, number of nodes to first male and female flowers, and number of primary branches per plant.

Munshi and Acharyya (2005) evaluated twelve genotypes of bottle gourd and observed high genotypic and phenotypic coefficient of variation for vine length, number of primary branches per vine, number of nodes on the main axis, peduncle length, sex ratio, number of fruits per plant, fruit length, girth and weight, crop yield and starch and calcium content. Fruit girth and length, number of days to first fruit harvest and number of days to first female flower anthesis exhibited moderate to high heritability with moderate genetic advance.

Gayen and Hossain (2006) studied genetic variability and heritability of bottle gourd and observed that magnitude of phenotypic coefficient of variation (PCV) was significantly higher than genotypic coefficient of variation (GCV) for all characters suggesting the effect of environment on expression of these traits. GCV and PCV were high for fruit yield per plant and fruit length. The estimation of heritability ranged from 60.60 to 95.45%. A very high broad sense of heritability (80% and above) was recorded for length of main vine, number of primary branches per plant, number of nodes of first male flower, number of nodes of first female flower, number of days to first male flower anthesis, number of days to first female flower anthesis, sex ration, fruit length, fruit weight, number of fruits per plant, fruit yield per plant, TSS, ascorbic acid, total sugar, seed width, 100-seed weight and number of seeds per fruit. High genetic advance as percentage of mean was recorded for sex ratio, fruit length, fruit yield per plant and TSS. The sex ratio, fruit length, fruit yield per plant and TSS showed high heritability (above 80%) coupled with high genetic advance.

Gangopadhyay *et al.* (2008) at New Delhi reported genetic diversity, clustering pattern and ordination (principal components) analyses were undertaken in 26 ash gourd accessions. The accessions showed significant inter-population differences and wide variation for quantitative and qualitative morphological descriptors observed. Low level of difference between the magnitude of PCV and GCV indicated that the descriptors were least influenced by environment and are genetically controlled. High heritability coupled with high genetic advance was observed for descriptors such as primary branches, fruits/ plant and fruit weight/plant.

Singh *et al.* (2008) conducted an experiment to determine the genetic variability in bottle gourd, the analysis of variance revealed significant differences among the parents and their F_1 hybrids in both summer and rainy seasons for all the characters studied. The highest genotypic and phenotypic coefficients of variation were recorded for yield per vine in summer and rainy seasons. All the characters under study were highly heritable except number of days for bearing first male and female flowers in both the seasons. High heritability coupled with high genetic advance and genetic coefficient of variation were recorded for number of female flowers per vine, number of primary branches per vine and yield per vine in both the seasons which indicated that these characters are more reliable for effective selection.

Yadav *et al.* (2008) evaluated eighteen genotype of bottle gourd and observed variability for all the traits. The fruit width had the highest co-efficient of genotypic and phenotypic variability. High heritability coupled with high genetic advance were observed for fruit length, fruit width, days to first female flowering, days to first male flowering and yield per plant.

Pandey *et al.* (2008) at Varanasi reported that the variability was observed for characters like days to first female flower, fruit weight, equatorial and polar diameter. Cluster analysis based on quantitative traits revealed a high degree of diversity among the accessions. A non-significant correlation was observed between the clustering based on quantitative traits and RAPD markers. But the accessions like IVAG-107 and IVAG-81 clearly separated from rest of the accessions based on the quantitative traits and as well as RAPD primers. Both the dendrogram revealed that the accessions from northeastern region of India are diverse from the accessions of other parts of India, as they cluster together in both the dendrogram.

Pandit *et al.* (2009) studied fifteen genotype of bottle gourd and reported variability for all traits except fruit/plant. The moderate GCV and genetic advance was observed for fruit length and fruit weight. Thus, improving these characters should be effective and rewarding during selection.

Sharma *et al*. (2010) conducted an experiment on nine diverse genotype of bottle gourd and reported variability for days to first female flower, first female flowering node, fruit diameter, inter node length and fruits per vine. Medium heritability was observed for days to first female flower, first female flowering node, fruit diameter, inter node length, fruits per vine and ascorbic acid content whereas low heritability was observed for days to first picking, fruit length, vine length, branches per vine, average fruit weight, total yield per vine, chlorophyll content and dry matter content of fruit.

Husna *et al*. (2011) evaluated thirty one genotypes of bottle gourd and observed significant variation for all the characters. High GCV was observed for fruit yield per plant followed by fruit weight whereas low GCV was observed for fruit breadth. In all cases, phenotypic variances were higher than the genotypic variance. High heritability with high GA in percent of mean was observed for fruit yield per plant and days of first male flowering.

Kumar *et al.* (2012) studied genetic variability, heritability and genetic advance in bottle gourd for identifying desirable parents. The experiment comprising 24 hybrids obtained by crossing 11 parents (eight lines viz. C-29, C-37, C-74, C-78, C-4, C-55, C-34, C-26 and three tester viz. C-12 (Azad Harit), C-21 (PSPL) and C-35 (KLG)). Analysis of variance revealed the adequate variability among the all genotypes (Parents and Hybrids) for all characters. It was observed that genotypic and phenotypic coefficient of variations was high for fruit yield per plant followed by fruit length and number of seeds per fruit. Heritability was high for fruit yield per plant, number of seeds per fruit and fruit diameter. Genetic advance was high for fruit yield per plant.

Narayan *et al.* (2013) conducted an experiment on ten diverse genotype of bottle gourd and reported variability for fruit and seed characters *viz.*, days to 50% germination, days to first male flower anthesis, days to first female flower anthesis, node number of first male flower, node number of first female flower, days to first fruit harvest, number of branches per vine, vine length, fruit length, number of fruits per vine, fruit yield per vine, number of seeds per fruit and 100 seed mass.

Sharma and Sengupta (2013) evaluated sixteen genotypes of bottle gourd and reported that high genotypic co-efficient of variation (GCV) was observed for fruit weight (39.48%). In all cases, phenotypic co-efficient variances were higher than the genotypic co-efficient variance. High heritability with high genetic advance in percent of mean was observed for all characters.

Bhardwaj *et al.* (2013) evaluated twenty genotypes of bottle gourd and result revealed that the mean sum of squares due to replication was highly significant for all traits except fruit diameter, whereas the mean sum of squares due to genotype was highly significant for all the traits. GCV and PCV both were higher for vine length and number of primary branches. Number of primary branches, vine length and yield per plant indicated that these characters can be improved through simple selection. The heritability was high for all the traits. Genetic advance as per cent of mean was observed for vine length, number of primary branches and yield per plant.

2.3 Correlation and path coefficient analysis studies

The efficiency of selection can be improved by using correlation between different characters. The phenotypic correlation indicates the extent of observed relationship between two characters and this includes both hereditary and environmental influences, while genotypic correlation coefficient provides a real association between two characters and is most useful in selection (Johnson *et al.*, 1955).

The original concept of correlation was presented by Galton (1888) which was further elaborated by Fisher (1918) and Wright (1921). Genetic correlation can result either from pleiotropy or from linkages. While phenotypic value is a non-additive combination of both genetic and environmental correlation. This study merely indicates the nature of association and this alone does not provide the exact insight of the relative effect of each component character. A component character may have no direct effect on considerable economic trait but it may influence it via related characters. Hence knowledge of direct and indirect effects of different characters on desired traits are essential for selection to improve the population. The technique of path coefficient was originally developed by Wright (1921) who defined the path coefficient as the ratio of the standard deviation of the effect to the total standard deviation when all the causes are constant, except the one in question, the variability of which is kept unchanged. The path coefficient divides the correlation into direct and indirect effects and thus determines the nature of association (Falconer, 1960).

Tyagi (1972) studied correlation in bottle gourd for different morphological characters and found that number of fruits per plant, girth of fruit and length of fruit showed high heritability. They also reported that yield have significant association with the characters having high heritability estimates.

Rahman *et al.* (1986) evaluated four lines of bottle gourd and observed that fruit weight per plant had strong positive genotypic correlation with days to first picking, length of main vine and fruit diameter and a negative correlation with fruit length. Path coefficient analysis revealed that fruit diameter and fruit length had high positive direct effect on fruit weight per plant. Number of fruits per plant also had considerable positive direct effect on fruit weight per plant.

Prasad *et al.* (1993) studied correlation in thirty genotypes of bottle gourd and reported that fruit yield had significant positive association with number of fruits per vine, average weight of fruit and number of female flowers on primary laterals or per vine.

Narayan *et al*. (1996) evaluated twenty five diverse genotypes of bottle gourd. Correlation coefficient revealed that fruit yield per plant can be successfully improved by making selection or greater fruit number, higher fruit weight, greater number of primary branches and genotypes with lesser number of days to an thesis of first male flower. Path coefficient analysis revealed that maximum weight age should be given primarily to days to the first harvest followed by average weight of edible fruit, number of fruits per plant and days to anthesis of first female flower.

Kumar and Singh (1998) studied Correlation and path coefficient analysis in sixteen parents of bottle gourd and result revealed that yield per plant was positively correlated with average weight of edible fruit and number of fruits per plant at both genotypic and phenotypic levels. Path coefficient analysis revealed that maximum weight should be given to average weight of edible fruit and number of fruits per plant, while formulating selection indices for improvement of yield per plant in bottle gourd.

Hawlader *et al.* (1999) conducted an experiment with thirteen cultivars of bottle gourd and reported that fruit yield per plant showed significant positive associations with number of female flowers and fruits per plant. Path analysis indicated the highest contribution of number of female flowers per plant to fruit yield.

Umamaheswarappa *et al.* (2004) studied correlation and path analysis in bottle gourd and reported that fruit yield/ha had strong positive association with vine length, number of leaves per vine, number of female flowers per vine, number of branches per vine, vine girth, total chlorophyll content in leaf, total dry weight of plant, number of fruits per vine, fruit weight, fruit length and fruit girth. Path coefficient analysis revealed that number of fruits per vine had maximum direct effect on fruit yield followed by fruit weight.

Singh *et al*. (2005) at Varanasi studied that the maximum heterosis for yield was exhibited by IVAG-90 x IVAG-114. The selection should be made for improvement of traits like number of fruits per plant, polar and equatorial circumference of fruit and yield. While number of branches, vine length and individual fruit weight may be improved through hybridization.

Ahmed *et al.* (2005) studied correlation and path coefficient in twenty three genotype of bottle gourd and reported that fruit yield exhibited strong positive and significant correlation both at genotypic and phenotypic levels with number of fruits per plant, average fruit weight and fruit length. The negative significant association with days to first fruit picking and fruit diameter indicate that selection for earliness and increased fruit diameter would not have positive bearing on fruit yield. The path coefficient analysis revealed appreciable amount of direct positive effect of average fruit weight, number of fruits per plant, fruit length, number of female flowers per plant and vine length on fruit yield.

Parvathi and Reddy (2006) studied correlation in bottle gourd and reported that fruit yield per vine showed significant positive correlation with fruit weight, fruit girth, fruit flesh thickness, fruits per vine and 100-seed weight, indicating that selection for these characters may improve fruit yield in bottle gourd.

Singh *et al.* (2006) observed correlation and path coefficient in bottle gourd and study revealed that yield per vine exhibited positive and significant correlation with number of primary branches per vine, number of female flowers per vine, number of nodes on main axis, fruit diameter, fruit length, fruit weight and number of fruits per vine. Path coefficient analysis indicated that characters like female flower per vine, fruit weight, number of fruits per vine and number of nodes on main axis had direct effect on yield of bottle gourd.

Gayen and Hossain (2007) conducted an experiment with nine genotypes of bottle gourd and study revealed that the fruit weight and fruit length had significant and positive correlations with fruit yield per plant. The path analysis at phenotypic and genotypic levels revealed that the fruit weight and fruit length had direct effects on yield.

Kumar *et al.* (2007) conducted an experiment on twenty diverse genotypes of bottle gourd and examine that the fruit yield showed positive and significant correlation with number of branches per vine, vine length, node number of first male flower, node number of first female flower, length of edible fruits, number of fruits per vine, number of seeds per fruit and 100 seed weight at genotype and phenotype levels.

Yadav *et al.* (2007) conducted an experiment to select the superior genotypes among eighteen strains of bottle gourd by correlation and path coefficient analysis. Yield per plant was positively and significantly associated with the number of fruits per plant, but has a negatively significant correlation with days to first female flowering at both genotypic and phenotypic levels. Studies on path coefficient analysis showed that days to first male flowering, number of nodes of first female flowering, days to edible fruit, fruit width, number of fruits per plant and yield per plant had maximum positive direct effect on yield. All the characters except days to first female flowering, number of nodes of first male flowering and fruit length had direct effect on yield. For indirect effects, the number of fruits per plant showed highly significant and positive association with yield per plant due to days to first male flowering, number of nodes of first female flowering, days to edible fruit, fruit width and number of fruits per plant

Resmi and Sreelathakumary (2012) study of Correlation and path coefficient studies were worked out for 25 genotypes of ash gourd of different geographical origin. Fruit length, fruit girth, average fruit weight, seeds per fruit and 1000-seed weight had positive and significant correlation with yield. The positive direct effect on yield was revealed by fruit length, average fruit weight and fruits per plant. Therefore, these traits may be considered as the most reliable selection indices for effective improvement in fruit yield in ash gourd.

Dewanl *et al.* (2014) The contributing characters of 46 ash gourd results of correlation coefficient analysis, yield plant^{-1} was significantly and positively correlated with average weight fruit^{-1}, vine length and number of fruits plant^{-1} and also positively correlated with fruit length and diameter, flesh thickness but negatively correlated with sex ratio. Path coefficient analysis indicated that number of fruits plant^{-1} had maximum direct and positive effect on yield plant^{-1}. The correlation of number of fruits plant^{-1} on yield plant^{-1} was also shown high and such high correlation with yield plant^{-1} was mainly due to the high positive direct effect on number of fruits plant^{-1} and considerable indirect effect via average weight fruit^{-1}.

2.4 Genetic divergence

The concept of D^2 statistics was originally developed by Mahalonobis (1936). Then 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. Cluster analysis helps to form groups of closely related individuals which help in determining genetic distance between them.

Jain et *al.* (1975) reported that the qualification of genetic diversity through biometrical procedures has made it possible to choose genetically diverse parents for a successful hybridization program. They reported that evaluation of genetic diversity is important to know the source of gene for a particular trait within the available germplasms

Mathew *et al.* (1986) studied on genetic distance among five botanical varieties of *Cucumis melo.* The genetic distance was calculated for nodes to first female flower, fruit weight, seeds per fruit and fruits per plant. Total D^2 was estimated according to Mahalanobis (1936). The magnitude of D^2 indicated closeness among the varieties. The character fruits per plant contributed maximum to total divergence (80%). Seeds per fruit did not contribute to the total divergence. Selection of botanical varieties based on fruits per plant would be a logical step in the selection of divergence parents in any hybridization program.

Mathew *et al.* (2001) studied genetic divergence in twenty eight accessions of bottle gourd collected from different parts of Kerala, India. Accessions were grouped into eight clusters. Clustering pattern indicated that there was no association between geographical distribution of accessions and genetic divergence for the characters such as number of fruits, average fruit weight, vine length and fruit set percentage, had the greatest contribution to genetic divergence.

Badade *et al*. (2001) studied genetic divergence using Mahalanobis D statistics for seven quantitative characters including yield per vine in a collection of twenty diverse cultivars of bottle gourd. The cultivars differed significantly for almost all the characters and were grouped into ten clusters based on the similarities of D^2 value. Considerable diversity within and between clusters was noted and it was observed for vine length, number of branches, percentage of female flowers, fruits per vine, length and diameter of fruit and yield per vine.

Islam (2004) studied genetic divergence among forty two bottle gourd accession from Bangladesh. The accessions were grouped into five clusters. No clear relationship was observed between geographic origin and genetic diversity. The maximum inter-cluster distance was between cluster I and cluster IV and the minimum was between cluster III and cluster IV. Primary branches per plant, fruit length and weight, number of fruits and yield per plant contributed the most of the total genetic divergence. The accessions included in the most divergent cluster I and II, are promising parents for a hybridization programme.

Singh *et al.* (2007) evaluated twenty eight bottle gourd genotypes for genetic diversity under two environmental conditions and grouped into twelve clusters. Cluster I was the biggest and contained six genotypes. There was no parallelism between the clustering pattern and geographic origin. Maximum genetic diversity was obtained between cluster III and XII. This indicated the potentiality of genotypes for heterosis and spectrum of variability.

Gangopadhyay *et al.* (2008) at New Delhi reported genetic diversity, clustering pattern and ordination (principal components) analyses were undertaken in 26 ash gourd accessions. The accessions showed significant inter-population differences and wide variation for quantitative and qualitative morphological descriptors observed. Low level of difference between the magnitude of PCV and GCV indicated that the descriptors were least influenced by environment and are genetically controlled. High heritability coupled with high genetic advance was observed for descriptors such as primary branches, fruits/ plant and fruit weight/plant.

Singhal, *et al* (2010) Genetic diversity was observed among twenty three germplasm lines of ash gourd Genotypes PAG-50, Pant Petha-1, PAG-64, PAG- 12, PAG-14 and PAG-09 were high yielding lines while considering both the seasons *summer* and *kharif.*

Sreelatha (2010) at Trivandrum reported that the genetic diversity of 25 ash gourd genotypes collected from different geographical locations was assessed at the molecular level and compared to morphological traits for degree of divergence. The clustering pattern based on Mahalanobis D^2 statistic indicated that there was no association between geographical distribution of genotypes and genetic divergence.

Narayan *et al.* (2011) at Jagdalpur (Bastar) reported the genetic diversity in the ash gourd collected from the tribal areas of Bastar (Chhattisgarh). Wide range of variability was recorded in the quantitative traits for fruit, yield and seed characters including days to germination, days to 1st male flower anthesis, days to 1st female flower anthesis, node no. of 1st male flower, node no. of 1st female flower, days to 1st fruit harvest, no. of branches per vine, vine length, fruit length, fruit girth, individual edible fruit weight, number of fruits per vine, fruit yield per vine, number of seeds per fruit and 100 seed mass.

Bhardwaj *et al.* (2013) evaluated twenty genotypes of bottle gourd for genetic diversity and grouped into five clusters. Among these, cluster I was the largest and consists of nine genotypes, followed by cluster II with five genotypes and cluster III with four genotypes. Clusters IV and V contained only one genotype. Mass selection based upon mean population performance or within populations is the breeding method more appropriate for improvement of fruit shape in bottle gourd. Thus, crossing between the genotypes of these two groups (cluster I and II) would produce high heterotic progeny and may produce new recombinants with desired traits.

Gulshan Ara *et al.* (2014) estimated genetic divergence among twenty eight bottle gourd genotypes using D^2 and anonical analysis. The genotypes were grouped into five clusters. The maximum intercluster distance was between cluster III and cluster I (31.10), and the minimum was between cluster IV and II (6.51). The crosses between the genotypes LS001, LS002, LS007, LS010, LS013, LS016, LS017, LS028 of cluster II and LS018, LS023 in cluster V would exhibit maximum heterosis and produce new recombinants with desired traits in bottle gourd.

CHAPTER- III

MATERIALS AND METHODS

This chapter deals with a concise description of the materials used and methods adopted in carrying out the present investigation entitled "Genetic variability and divergence analysis in Ash gourd [*Benincasa hispida* (Thumb) Cogn.] The investigation was conducted during kharif season of the year 2014-15 at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

3.1 Geographical Situation

Raipur is situated in mid eastern part of Chhattisgarh at latitude $21^{o}16'$N, longitude $81^{o}36'$E and at an altitude of 289.56 meters above the mean sea level.

3.2 Climatic condition

The general climatic condition of Raipur is sub-humid to semi-arid. The mean annual precipitation of the region is 1326 mm (based on 80 years mean) and about 85% of rainfall is received during rainy season that is middle of June to September with occasional showers in winter and summer months. The weekly maximum temperature raises upto 42˚C during summer and minimum temperature drop down as low as 8˚C during winter season. The relative humidity is high from June to October and wind velocity is high from May to August with its peak in June-July months.

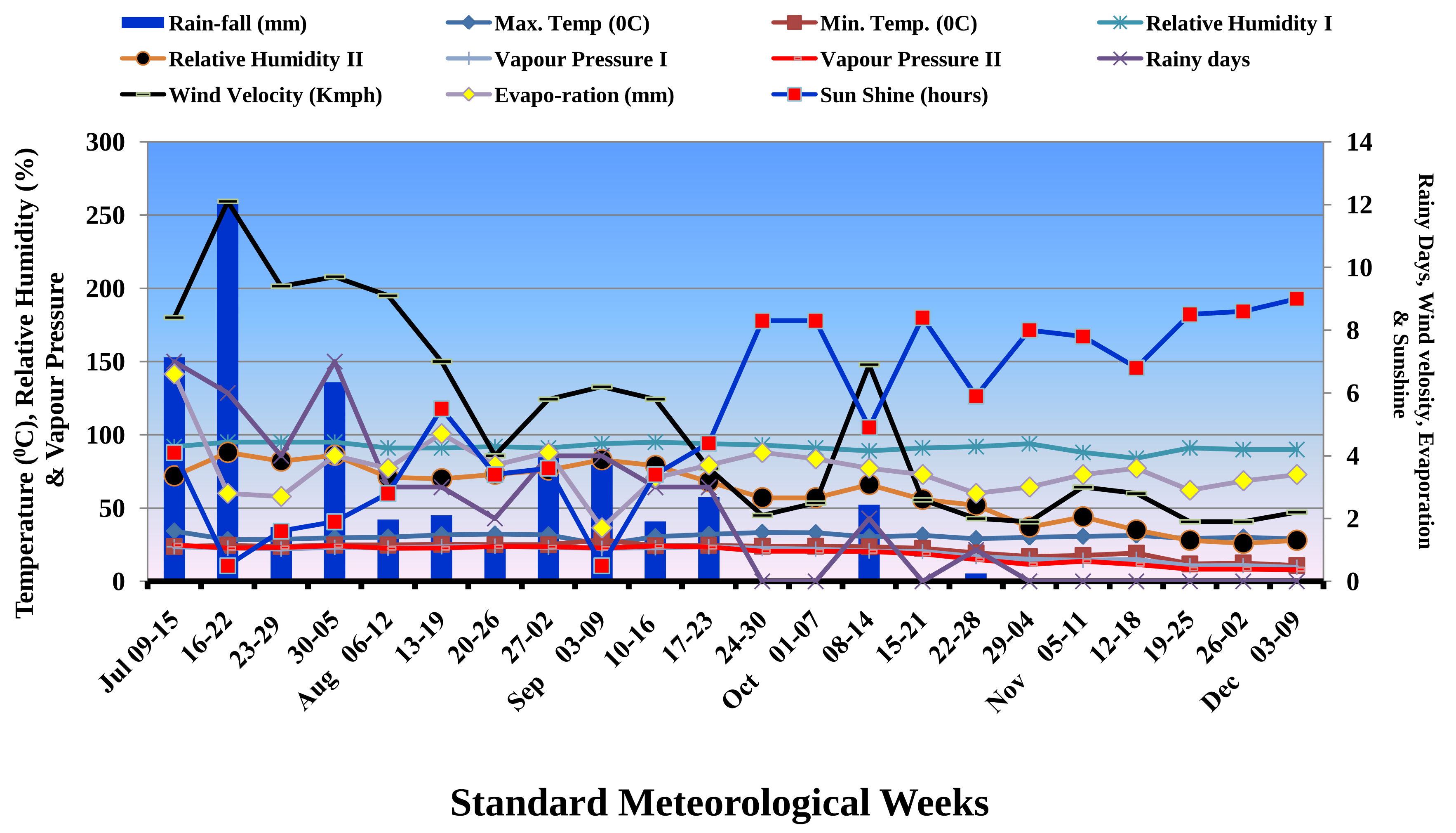


Fig.3.1 Weekly meterological parameters during crop growth period (09/07/2014 to 09/12/2014

3.3 Soil of the experimental field

The soil samples were collected randomly from six places before laying out of the experiment. The samples were mixed well and a uniform composite sample was analyzed for assessing the initial status of the soil. The chemical composition of soil sample is presented in **table 3.1**

Table 3.1: Physico-chemical analysis of the experimental soil

	Properties	Analysis Values	Group/ Class	Method used
A.	**Physical properties**			
1.	Mechanical composition			
	Sand (%)	21.45		
	Silt (%)	34.36		
	Clay (%)	43.22		
	Textural class		Clay (*Vertisols*)	
2.	Bulk density (Mg m^{-3})	1.40		
B.	**Chemical properties**			
1.	Available N (kg ha^{-1})	238.33	Low	Alkaline permanganate method (Subbiah and Asija, 1956)
2.	Available P_2O_5 (kg ha^{-1})	18.81	Medium	Olsen's method (Olsen *et al*., 1954)
3.	Available K_2O (kg ha^{-1})	386.4	High	Flame photometric method (Jackson, 1963)
4.	pH (1: 2.5, soil: water)	7.22	Neutral	Glass electrode pH meter (Piper, 1966)
5.	EC (dsm^{-1} at 25^oC)	0.17	Normal	

3.4 Field preparation

The preparation of field was done by tractor-drawn cultivator followed by two cross-harrowing to pulverize the soil and finally the field was levelled with planker. The layout of prepared field was prepared as per the experimental design. Field was divided into small plots according to treatments and replications with randomized block design. The layout of experimental design is shown in **Fig 3.3**.

3.5 Details of treatments

The experiment consists of thirty genotypes of Ash gourd, which was laid out in randomized block design with three replications. Details of treatment are given in **Table 3.2**.

R-I	R-II	R-III
T_1	T30	T16
T_2	T29	T17
T_3	T28	T18
T_4	T27	T19
T5	T26	T20
T6	T25	T21
T7	T24	T22
T8	T23	T23
T9	T22	T24
T10	T21	T25
T11	T20	T26
T12	T19	T27
T13	T18	T28
T14	T17	T29
T15	T16	T30
T16	T15	T1
T17	T14	T2
T18	T13	T3
T19	T12	T4
T20	T11	T5
T21	T10	T6
T22	T9	T7
T23	T8	T8
T24	T7	T9
T25	T6	T10
T26	T5	T11
T27	T4	T12
T28	T3	T13
T29	T2	T14
T30	T1	T15

Treatment Details: -

T_1	:	IAG - 1
T_2	:	IAG - 2
T_3	:	IAG - 3
T_4	:	IAG – 4
T_5	:	IAG - 5
T_6	:	IAG - 6
T_7	:	IAG - 7
T_8	:	IAG - 8
T_9	:	IAG - 9
T_{10}	:	IAG - 10
T_{11}	:	IAG - 11
T_{12}	:	IAG - 12
T_{13}	:	IAG - 13
T_{14}	:	IAG - 14
T_{15}	:	IAG - 15
T_{16}	:	IAG - 16
T_{17}	:	IAG - 17
T_{18}	:	IAG - 18
T_{19}	:	IAG - 19
T_{20}	:	IAG - 20
T_{21}	:	IAG - 21
T_{22}	:	IAG - 22
T_{23}	:	IAG - 23
T_{24}	:	IAG - 24
T_{25}	:	IAG - 25
T_{26}	:	IAG - 26
T_{27}	:	IAG - 27
T_{28}	:	IAG - 28
T_{29}	:	IAG - 29
T_{30}	:	IAG - 30

Fig. 3.2: -Layout plan of Experiment Field

Table 3.2 Details of the genotypes/ varieties

S. No.	Treatments/Genotypes	Source
1.	IAG-1	local callection from Bastar
2.	IAG-2	local callection from Bastar
3.	IAG-3	local callection from Bastar
4.	IAG-4	local callection from Bastar
5.	IAG-5	local callection from Bastar
6.	IAG-6	local callection from Bastar
7.	IAG-7	local callection from Bastar
8.	IAG-8	local callection from Bastar
9.	IAG-9	local callection from Bastar
10.	IAG-10	local callection from Bastar
11.	IAG-11	local callection from Bastar
12.	IAG-12	local callection from Bastar
13.	IAG-13	local callection from Bastar
14.	IAG-14	local callection from Bastar
15.	IAG-15	local callection from Bastar
16.	IAG-16	local callection from Bastar
17.	IAG-17	local callection from Bastar
18.	IAG-18	local callection from Bastar
19.	IAG-19	local callection from Bastar
20.	IAG-20	local callection from Bastar
21.	IAG-21	local callection from Bastar
22.	IAG-22	local callection from Bastar
23.	IAG-23	local callection from Bastar
24.	IAG-24	local callection from Bastar
25.	IAG-25	local callection from Bastar
26.	IAG-26	local callection from Bastar
27.	IAG-27	local callection from Kondagoan
28.	IAG-28	local callection from Kondagoan
29.	IAG-29	local callection from Narayanpur
30.	IAG-30	local callection from Bastar

3.6 Experimental material

Thirty genotypes of Ash gourd were grown in a randomized block design with three replications. The sowing of experimental material was done on 5 July 2014. The seeds are sown in direct field at the distance 3 m for row to row and 50 cm for plant to plant was maintained and the plot size was 30 m^2. Recommended dose of fertilizers and other cultural package of practices were adopted for better crop growth. Five competitive plants were selected randomly from each plot to record observation on various characters. The average value of each character was calculated on the basis of five plants for each genotype in every replication.

3.7 Observations procedure

Observations on quantitative traits were recorded on five randomly selected competitive plants in each genotype from all the three replication and averaged.

3.7.1 Days to 50% flowering

This was recorded as number of days from sowing date to the date when 50% plants of the plot bloomed and the average value was calculated.

3.7.2 Number of branches per plant

The number of branches per plant was recorded from five randomly selected plant of each plot at the time of last picking and average was presented as number of branches per plant.

3.7.3 Node number of first female flower appears

Node number of first female flower appears was noted as the node number from the base of the plant at which first female flower appeared and average value was calculated.

3.7.4 Node number of first male flower appears

Node number of first male flower appears was noted as the node number from the base of the plant at which first male flower appeared and average value was calculated.

3.7.5 Days to fruit set

Days to fruit set were recorded from sowing to the date of first fruit setting of selected plants and the average value was calculated.

3.7.6 Days to first fruit harvest

Days to first fruit harvest was recorded as number of days taken from the date of sowing to the date of first picking of edible fruits from randomly selected plants of each genotype and average value was calculated.

3.7. 7 Fruit length (cm)

Fruit length was recorded in cm for five fruits from five randomly selected plants of each genotype in each replication and average value was calculated.

3.7. 8 Fruit girth (cm)

Girth of fruits was recorded in cm on five fruits from five randomly selected plants of each genotype in each replication. Girth of fruits was measured at the centre of the fruits and the average value was recorded as fruit girth in cm.

3.7.9 Average fruit weight (kg)

Average weight of fruits was recorded on five fruits in gram from five randomly selected plants of each genotype in each replication and then average fruit weight was calculated.

3.7.10 Number of fruits per plant

The number of fruits per plant was recorded in each genotype from five randomly selected plants at marketable stage of fruits and average value was calculated.

3.7.11 T.S.S. (%)

A drop of ash gourd fruit juice was used to determine the TSS with the help of “Erma” (0.32) hand reflectometer and the value was noted at room temperature.

3.7.12 100 Seed weight

One hundred seeds counted from the bulk produce of each treatment taken for weight. Weight was recorded using electronic balance and expressed in gram.

3.7.13 Yield / plot (Kg)

This was recorded as average of cumulative marketable fruit yield of all pickings.

3.7.14 Yield (q/ha)

The fruit yield in q/ha was worked out with the help of the following formula:

$$\text{Fruit Yield (q/ha)} = \frac{\text{Weight of fruit (kg per plot)}}{\text{Net plot area (sq.m}^2\text{.)}} \times \frac{10000}{100}$$

3.7.15 Duration of crop (sowing to last harvest)

Duration of crop was recorded as days from sowing to last day of harvesting.

3.8 Statistical and Biometrical analysis

3.8.1 Analysis of variance (ANOVA)

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

Skeleton of ANOVA

Source of variation	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F value**	
				calculated	**tabulated**
Replication	(r-1)	RSS	RMS		
Treatment	(t-1)	TrSS	TrMS	M1/M2 *Significant at 5%, **Significant at 1%	
Error	(r-1) (t-1)	ErSS	EMS		

To test the significance of treatment, the calculated value of "F" was compared with tabular value of "F" at 5 and 1 per cent levels of probability against error degree of freedom. 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

TMS = Mean sum of squares due to treatment

EMS = Mean sum of squares due to error

a. Critical difference

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

$$SE(d) = \sqrt{\frac{2EMS}{r}}$$

Where,

S Ed = Standard error of difference between two treatment means

EMS = Error Mean of square

r = Number of replication

b. Standard error of mean

$$SE(m) \pm = \sqrt{\frac{2EMS}{r}}$$

c. Coefficient of variation (CV) (%)

Coefficient of variation is standard deviation expressed as percentage of Mean.

$$CV\ \% = \frac{SD}{\overline{X}} \times 100$$

Where,

SD = Standard deviation

$\overline{X}$ = Mean of character

3.8.2. Estimation of genetic parameter of variation

1) Mean

Mean of the character was estimated by summing up of all the observation and dividing the sum by the number of observation.

$$(\overline{X}) = \frac{\sum Xi}{N}$$

Where,

$\sum Xi$ = Summation of all the observation,

N = Number of observations

2) Range

Range is the differences between the last and greatest terms of a series of observation and thus provides the information about the variability present in the trait.

3**) Estimation of coefficients of variation**

The coefficient of variation for different characters was estimated by formula as suggested by Burton (1952).

$$\text{GCV (\%)} = \frac{\sqrt{\sigma\ 2g}}{\overline{X}} \text{ X } 100$$

$$\text{PCV (\%)} = \frac{\sqrt{\sigma\ 2p}}{\overline{X}} \text{ X } 100$$

Where,

PCV = Phenotypic coefficient of variation

GCV = Genotypic coefficient of variation

$\overline{X}$ = Mean of character

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

The estimates of genotypic and phenotypic coefficient of variance were classified as low (less than 10 %), moderate (10 to 20%) and high (more than 20 %) as suggested by Sivasubramanium and Madhavamenon (1973).

4) Genetic advance

Improvement in the mean genotypic value of selected plants over the parental population is known as genetic advance. The expected advance was calculated by the formula given by Johnson *et al*. (1955) as described below.

$$GA = K.h^2.\sigma p$$

Where,

GA = Genetic advance

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

h^2 = Heritability of the character

σp = Phenotypic standard deviation

The genetic advance as percentage of mean was estimated as per the below formula

$$\text{Genetic advance as percent of mean} = \frac{\text{Genetic advance}}{\text{General mean}} \times 100$$

The magnitude of genetic advance as percent of mean was categorized as high (more than 20%), moderate (20-10%) and low (less than10%).

5) Estimation of heritability

Heritability in broad sense (h^2 bs) defined as the proportion of the genotypic variance to the total variance (phenotypic) was calculated as per the formula suggested by Burton and De Vane (1953).

$$h^2 (bs) \% = \frac{\sigma^2_g}{\sigma^2_P} \times 100$$

Where,

h^2 (bs) = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

The broad sense heritability estimates were classified as low (<50%), moderate (50-70%) and high (<70%) as suggested by Robinson (1966).

3.8.3 Estimation of correlation coefficient

Correlation coefficient analysis measures the mutual relationship between various characters at genotypic (g), phenotypic (p) and environmental levels with the help of formula suggested by Miller *et al*. (1958).

1. Genotypic correlation coefficient character x and y

   $$rxy (g) = Covxy(g) / \sqrt{varx(g) \times vary(g)}$$

2. Phenotypic correlation coefficient between character x and y

   $$rxy(p) = Covxy(p) / \sqrt{varx(p) \times vary(p)}$$

3. Environmental correlation coefficient between characters x and y

   $$rxy (e) = Covxy(e) / \sqrt{varx(e) \times vary(e)}$$

Where,

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

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

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

The significance of correlation coefficient (r) was tested by comparing "t" value at (n-2) degree of freedom

$$t = \sqrt{r\ (n - 2\ /\ 1 - r2)}$$

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.

3.8.4 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).

$$R = \sqrt{1 - \quad di\ x\ rij}$$

Where,

Di = direct effect of i^{th} character

r_{ij} = 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

3.8.5 Genetic divergence 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:

Formula:

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

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 ith character

j = the difference in the mean value for the jth 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.

CHAPTER- IV

RESULTS AND DISCUSSION

The present investigation was undertaken to study the mean performance of ash gourd genotypes, to assess the genetic variability, correlation co-efficient, path coefficient analysis and divergence analysis in ash gourd for fruit yield and its component characters. The results obtained are presented as under following heads:

4.1 Analysis of variance

4.2 Mean performance

4.3 Genetic variability

4.4 Correlation analysis

4.5 Path coefficient analysis

4.6 Genetic divergence analysis

4.1 Analysis of variance

The analysis of variance of all the characters under study is presented in **Table 4.1**. The analysis of variance revealed that mean sum of squares due to genotypes was highly significant for all characters. Which revealed existence of considerable variability in material studied for improvement for various traits. These findings are in general agreement with the findings of Pandit *et al.* (2009), Kumar *et al.* (2012) and Bhardwaj *et al.* (2013).

Table 4.1: Analysis of variance for fruit yield and its component characters in ash gourd.

S. No.	Character (df)	Mean sums of square		
		Replication (2)	**Treatment (30)**	**Error (60)**
01	Days to 50% flowering	78.478	219.441**	85.961
02	No. of branches per plant	1.733	3.324**	1.561
03	N0de no. of 1st female flower appears	11.078	90.651**	5.227
04	Node no. 1st male flower appears	4.133	5.314**	2.995
05	Days to fruit set	307.033	169.682 **	57.022
06	Days to 1stfruit harvest	22.933	22.703**	9.037
07	Fruit length (cm)	2.178	4.651**	2.592
08	Fruit girth (cm)	0.144	29.349**	7.466
09	Average fruit weight (kg)	0.017	0.291**	0.068
10	No. of fruits per plant	0.133	4.486**	1.616
11	T.S.S	0.004	0.084**	0.050
12	100 seed weight	0.674	1.128**	0.288
13	Fruit yield/plot (kg)	2.614	87.320**	20.401
14	Fruit yield (q/ha)	27.862	968.997**	226.736
15	Duration of crop (sowing to last harvest)	28.211	39.970*	18.786

***: Significant at 5%, **: Significant at 1%.**

4.2. Mean performance

The observation on five plants from each genotype in all three replications for fruit yield and its components characters were used for calculating the mean performance. The observations were first averaged for five plant taken randomly for each genotype in each replication and were later averaged over the replications. The mean performance of different genotype are presented in **Table 4.2 and Table 4. 3** and described below.

Table 4.2 Mean performance for fruit yield & its component in ash gourd

Characters	Days to 50% Flowering	No. of branches per plant	Node no at which 1st female flower appears	Node no at which 1st male flower appears	Days to fruit set	Days to 1st fruit harvest	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (kg.)	No of fruits per plant	T.S.S.	100 seed weight	Fruit yield per (kg)	Fruit yield per ha (q/ha)	Duration of crop (sowing to last harvest)
IAG-1	85.67	11.00	47.33	31.00	76.67	126.67	22.33	52.33	2.37	8.33	2.07	4.67	19.53	65.11	135.00
IAG- 2	82.00	12.00	37.00	30.00	70.67	127.00	21.67	51.00	3.00	8.33	2.47	4.17	25.17	83.89	136.33
IAG- 3	85.67	11.33	47.00	31.33	74.33	129.00	24.00	52.00	2.85	9.00	2.13	4.33	25.50	85.00	137.67
IAG- 4	83.67	12.33	37.00	32.00	74.67	133.33	23.00	49.00	2.60	9.00	2.33	4.57	23.27	77.55	145.00
IAG- 5	92.33	11.33	44.00	31.67	81.33	125.33	22.33	51.67	2.27	10.00	2.40	5.16	22.77	75.89	135.67
IAG -6	89.00	10.00	45.00	30.00	80.67	131.67	21.33	50.67	2.24	8.00	2.13	3.33	17.93	59.78	140.00
IAG-7	89.67	10.00	44.67	32.00	68.67	128.33	23.67	51.67	2.87	8.67	2.13	4.30	24.00	79.99	144.00
IAG- 8	90.67	11.67	30.00	29.33	81.00	132.00	22.33	52.33	3.17	9.33	2.27	4.33	29.67	98.89	137.67
IAG- 9	90.33	13.67	32.67	32.00	78.67	133.33	23.33	50.67	3.10	9.67	2.53	3.83	29.93	99.77	137.67
IAG- 10	93.33	14.00	48.67	30.67	82.33	133.33	24.33	62.33	3.35	14.00	2.67	6.10	47.23	157.44	143.67
IAG- 11	98.67	11.33	34.00	33.67	87.67	132.00	24.00	53.67	2.80	9.67	2.53	4.14	27.47	91.55	134.33
IAG- 12	110.00	11.33	47.33	32.00	93.33	125.33	20.67	50.33	3.23	8.00	2.27	3.80	25.77	85.89	134.00
IAG- 13	95.33	10.67	43.00	31.67	75.67	127.00	24.67	49.67	2.85	9.67	2.60	4.83	27.43	91.44	137.33
IAG- 14	96.67	10.33	45.33	30.33	84.00	129.67	22.67	48.67	2.53	9.00	2.40	3.33	22.75	75.83	139.67
IAG- 15	91.33	10.33	35.33	28.67	82.00	132.67	25.00	48.33	2.33	8.33	2.40	4.50	19.33	64.44	133.00
IAG- 16	96.33	10.00	45.00	32.67	77.67	127.33	26.00	49.00	2.70	8.00	2.33	5.17	21.47	71.55	140.00
IAG- 17	83.67	10.00	30.00	31.00	71.33	130.67	22.33	50.67	3.14	8.67	2.53	4.33	27.37	91.22	143.33
IAG- 18	95.00	10.00	32.00	30.00	85.00	130.67	24.00	53.67	3.03	11.00	2.40	4.50	33.30	111.00	136.67
IAG- 19	99.67	10.67	47.67	30.00	86.67	127.67	22.67	58.00	2.55	9.00	2.47	4.39	19.20	64.01	136.00
IAG- 20	86.33	10.33	40.00	33.67	79.67	128.67	23.00	53.00	3.27	9.67	2.33	3.33	29.50	98.33	141.33
IAG- 21	108.00	10.00	39.00	30.00	85.33	127.67	24.00	57.00	2.77	11.00	2.47	4.33	28.53	94.44	143.00
IAG- 22	99.67	11.00	40.67	32.00	88.67	132.33	24.33	52.00	2.39	8.67	2.47	3.50	23.15	77.18	140.00
IAG- 23	103.33	10.33	46.67	33.33	88.00	131.67	23.67	55.67	3.20	7.67	2.67	4.00	26.67	88.89	146.33
IAG- 24	102.33	11.33	43.00	31.67	95.00	129.33	21.00	55.67	3.00	8.67	2.20	3.33	24.45	81.50	143.67
IAG- 25	108.67	10.67	41.00	31.33	83.67	134.33	24.33	51.67	2.93	9.67	2.40	4.50	27.00	90.00	137.33
IAG- 26	97.00	10.33	40.00	34.00	85.33	129.00	24.33	53.00	2.82	8.33	2.53	4.30	23.53	78.44	141.33
IAG- 27	105.67	10.33	39.33	32.67	92.00	131.67	22.33	55.00	2.90	9.67	2.53	4.33	28.07	93.55	142.00
IAG- 28	106.00	10.00	38.00	30.33	93.00	131.67	24.00	50.33	2.62	10.00	2.47	4.30	26.10	87.00	141.00
IAG- 29	109.00	10.00	36.00	32.00	97.00	124.33	22.00	49.67	2.58	8.67	2.40	3.50	22.42	74.72	134.67
IAG- 30	107.33	9.67	40.00	32.00	93.00	132.33	23.33	55.67	2.85	9.33	2.07	4.33	26.60	88.66	136.67
Mean (x)	96.08	10.87	40.56	31.43	83.10	129.87	23.22	52.48	2.81	9.23	2.39	4.25	25.84	86.10	**139.14**
SEm±	5.352	0.721	1.320	0.999	4.359	1.735	0.929	1.577	0.150	0.734	0.129	0.310	2.607	8.693	2.502
CD (p=0.05)	15.153	2.042	3.736	2.828	12.341	4.913	2.631	4.465	0.425	2.077	0.365	0.877	7.382	24.610	7.083
CV (%)	9.650	11.497	5.637	5.506	9.087	2.314	6.932	5.206	9.262	13.768	9.366	12.629	17.481	17.489	3.114

Table 4.3: Morphological characters observed in ash gourd

Characters	**Vine growth Habit**	**Fruit colour**	**Fruit shape**
IAG-1	Medium	Light green	Cylindrical
IAG-2	Medium	Light green	Cylindrical
IAG-3	Long	Light green	Cylindrical
IAG-4	Medium	Light green	Cylindrical
IAG-5	Long	Light green	Cylindrical
IAG-6	Medium	Dark green	Cylindrical
IAG-7	Long	Light green	Cylindrical
IAG-8	Long	Light green	Cylindrical
IAG-9	Medium	Light green	Cylindrical
IAG-10	Long	Light green	Cylindrical
IAG-11	Medium	Light green	Cylindrical
IAG-12	Long	Light green	Cylindrical
IAG-13	Medium	Light green	Cylindrical
IAG-14	Medium	Light green	Cylindrical
IAG-15	Long	Light green	Cylindrical
IAG-16	Medium	Light green	Cylindrical
IAG-17	Medium	Light green	Club shaped
IAG-18	Medium	Light green	Cylindrical
IAG-19	Medium	Light green	Cylindrical
IAG-20	Medium	Dark green	Cylindrical
IAG-21	Medium	Light green	Cylindrical
IAG-22	Medium	Light green	Cylindrical
IAG-23	Medium	Dark green	Club shaped
IAG-24	Medium	Dark green	Cylindrical
IAG-25	Medium	Light green	Cylindrical
IAG-26	Medium	Light green	Cylindrical
IAG-27	Medium	Light green	Cylindrical
IAG-28	Short	Light green	Cylindrical
IAG-29	Medium	Dark green	Cylindrical
IAG-30	Medium	Light green	Cylindrical

4.2.1 Days to 50% flowering

Mean days of 50% flowering ranged from 82 days (IAG-2) to 110 days (IAG 12) with a mean of 96.08 days. Earliest days to 50% flowering was recorded in the genotype IAG 2 (82.00 days) which was followed by IAG 4 (83.67 days), IAG 17 (83.67 days) and delayed flowering was recorded in IAG 12 (110 days).

4.2.2 Number of branches per plant

Maximum number of branches was recorded from IAG 10 (14) followed by IAG 9 (13.67), IAG 4 (12.33), IAG 2 (12.00) and minimum ranged IAG 30 (9.67) with an overall mean of 10.87 and least branching was recorded in the genotype IAG 10 (14).

4.2.3 Node number at which first female flower appears

The node number at which first female flower appears ranged from 30 (IAG 8, IAG 17) to 48.67 (IAG 10) with an overall mean of 10.56. Earliest female node was found in IAG 8, IAG 17 (30) followed by IAG 1 8 (32.00), IAG 9 (32.67) and higher female node was recorded in IAG 10 (48.67).

4.2.4 Node number at which first male flower appears

The node number at which first male flower appears ranged from 28.67 (IAG 15) to 34 (IAG 26) with an overall mean of 31.43. Earliest male node was found in IAG 15 (28.67) followed by IAG 8 (29.33), IAG 21, IAG 6 (30) while higher node number was recorded in the genotype IAG 26 (34).

4.2.5 Days to first fruit set

Mean days to first fruit set ranged from 68.67 days (IAG 7) to 97 days (IAG 29) with a mean of 83.10 days. Earliest fruit setting was recorded in the genotype IAG 7 (68.67 days) followed by IAG 2 (70.67 days), IAG 4 (74.67 days) whereas, maximum days to first fruit set was noted in the genotype IAG 29 (97 days).

4.2.6 Days to first fruit harvest

Days taken to first fruit harvest ranged from 124.33 days (IAG 29) to 134.33 days (IAG 25) with a mean of 129.87 days. Early harvest was recorded in the genotype

IAG 29 (124.33 days) which was followed by IAG 4 (133.33 days), IAG 9 (133.33 days), IAG 1 0 (133.33 days), whereas, maximum days to first fruit harvest was recorded in the genotype IAG 25 (134.33 days).

4.2.7 Fruit length (cm)

Length of fruit ranged from 20.67 cm (IAG 12) to 26 cm (IAG 16) with an overall mean of 23.22 cm. Genotype IAG 16 was recorded for maximum fruit length *i.e.* 26 cm which was followed by IAG 15 (25 cm), IAG 13 (24.67 cm). Lowest fruit length was recorded in IAG 12 (20.67cm).

4.2.8 Fruit girth (cm)

Fruit girth ranged from 48.33 cm (IAG 15) to 62.33 cm (IAG 10). Genotype IAG 10 was recorded maximum fruit girth *i.e*. 62.33 cm followed by IAG 19 (58 cm) with an overall mean of 52.48 cm.

4.2.9 Average fruit weight (kg)

Average fruit weight ranged from 2.24 kg (IAG 6) to 3.35 kg (IAG 10) followed by IAG 12 (3.23 kg), IAG 23 (3.20 kg) with a mean of 2.81 kg.

4.2.10 Number of fruits per plant

Among the genotypes number of fruits per plant ranged from 8 (IAG 16) to 14 (IAG 10) with a mean of 9.23. Maximum number of fruits per plant was recorded in the genotype IAG 10 (14) which was followed by IAG 18, IAG 21 (11) and IAG 5 (10). Genotype IAG 16 (8) were noted for minimum number of fruits per plant.

4.2.11 Total Soluble Solid (%)

Total soluble solid ranged from 2.07% (IAG 1) to 2.67% (IAG 10, IAG 23) followed by IAG 13 (2.60%), IAG 9, IAG 11, IAG 17 (2.53%) with an overall mean of 2.39%.

4.2. 12. 100 Seed weight (gm)

100 seed weight ranged from 3.33 g (IAG 14, IAG 6) to 6.10 g (IAG 10) followed by IAG 16 (5.17 g), IAG 5 (5.16 g) with an overall mean of 4.25 g.

4.2. 13 Fruit yield per plot (kg)

Fruit yield per plot ranged from 17.93 kg (IAG 6) to 47.23 kg (IAG 10) followed by IAG 18 (33.30 kg), IAG 20 (29.50 kg) with an overall mean of 25.84 kg.

4.2. 14 Fruit yield (q/ha)

Fruit yield quintal per hectare ranged from 59.78q (IAG 6) to 157.44q (IAG 10) followed by IAG 13 (64.44 q), IAG 17 (64.01 q) with an overall mean of 86.10 q/ha.

4.2.1.15 Duration of crop (sowing to last harvest)

Duration of crop ranged from 133 days (IAG 15) to 146.33 days (IAG 23) with a mean of 139.14 days. Minimum crop duration was recorded in the genotype IAG 15 (133 days) which was followed by IAG 12 (134 days), IAG 11 (134.33 days) whereas, maximum crop duration was recorded in IAG 23 (146.33 days).

A wide range of variation was recorded for node number at which first female flower appears, days to first male and female flower appears, days to 50% flowering, fruit length, fruit weight and yield per plot which indicated that there is better scope for selection for the improvement of these characters. These findings are in close proximity with the results of Ram *et al.* (2007) who reported variability for flowering, fruit size, number of nodes on main vine, fruit weight and yield/plant. Similar finding were also reported by Rahman *et al.* (1986), Prasad *et al.* (1993), Mathew *et al.* (2000), Sharma *et al*. (2010), and Narayan, (2013).

4.3 Genetic variability

The genetic variability was estimated and presented in **Table 4.4** which is discussed under the following heads:

4.3.1 Genotypic and phenotypic coefficient of variation

Genotypic and phenotypic coefficient of variation are simple measure of variability, these measures are commonly used for the assessment of variability. The relative value of these types of coefficients gives an idea about the magnitude of variability present in a genetic population. Thus, the component of variation such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed. The phenotypic coefficient of variation was marginally higher than the corresponding genotypic coefficient of variation indicated the influence of environment in the expression of the character under study.

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are categorized as low (less than 5%), Moderate (5-10%) and high (more than 10%)

Table 4.4: Genetic parameter of variability for fruit yield and its component character in ash gourd

S. No.	Characters	Mean	Range		Coefficient of variation (%)		Heritability (h^2 %)	GA as percent of mean
			Min.	Max.	GCV	PCV		
01	Days to 50% flowering	96.08	82.00	110.00	6.94	11.89	34.1	8.34
02	No. of branches per plant	10.87	10.67	14.00	7.06	13.49	27.4	7.63
03	Node no. of 1st female flower appears	40.56	30.00	48.67	13.16	14.31	84.5	24.90
04	Node no. 1st male flower appears	31.43	28.67	34.00	2.80	6.18	20.5	2.60
05	Days to fruit set	83.10	68.67	97.00	7.37	11.70	39.7	9.56
06	Days to 1st fruit harvest	129.87	124.33	134.33	1.64	2.84	33.5	1.96
07	Fruit length (cm)	23.22	20.67	26.00	3.57	7.80	20.9	3.35
08	Fruit girth (cm)	52.48	48.33	62.33	5.15	7.32	49.4	7.45
09	Average fruit weight (kg.)	2.81	2.24	3.35	9.71	13.42	52.4	14.59
10	No. of fruits per plant	9.23	8.00	14.00	10.59	17.37	37.2	13.32
11	T.S.S. (%)	2.39	2.07	2.67	4.46	10.38	18.5	3.76
12	100 seed weight (g.)	4.25	3.33	6.10	12.44	17.73	49.3	17.88
13	Fruit yield/plot (kg)	25.84	17.93	47.23	18.28	25.29	52.2	27.20
14	Duration of crop (sowing to last harvest)	139.14	133.00	146.33	1.91	3.65	27.3	2.05

as suggested by Sivasubramanian and Madhavamenon (1973).

. Genotypic and phenotypic coefficients of variation of different characters are presented in **Table 4.4**. High magnitude of genotypic as well as phenotypic coefficient of variations were recorded for traits *viz*., fruit yield per plot in kg (18.28 and 25.29), node number at which first female flower appears (13.16 and 14.31) and 100 seed weight (12.44 and 17.73), number of fruit per plant (10.59 and 17.37), suggested that substantial improvement on ash gourd through selection for these traits. Moderate GCV and PCV were recorded for average fruit weight (9.71 and 13.42), days to fruit set (7.37 and 11.70) number of branches per plant (7.06 and 13.49), and days to 50% flowering (6.94 and 11.89), fruit girth (cm) (5.15 and 7.32) suggested existence of considerable variability in the population. Selection for these traits may also be given the importance for improvement programme. Characters like total soluble solid (4.46 and 10.38), and fruit length cm (3.57 and 7.80), node number at first male flower appears (2.80 and 6.18), duration of crop (1.91 and 3.65) and days to first fruit harvest (1.64 and 2.84) had low genotypic and phenotypic coefficient of variation. Similar finding were also reported earlier by Rahman *et al*. (1986), Singh and Kumar (2002), Munshi and Acharyya (2005), Gayen and Hossain (2006) and Pandit *et al*. (2009).

Phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the traits indicating that environmental factors were influencing the expression of traits. Wide difference between phenotypic and genotypic coefficient of variations indicated their sensitiveness to environmental fluctuations whereas narrow difference showed less environmental interference on the expression of these traits. The traits which showed high phenotypic and genotypic coefficient of variations are of economic importance and there is scope for improvement of these traits through selection.

4.3.2 Heritability and genetic advance as percent of mean

Heritability governed the resemblance between parents and their progeny whereas, the genetic advance provide the knowledge about expected gain for a particular character after selection. Heritability suggests the relative role of genetic factors in expression of phenotypes and also act as an index of transmissibility of a particular trait to its off springs. However, the knowledge of heritability alone does not help to formulating concrete breeding programme, genetic advance along with heritability help to ascertain the possible genetic control for any particular trait. The nature and extent of the inherent ability of a genotype for a character is an important parameter determining the extent of improvement of any crop species. Heritability and genetic advance are the important genetic parameters for selecting a genotype that permit greater effectiveness of selection by separating out environmental influence from total variability.

Heritability estimate provide the information regarding the amount of transmissible genetic variation to total variation and determine genetic improvement and response to selection. Heritability estimate along genetic advance are normally more useful in predicting the gain under selection than that of heritability alone. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance (Johnson *et al*. 1955). An attempt has been made in the present investigation to estimate heritability in broad sense and categorized as low (<40%), moderate (40%-50%) and high (>50%) as suggested by Robinson (1966).

The highest heritability was recorded for the characters, node number of first female flower (84.5%), average fruit weight (52.4), and fruit yield per plot (52.2) and medium heritability was recorded for the characters fruit length (49.4) and 100 seed weight (49.3) and low heritability was recorded for the characters days to fruit set (39.7), number of fruits per plant (37.2), days to first fruit harvest (33.5), days to 50% flowering (34.1), number of branches per plant (27.4), duration of crop (27.3) and fruit length (20.9). Similar results reported by Singh and Kumar (2002) for fruit length, fruit girth, fruit weight and female flower and fruit yield per plant; Similar results were also reported by Rahman *et al.* (1986), Munshi and Acharyya (2005). Low heritability was observed for duration of crop (21.5%).

The heritability value alone however, provides no indication of the amount of genetic improvement that would result from selection of superior genotypes. The heritability estimates would be reliable if it is limited in broad sense, additive and non additive gene effect are accompanied with high genetic advance. To facilitate the comparison of progress in various characters of different genotypes genetic advance was calculated as percentage of mean. The magnitude of genetic advance as percentage of mean easy categorized as high (>10-20%), moderate (5-10%) and low (<5%) as suggested by Johnson *et al*., (1955).

Genetic advance as percentage of mean was observed high for fruit yield per plot (27.20%), node number of first female flower appears (24.90%),100 seed weight (17.88%), average fruit weight (14.59%) and number of fruit per plant (13.32%) .The moderate genetic advance as percentage of mean was observed for days to first fruit set (9.56%), days to 50% flowering (8.34%), number of branches per plant (7.63%), fruit girth cm (7.45%). total solid soluble (3.76%), fruit length (3.35%), node number of first male flower (2.60%), Duration of crop (2.05%) and days to first fruit harvest (1.95%) showed low genetic advance as percentage of mean. The high value of genetic advance for these traits showed that these characters are governed by additive genes and selection will be rewarding for the further improvement of these traits. Moderate genetic advance for the traits suggest that both the additive and non-additive variance are operating in these traits and the traits exhibiting low genetic advance indicates significance of non-additive gene effects.

Heritability estimates along with genetic advance are more useful than the heritability value alone for selecting the best individual. High heritability coupled with high genetic advance was observed for node number of first female flower appears (84.5), average fruit weight (52.4) and fruit yield per plot (52.3) and indicating that most likely the heritability is due to additive gene effects and selection may be effective. Low heritability coupled with low genetic advances was observed for duration of crop indicating that the heritability is due to non-additive gene effects and heterosis may be effective. Similar results were also reported by Rahman *et al.* (1986), Singh and Kumar (2002), Gayen and Hossain (2006) and Yadav *et al.* (2008). Rest of the traits showed moderate to low heritability estimates coupled with moderate to low genetic advance as percentage mean indicated the role of non additive genetic variance in their expression.

IAG-21

IAG-22

IAG-23

IAG-24

IAG-25

IAG-26

IAG-27

IAG-28

IAG-29

IAG-30

Fig.1c) : Fruit shape, size and appearance of Ash gourd genotypes

IAG-11

IAG-12

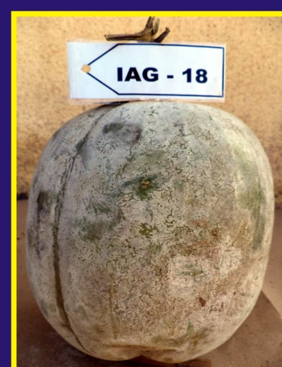
IAG-13

IAG-14

IAG-15

IAG-16

IAG-17



IAG-18

IAG-19

IAG-20

Fig.1b) : Fruit shape, size and appearance of Ash gourd genotypes

IAG-1

IAG-6

IAG-2

IAG-7

IAG-3

IAG-8

IAG-4

IAG-9

IAG-5

IAG-10

Fig.1a) : Fruit shape, size and appearance of Ash gourd genotypes

4.4 Correlation analysis

Association analysis is an important approach in a crop improvement programme. It gives an idea about relationship among the various characters and determines the component characters, on which selection can be used for genetic improvement in the fruit yield. The degree of association also affects the effectiveness of selection process. The degree of association between independent and dependent variables was first suggested by Galton (1888) and its theory was developed by Pearson (1904) and their mathematical utilization at phenotypic, genotypic and environmental levels was described by Searle (1961).

The major causes underlying association are either due to pleiotropic gene action or linkage or both. The phenotypic correlation includes a genotypic and environmental effect, which provides information about total association between the observable characters. Genotypic correlation provided a measure of genetic association between the characters and normally used in selection, while environmental as well as genetic architecture of a genotype plays a great role in achieving higher yield combined with better quality.

The genotypic and phenotypic correlation for fruit yield and its component in ash gourd are presented in **Table 4.5** and only significant correlations are discussed here.

Days to 50% flowering exhibited significant positive correlation with days to fruit set at phenotypic level only. It also showed significant positive correlation with total soluble solid (%) at genotypic level only.

Number of branches per plant showed significant positive correlation with fruit girth, number of fruit per plant, total soluble solid (%), 100 seed weight and fruit yield per plot (kg) at only genotypic level.

Node number of first female flower appears had negatively and significant correlation with days to first fruit harvest at genotypic level only.

Node number of first female flower appears had showed significant positive correlation with average fruit weight, number of fruit per plant and total soluble solid at only genotypic level.

Table 4.5: Genotypic and phenotypic correlation coefficient between fruit yield and its component characters in ash gourd

Characters		01. Days to 50% flowering	02. No. of branches per plant	03. Node no. of first female flower	04. Node no. of first male flower	05. Days to fruit set	06. Days to 1st fruit harvest	07. Fruit length (cm)	08. Fruit girth (cm)	09. Average fruit weight(kg)	10. No. of fruits per plant	11. T.S.S.	12. 100 seed weight	13. Fruit yield/plot (kg)	14. Duration of crop (sowing to last harvest)
01.	P	1.000	-0.360	0.052	0.230	0.743**	-0.031	0.144	0.140	0.007	0.135	0.012	-0.045	0.098	0.049
	G	1.000	-0277	0.222	0.065	1.000	-0.043	-0.169	0.379	0.074	-0.010	0.452*	-0.270	-0.032	-0.258
02.	P		1.000	0.039	-0.124	-0.249	0.196	-0.002	0.079	0.242	0.117	0.136	0.125	0.256	0.012
	G		1.000	-0.014	0.156	-0.152	0.333	-0.295	0.439*	0.411*	0.878**	0.463**	0.545**	0.830**	-0.013
03.	P			1.000	0.083	-0.030	-0.258	0.038	0.183	-0.116	0.024	-0.169	0.122	-0.088	0.000
	G			1.000	0.220	0.091	-0.398*	-0.022	0.342	-0.198	0.085	-0.278	0.169	-0.163	0.262
04.	P				1.000	0.138	-0.038	0.142	0.033	0.081	-0.057	-0.083	-0.045	-0.018	0.232
	G				1.000	0.187	-0.164	0.052	0.069	0.521**	-0.419*	0.739**	-0.283	0.113	0.314
05.	P					1.000	0.061	-0.040	0.199	-0.007	0.044	0.110	-0.134	0.069	0.000
	G					1.000	-0.025	-0.431*	0.377*	-0.060	0.076	0.075	-0.510**	-0.037	-0.327
06.	P						1.000	0.250	-0.017	0.118	0.085	0.070	0.027	0.219	0.194
	G						1.000	0.422*	0.382*	0.204	0.514**	0.419*	0.089	0.481**	0.462**
07.	P							1.000	-0.042	-0.034	0.149	0.131	0.243	0.091	0.077
	G							1.000	0.092	-0.084	0.470**	0.814**	0.880**	0.358*	0.089
08.	P								1.000	0.191	0.406*	0.125	0.184	0.359*	0.175
	G								1.000	0.561**	0.810**	0.387*	0.428*	0.790**	0.475**
09.	P									1.000	0.175	0.197	0.033	0.651**	0.172
	G									1.000	0.451*	0.414*	0.115	0.803**	0.490**
10.	P										1.000	0.152	0.436*	0.802**	0.090
	G										1.000	0.761**	0.659**	0.881**	0.196
11.	P											1.000	0.164	0.260	0.246
	G											1.000	0.389	0.740**	0.121
12.	P												1.000	0.363*	-0.001
	G												1.000	0.494**	0.006
13.	P													1.000	0.156
	G													1.000	0.434*
14.	P														1.000
	G														1.000

Days to fruit set had positive and significant correlation with fruit girth and it also shows negatively and significant correlation with fruit length and 100 seed weight at genotypic level only. Days to first fruit harvest exhibited significant and positive correlation with fruit length (cm), fruit girth, number of fruits per plant, total soluble solid, fruit yield per plot and duration of crop at genotypic level only.

Fruit length had significant positive correlation with number of fruits per plant, total soluble solid, 100 seed weight and fruit yield per plot at genotypic level only. Fruit girth showed significant positive correlation with number of fruit per plot and fruit yield per plot at both phenotypic and genotypic level and it also showed significant positive correlation with average fruit weight, total soluble solids, 100 seed weight and duration of crops at genotypic level only.

Average fruit weight showed significant positive correlation with fruit yield per plot at both phenotypic and genotypic level. It also showed significant positive correlation with number of fruit per plant, total soluble solid, and duration of crops at genotypic level only.

Number of fruits per plant showed significant positive correlation with 100 seed weight and fruit yield per plot at both phenotypic and genotypic levels. It also showed significant positive correlation with total soluble solid at genotypic level only.

Total soluble solids had significant and positive correlation with 100 seed weight at genotypic level only.

100 seed weight had significant and positive correlation with fruit yield per plot at both phenotypic and genotypic level only.

Fruit yield per plot had significant and positive correlation with duration of crop at genotypic level only.

The findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the characters studied. The low phenotypic value might be due to appreciable interaction of the genotypes with the environments.

An overall observation of correlation coefficient analysis revealed that fruit girth, average fruit weight, number of fruits per plant and 100 seed weight exhibited the significant positive correlation with yield per plot. Hence, direct selection for these traits may lead to the development of high yielding genotypes of ash gourd.

The present findings are in conformity with Umamaheswarappa *et al.* (2004) who reported that fruit yield per ha had strong positive association with number of fruits per vine, fruit weight, fruit length and fruit girth. Similar results were also reported by Ahmed *et al.* (2005), Kumar *et al.* (2007), Ram *et al.* (2007), Srivastava *et al.* (2007), Wani *et al.* (2008), and Bhardwaj *et al.* (2013).

4.5 Path coefficient analysis

Path coefficient analysis is an important tool for partitioning the correlation coefficients into the direct and indirect effects of independent variables on a dependent variable. With the inclusion of more variables in correlation study, their indirect association becomes more complex. Two characters may show correlation, just because they are correlated with a common third one. In such circumstances, path coefficient analysis provides an effective means of a critical examination of specific forces action to produce a given correlation and measure the relative importance of each factor. In this analysis, fruit yield was taken as dependent variable and the rest of the characters were considered as independable variables.

The path coefficient analysis which splits total correlation coefficient of different characters into direct and indirect effects on fruit yield per plant in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation as presented in **Table 4.6**. The data revealed that number of fruit per plant showed the highest positive direct effect (0.451) on fruit yield followed by fruit girth (0.277), average fruit weight(0.212), 100 seed weight (0.136), node number of first male flower appears (0.135) total soluble solid (0.132), duration of crop (0.102), number of branches per plant (0.013) whereas, node number of first female flower appears (-0.212), fruit length (-0.113), days to 50% flowering (-0.112) days to first fruit harvest (-0.038), day to fruit set showed negative direct effects on fruit yield per plot.

Table 4.6: Direct and indirect effect of component character on fruit yield in Ash gourd

Characters	Days to 50% flowering	No. of branches per plant	Node no. of first female flower	Node no. of first male flower	Days to fruit set	Days to 1^{st} fruit harvest	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (kg)	No. of fruits per plant	T.S.S.	100 seed weight	Duration of crop (sowing to last harvest)	Yield (q/ha)
Days to 50% flowering	**-0.112**	-0.004	-0.047	0.009	-0.012	0.002	0.019	0.105	0.016	-0.005	0.060	-0.037	-0.026	-0.032
No. of branches per plant	0.031	**0.013**	0.003	0.021	0.002	-0.013	0.033	0.122	0.087	0.396	0.062	0.074	-0.001	0.830
Node no. of first female flower	-0.025	0.000	**-0.212**	0.030	-0.001	0.015	0.003	0.095	-0.042	-0.038	-0.037	0.023	0.027	-0.163
Node no. of first male flower	-0.007	0.002	-0.047	**0.135**	-0.002	0.006	-0.006	0.019	0.111	-0.189	0.097	-0.037	0.032	0.113
Days to fruit set	-0.112	-0.002	-0.019	0.025	**-0.012**	0.001	0.049	0.104	-0.013	0.034	0.010	-0.069	-0.033	-0.037
Days to 1^{st} fruit harvest	0.005	0.004	0.085	-0.022	0.000	**-0.038**	-0.048	0.106	0.043	0.232	0.055	0.012	0.047	0.481
Fruit length (cm)	0.019	-0.004	0.005	0.007	0.005	-0.016	**-0.113**	0.026	-0.018	0.212	0.107	0.120	0.009	0.358
Fruit girth (cm)	-0.043	0.006	-0.073	0.009	-0.004	-0.015	-0.010	**0.277**	0.119	0.365	0.051	0.058	0.048	0.790
Average fruit weight (g)	-0.008	0.005	0.042	0.070	0.001	0.008	0.010	0.155	**0.212**	0.203	0.055	0.016	0.050	0.803
No. of fruits per plant	0.001	0.012	0.018	-0.057	-0.001	-0.020	-0.053	0.224	0.096	**0.451**	0.100	0.090	0.020	0.881
T.S.S.	-0.051	0.006	0.059	0.100	-0.001	-0.016	-0.092	0.107	0.088	0.343	**0.132**	0.053	0.012	0.740
100 seed weight	0.030	0.007	-0.036	-0.038	0.006	-0.003	-0.100	0.119	0.024	0.298	0.051	**0.136**	0.001	0.494
Duration of Crop (sowing to last harvest)	0.029	0.000	-0.056	0.042	0.004	-0.018	-0.010	0.131	0.104	0.089	0.016	0.001	**0.102**	0.434

Residual value: 0.0687, Diagonal and bold underline figures shows direct effect on fruit yield

Days to 50% flowering showed positive indirect effect on fruit yield through fruit girth (0.105), total soluble solid (0.060), fruit length (0.019), average fruit weight (0.016) and node number of first male flower appears (0.009), day to first fruit harvest (0.002). Similarly, number of branches per plant exhibited positive indirect effect on fruit yield *via*. number of fruits per plant (0.396), fruit girth (0.122) and average fruit weight (0.087).

Node number of first female flower appears exhibited positive indirect effect on fruit yield through fruit girth (0.095) and node number of first male flower appears (0.030), duration of crop (0.027) and 100 seed weight (0.023). Node number of first male flower appears had positive indirect effect on fruit yield through Fruit yield per plot (0.113), average fruit weight (0.111), T.S.S.(0.097) and duration of crop (0.2032). Days to fruit set showed positive indirect effect on fruit yield *via*, fruit girth (0.104) and fruit length (0.049), number of fruit per plant (0.034), node number of first male flower appears (0.025). Days to first fruit harvest showed positive indirect effect on fruit yield *via*. number of fruits per plant (0.232), fruit girth (0.106) and node number of first female flower appears (0.085).

Fruit length showed positive indirect effect on fruit yield *via*, number of fruit per plant (0.212), 100 seed weight (0.120) and total soluble solid (0.107). Fruit girth showed positive indirect effect on fruit yield through number of fruit per plant (0.365), average fruit weight (0.119) and 100 seed weight (0.058). Average fruit weight showed positive indirect effect on fruit yield through fruit yield per plot (0.803), number of fruit per plant (0.203),fruit girth (0.155) node number of first male flower appear (0.070) and total soluble solid (0.055).

Number of fruits per plant showed positive indirect effect on fruit yield *via*, fruit girth (0.224), total soluble solid (0.100) and average fruit weight (0.096). Total soluble solid showed positive indirect effect on fruit yield through fruit yield per plot (0.740), number of fruit per plant (0.343), fruit girth (0.107), node number of first male flower appear (0.100) and node number of first female flower appear (0.059).100 seed weight showed positive indirect effect on fruit yield per plot *via*, number of fruits per plant (0.298), fruit girth (0.119) and total soluble solid (0.051). Whereas, duration of crop showed positive indirect effect on fruit yield per plot through fruit girth (0.131), average fruit weight (0.104) and node number of first male flower appear (0.042).

The effect of residual factor (0.0687) on fruit yield per plot was negligible, thereby, suggested that no other major yield contributing component is left over.

In present investigation, no. of fruits per plant followed by node no. of first male flower, node no. of first female flower and T.S.S. showed high positive & direct effect and had significant positive correlation with fruit yield. Therefore, plant having more number of fruits, node number of male and female and T.S.S (%) of fruit should be considered in selection criteria for increasing fruit yield per plant. The present study suggested that more emphasis should be given to selecting genotypes with higher no. of fruits per plant. Directly or indirectly all characters showed positive effect on fruit yield per plant, which is in confirmation to the finding of Umamaheswarappa *et al.* (2004) who also reported that number of fruits per vine had maximum direct effect on fruit yield followed by fruit weight. Ahmed *et al.* (2005) also reported that fruit weight, number of fruits per plant, fruit length had positive direct effect on fruit yield of bottle gourd. Similar results were obtained by Singh *et al.* (2006), Gayen and Hossain (2007) and Muralidharan *et al.* (2013).

Overall the path analysis confined that direct effect of no of branches per plant, node number of first male flower, fruit girth, fruit weight, number of fruits per plant, T.S.S., 100 seed weight and duration of crop whereas, indirect effect of days to 50% flowering, node number of first female flower, day to fruit set, days to first fruit harvest and fruit length should be considered simultaneously for amenability in fruit yield of ash gourd.

4.6 Divergence analysis

The concept of D^2 statistics was originally developed by Mahalonobis (1936). Then Rao (1952) suggested the application of this technique for the arrangement of genetic diversity in plant breeding. Now, this technique is being extensively used in vegetable breeding also to study the selection of different parents. Genetic variability and selection of parents from diverse breeding material including germplasm and there diverse parents, can be used for the development of hybrids in bottle gourd.

On the basis of D^2 analysis, thirty genotypes were grouped into five Clusters (**Table 4.7**). Maximum number of genotypes were grouped into cluster II (IAG-11, IAG-18, IAG-21, IAG-22, IAG-23, IAG-25, IAG-26, IAG-27, IAG-28, IAG-30) included ten genotypes, whereas, cluster V (IAG-1, IAG-3, IAG-5, IAG-7, IAG-13, IAG-15, IAG-16) included seven genotypes. The cluster I (IAG-2, IAG-4, IAG-8, IAG-9, IAG-17, IAG-20) and cluster IV (IAG-6, IAG-12, IAG-14, IAG-19, IAG-24, IAG-29) has six genotypes in each and cluster III (IAG-10) had only one genotype.

Table 4.7: Composition of clusters

Cluster Number	Number of genotypes included	Name of genotypes
I	6	IAG-2, IAG-4, IAG-8, IAG-9, IAG-17, IAG-20
II	10	IAG-11, IAG-18, IAG-21, IAG-22, IAG-23, IAG-25, IAG-26, IAG-27, IAG-28, IAG-30
III	1	IAG-10
IV	6	IAG-6, IAG-12, IAG-14, IAG-19, IAG-24, IAG-29
V	7	IAG-1, IAG-3, IAG-5, IAG-7, IAG-13, IAG-15, IAG-16

from the **Table 4.8** that maximum inter cluster distance was observed between cluster III and cluster IV (10.048) followed by cluster III and V (9.279), cluster III and I (8.553), cluster III and II (8.265), cluster IV and I (3.991), cluster I and II (3.368), cluster IV and V (3.365), cluster V and I (3.346). The minimum inter-cluster D^2 values were recorded in case of cluster V to cluster II (3.346) followed by cluster IV and II (3.100). The higher inter-cluster distance indicated greater genetic divergence between the genotypes of those cluster, while lower inter-cluster values between the cluster suggested that the genotypes of the clusters were not much genetically diverse from each other.

The intra-cluster distance varied from 2.570 to 2.882. The maximum intra-cluster distance was shown by IV cluster (2.882) followed by cluster V (2.719), cluster I (2.647), cluster II (2.570) and cluster III (0.000), which indicate distance within the cluster. These results are in general agreement with the findings of Badade *et al.* (2001), Islam (2004), Mathew *et al.* (2001), Singh *et al.* (2007) and Bhardwaj *et al.* (2013).

Table 4.8: Intra (bold) and Inter cluster distance values in ash gourd

Cluster Number	I	II	III	IV	V
I	**2.647**				
II	3.368	**2.570**			
III	8.553	8.265	**0.000**		
IV	3.991	3.108	10.048	**2.882**	
V	3.346	3.338	9.279	3.365	**2.719**

4.6.1 Mean performance of clusters

The mean performance for different clusters of genotypes for fruit yield and its components are presented in **Table 4.9**. The data of cluster means for all the characters showed appreciable differences.

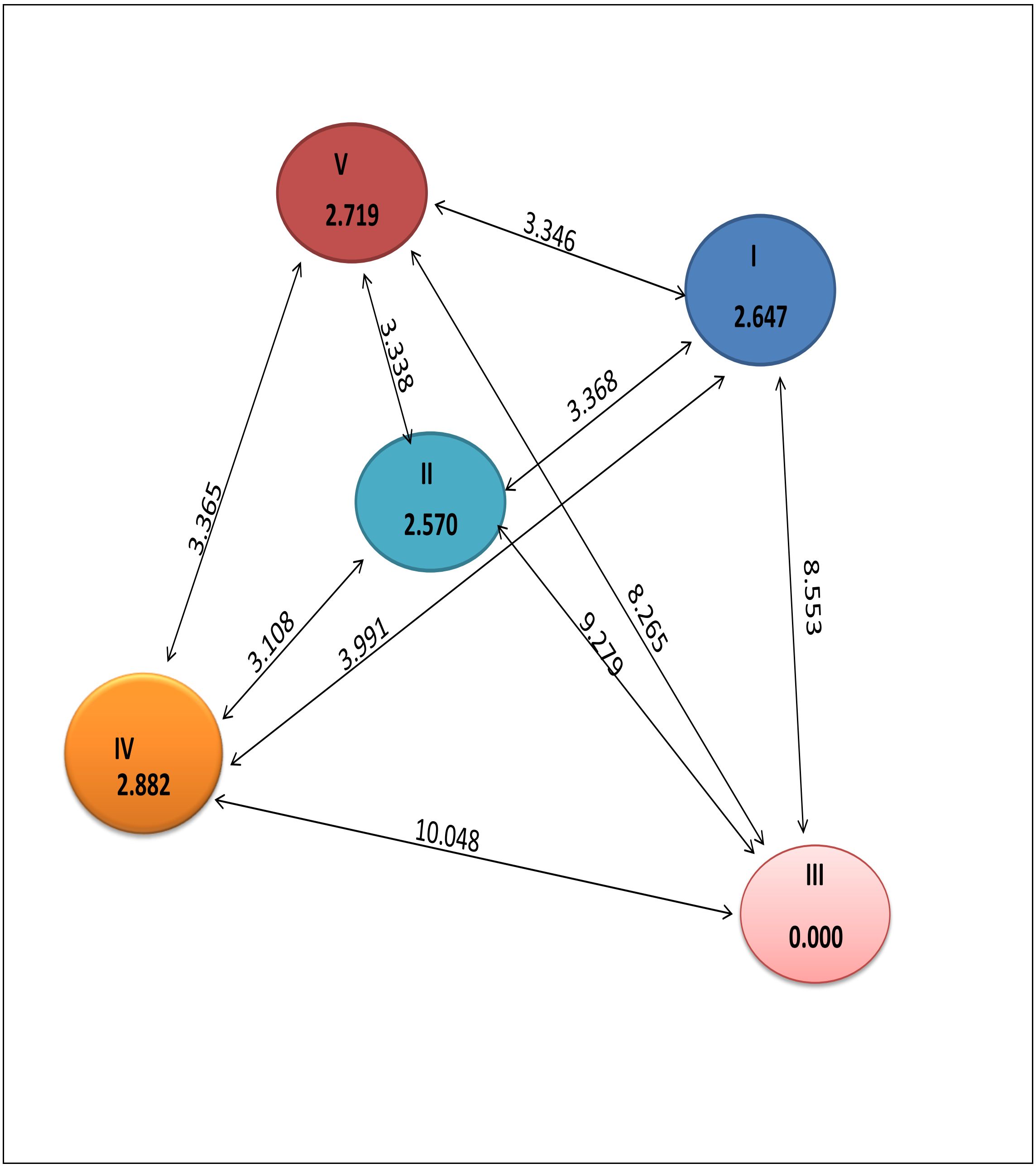


Fig.4.1: Cluster diagram of Ash gourd

(Values inside circle is intra-cluster distance)

Days to 50% flowering showed the lowest cluster mean for cluster I (86.11days), which was followed by cluster V (90.90 days), cluster III (93.33days), cluster IV (101.11days) and highest in cluster II (102.93 days). Number of branches per plant showed maximum cluster mean in cluster III (14.00), which was followed by cluster I (11.67), cluster V (10.67), cluster IV (10.61) and cluster II (10.37).

Node number of first female flower appear showed the lowest cluster mean for cluster I (34.44), which was followed by cluster II (39.07), cluster V (43.76), cluster IV (44.06) and cluster III (48.67). Node number of first male flower exhibited the lowest mean performance for cluster III (30.67) followed by cluster IV (31.00), cluster V (31.29), cluster I (31.33) and most delayed male flowering showed by cluster II (31.93).

As regard to days to fruit set the earliest cluster mean was recorded in cluster I (76.00 days), which was followed by cluster V (76.62 days), cluster III (82.33 days), cluster II (88.17 days) and cluster IV (89.44 days). Days to first fruit harvest showed minimum cluster mean in cluster IV (128.00 days), which was followed by cluster V (128.05 days), cluster I (130.83 days), cluster II (131.33 days) and cluster III (133.33 days).

Fruit length showed maximum cluster mean in cluster III (24.33 cm), which was followed by cluster V (24.00 cm), cluster II (23.83 cm), cluster I (22.61 cm) and cluster IV (21.72 cm). Fruit girth showed maximum cluster mean in cluster II (53.77cm), which was followed by cluster IV (52.17cm), cluster I (51.11cm), cluster V (50.67 cm) and cluster III (24.33 cm).

As regard to average fruit weight, the highest average mean was recorded in cluster III (3.35 kg.), which was followed by cluster I (3.05 kg.), cluster II (2.83 kg.), cluster IV (2.69) and cluster V (2.60 kg.).

Table 4.9: Mean performance of genotypes in individual cluster for yield and its components in ash gourd.

Character Cluster		Days to 50% flowering	No. of branches per plant	Node no. of first female flower appears	Node no. first male flower appears	Days to fruit set	Days to first fruit harvest	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (km)	No. of fruits per plant (g)	T.S.S	100 seed weight	Duration of crop (sowing to last harvest)	Fruit yield/plot (kg)
I	6	86.11	11.67	34.44	31.33	76.00	130.83	22.61	51.11	3.05	9.11	2.41	4.09	140.22	27.48
II	10	102.93	10.37	39.07	31.93	88.17	131.33	23.83	53.77	2.83	9.50	2.45	4.22	139.87	27.04
III	1	93.33	14.00	48.67	30.67	82.33	133.33	24.33	24.33	3.35	14.00	2.67	6.10	143.67	47.23
IV	6	101.11	10.61	44.06	31.00	89.44	128.00	21.72	52.17	2.69	8.56	2.31	3.61	138.00	22.09
V	7	90.90	10.67	43.76	31.29	76.62	128.05	24.00	50.67	2.60	8.86	2.30	4.71	137.52	22.86

Number of fruits per plant exhibited the highest mean for cluster III (14.00) followed by cluster II (9.50), cluster I (9.11), cluster V (8.86) and cluster IV (8.56). Total soluble solid showed maximum cluster mean in cluster III (2.67), which was followed by cluster II (2.45), cluster I (2.41), cluster IV (2.31) and cluster V (2.30). 100 seed weight showed maximum cluster mean performance in cluster III (6.10), which was followed by cluster V (4.71), cluster II (4.22), cluster I (4.09) and cluster IV (3.61).

Yield per plot showed maximum cluster mean performance in cluster III (47.23 kg), which was followed by cluster I (27.48 kg), cluster II (27.04 kg), cluster V (22.86 kg) and cluster IV (22.09 kg). Duration of crop exhibited the lowest mean value for cluster V (137.52 days) and highest mean performance for cluster III (143.67 days) followed by cluster I (140.22 days), cluster II (139.87 days) and cluster IV (138.00 days).

The cluster mean for various traits showed that different cluster respond differentially for various traits. Cluster V expressed highest mean value for fruit length, number of fruit per plant, 100 seed weight, duration of crop and fruit yield per plot and lowest mean value for node number of first male flower appears and duration of crop. Cluster IV showed highest mean performance for average fruit weight. Cluster III showed highest mean value for number of branches per plant, fruit yield per plot and total soluble solid. Cluster II showed lowest mean performance for node number of first female flower appears. Cluster I showed lowest mean value for days to fruit set, days to first fruit harvest and highest mean value for fruit girth.

The better genotypes can be selected for most of characters on the basis of mean performance in the cluster. The best genotypes which had chosen for different characters are presented in **Table 4.10**.

Table 4.10: Desirable genotypes based on cluster mean performance

S. No.	Cluster Characters	I	II	III	IV	V
1.	Days to 50% flowering	IAG-2	IAG- 18	IAG- 10	IAG- 6	IAG- 1
2.	Number of branches per plant	IAG-4	IAG- 11	IAG- 10	IAG- 12	IAG- 3
3.	Node number of first female flower appears	IAG- 8	IAG- 18	IAG- 10	IAG- 29	IAG- 15
4.	Node number of first male flower appears	IAG- 8	IAG- 18	IAG- 10	IAG- 6	IAG- 15
5.	Days to fruit set	IAG- 2	IAG- 18	IAG- 10	IAG- 6	IAG- 7
6.	Days to first fruit harvest	IAG- 2	IAG- 21	IAG- 10	IAG- 29	IAG- 5
7.	Fruit length (cm)	IAG- 9	IAG- 22	IAG- 10	IAG- 14	IAG- 16
8.	Fruit girth (cm)	IAG- 20	IAG- 21	IAG- 10	IAG- 19	IAG- 1
9.	Average fruit weight (kg)	IAG- 20	IAG- 23	IAG- 10	IAG- 12	IAG- 7
10.	Number of fruits per plant	IAG- 9	IAG- 18	IAG- 10	IAG- 14	IAG- 5
11.	T.S.S (%)	IAG- 9	IAG- 23	IAG- 10	IAG- 19	IAG- 5
12.	Fruit yield/plot (kg)	IAG- 20	IAG- 22	IAG- 10	IAG- 6	IAG- 3
13.	Fruit yield/plot (kg)	IAG- 9	IAG- 18	IAG- 10	IAG- 12	IAG- 3
14.	Duration of crop (sowing to last harvest)	IAG- 2	IAG- 11	IAG- 10	IAG- 12	IAG- 15

4.6.2 Contribution of characters towards divergence

In the contribution of each character to divergence presented in **Table 4.11** which showed that node number of first female flower appears contributes highest (45.54%) to divergence followed by fruit girth (10.64%), average fruit weight (10.39%) and duration of crop (10.39%) Whereas, 100 seed weight (6.18%), day to first fruit harvest (2.97%) and T.S.S (2.97%), fruit length (2.47%), day to 50% flowering (2.22%), fruit yield/plot (1.98%), node no. of first male flower(1.48%), node number of first male flower appears (1.23%), number of branches per plants (0.74%) and day to fruit set (0.74%) contribute lowest to divergence. The results of the present study was close agreement with findings of Islam *et al.* (2004) who reported that primary branches per plant, fruit length and weight, number of fruits and yield per plant contributed the most of the total genetic divergence.

The inter-cluster distances in present investigation were higher than the intra-cluster distance reflecting the wider diversity among the breeding lines of the distant group. Hence, it is suggested that intercrossing of genotypes from diverse clusters showing high mean performance will be helpful in obtaining better recombinants with higher genetic variability.

Genetic divergence is one of the useful tools for selection and efficient use of parents for hybridization to develop high yielding potential cultivars/hybrids. Inclusion of more diverse parents in hybridization is believed to increase the chances of obtaining stronger heterosis and gives broad spectrum of variability in segregating generations.

This implied that there was no parallelism between genetic divergence and geographical divergence. This has been observed that diverse the parents within its overall limits of fitness, the greater are the chances of heterotic expression in F_1's and a broad spectrum of variability in segregating generations.

Table 4.11: Contribution of each character to divergence

Characters	Days to 50% flowering	No. of branches per plant	Node no. of first female flower	Node no. of first male flower	Days to fruit set	Days to 1^{st} fruit harvest	Fruit length (cm)	Fruit girth (cm)	Avg. fruit weight (kg)	No. of fruits per plant	T.S.S	100 seed weight	Fruit yield/ lot (kg)	Duration of crop (sowing to last harvest)	Total
Number times appearing first time	9	3	184	6	3	12	10	43	42	5	12	25	8	42	404
Percent contribution	2.22	0.74	45.54	1.48	0.74	2.97	2.47	10.64	10.39	1.23	2.97	6.18	1.98	10.39	100

In this study, group constellation showed that cluster II (IAG-11, IAG-18, IAG-21, IAG-22, IAG-23, IAG-25, IAG-26, IAG-27, IAG-28, IAG-30.) were highly divergent from all other genotypes and may be used as parents in transgenic breeding programme and may directly be used as a pure line variety for fruit yield and it's component characters in ash gourd [*Benincasa hispida* (Thumb) Cogn.] for Chhattisgarh plains.

CHAPTER-V

SUMMARY AND CONCLUSION

The present investigation entitled **“Genetic variability and divergence analysis in ash gourd [*Benincasa hispida* (Thumb) Cogn.]”** was conducted during kharif season of the year 2014-15 at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was comprised of thirty genotypes of ash gourd laid out in Randomized Block Design (RBD) with three replications to estimate the genetic variability, correlation coefficient, path analysis and genetic divergence.

Five randomly selected plants were considered for observations of different characters *viz*., days to 50% flowering, number of branches per plant, node number at which first female flower appears, node number at which first male flower appears, days to fruit set, days to first fruit harvest, fruit length (cm), fruit girth (cm), average fruit weight (gm), number of fruits per plant, total soluble solid (%), 100 seed weight, fruit yield /plot (kg), fruit yield (q/ha), duration of crop (sowing to last harvest).

The analysis of variance indicated that the mean sum of square due to genotypes were highly significant for all the characters. Significant mean sum of squares due to fruit yield and attributing characters revealed existence of considerable variability in material studied for improvement of various traits.

The highest yield quintal per hectare was recorded in genotype IAG 10 (157.44 q) followed by IAG 13 (64.44 q), IAG 17 (64.01 q).). The earliest flowering was recorded in IAG 2 (82 days) which was followed by IAG 20 (86.33 days), IAG 3 (85.67 days). Maximum number of fruits per plant was recorded in IAG 10 (14) followed by IAG 18 (11), IAG 5 (10). Maximum fruit length was recorded in IAG 16 (26 cm) followed by IAG 15 (25 cm), IAG 13 (24.67 cm). Maximum fruit girth was recorded in IAG 10 (62.33 cm) followed by IAG 19 (58 cm), IAG 15 (48.33 cm). Average fruit weight ranged from 2.26 kg. (IAG 6) to 3.35 kg (IAG 10) followed by IAG 12 (3.23 kg), IAG 23 (3.20 kg).

Earliest harvesting was recorded in the genotype IAG 15 (133 days) followed by IAG 12 (134 days), IAG 11 (134.33 days).

The highest genotypic and phenotypic coefficient of variation was recorded for fruit yield per plot (18.28 % and 25.29 %), node number at which first female flower appears (13.16% and 14.31 %) and 100 seed weight (12.44 % and 17.73%). The phenotypic coefficients of variation were higher than the genotypic coefficient of variation. The highest heritability was noted in characters like node number of first female flower (84.5%), average fruit weight (52.4%) and fruit yield per plot (52.2%). Whereas, highest heritability coupled with highest genetic advance were observed for characters *viz.*, days to first female flower appears, average fruit weight and fruit yield per plot. Hence, these characters might be improved by simple selection.

Fruit yield per plot showed positive and significant correlation with fruit girth (cm.), average fruit weight, number of fruits per plant and fruit yield per plot at genotypic and phenotypic level but with number of branches per plant, day to first fruit harvest, fruit length and total soluble solid only at genotypic level. It indicated that major emphasis should be given on these components for increasing the fruit yield per plot.

Path coefficient analysis revealed that fruit weight showed the highest positive direct effect (0.451) number of fruits per plant followed by fruit girth (0.277), average fruit weight (0.212), 100 seed weight (0.136), node number of first male flower appears (0.135), total soluble solid (0.132), duration of crop (0.102) and number of branch per plant (0.013). On the other hand node number of first female flower appear, fruit length, days to 50% flowering, days to first fruit harvest and day to fruit set.

D^2 values recorded on fruit yield and its components for thirty genotypes, which were grouped into five clusters based on relative magnitude of D^2 values. The group constellation showed that cluster II (IAG-11, IAG-18, IAG-21, IAG-22, IAG-23, IAG-25, IAG-26, IAG-27, IAG-28, IAG-30) were highly divergent from all other genotypes and may be used as parents, to exploit heterotic expression for fruit yield and its component characters in ash gourd for Chhattisgarh plains.

Thus, while planning hybridization programme for the development of heterotic hybrids and better transgressive segregants one should select genotypes (IAG-11, IAG-18, IAG-21, IAG-22, IAG-23, IAG-25, IAG-26, IAG-27, IAG-28, IAG-30) from cluster II for node number of first female flower appears. Similarly genotypes IAG 6, IAG 12, IAG 14, IAG 19, IAG 22, IAG 29 from cluster IV for average fruit weight. Genotypes IAG 10, from cluster III for number of branches per plant, fruit yield per plot and total soluble solid (%). Whereas, genotypes IAG 1, IAG 3, IAG 5, IAG 7, IAG 13, IAG 15, IAG 16 from cluster V for fruit length, number of fruit per plant, 100 seed weight and fruit yield per plot. IAG 2, IAG 4, IAG 8, IAG 9, IAG 17, IAG 20 from Cluster I for days to fruit set, days to first fruit harvest and fruit girth.

Conclusion

The analysis of variance showed that considerable variability existed among the genotypes for most of the traits showing possibilities of further genetic improvement, in ash gourd.

The mean performance for yield quintal per hectare of IAG 10 was superior among all the genotype. Higher heritability estimates coupled with high genetic advance as percent of mean were observed for node number of first female flower appears, average fruit weight and fruit yield per plot. Correlation studies revealed that fruit yield per plot showed the highest positive and significant correlation with fruit girth, average fruit weight, number of fruit per plant and 100 seed weight at both genotypic and phenotypic levels and number of branches per plant, day to 1st fruit set, fruit length and total soluble solid at genotypic level only.

The D^2 values recorded for thirty genotypes indicated the presence of appreciable amount of genetic diversity among the genotypes. In this study, group constellation showed that genotype of cluster II i.e. (IAG-11, IAG-18, IAG-21, IAG-22, IAG-23, IAG-25, IAG-26, IAG-27, IAG-28, and IAG-30 were highly divergent from all other genotypes. This indicated that crossing programme with IAG-11, IAG-18, IAG-21, IAG-22, IAG-23, IAG-25, IAG-26, IAG-27, IAG-28, and IAG-30 will be planned by using this desirable useful trangressive genotype for fruit yield in ash gourd for Chhattisgarh plains.

SUGGESTIONS FOR FUTURE RESEARCH WORK

Since the results of present investigation belong to only one year of experiment, for reaching to any definite conclusion and recommendation, it need further conduction of the same experiment for at least two successive years in different environment. However, following studies are also suggested to be undertaken in future.

1. The experiment may be conducted during different seasons.
2. There is need of in depth study on qualitative aspect.
3. More number of genotypes may be collected from different untouched places of India and included in further studies.
4. In order to improve the fruit yield per plant and other important attributes, the Genotypes falling in distant characters may be utilized in future breeding programme.
5. From the study of cluster analysis those diverse parents belonging to different clusters depending upon performance may be involved in the future hybridization program.
6. On the basis of selection the best accession should be evaluated in next year for confirmation along with check varieties under different agro climatic zone of Chhattisgarh.
7. There are large numbers of local genotypes available in Chhattisgarh which may have valuable genes for different characters, should be collected and evaluated for different quality and processing parameters along with resistance to different biotic and abiotic stresses.

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Appendix-I: Weekly meteorological data during the crop period (July 9, 2014 to December 9, 2014)

Months and year	Standard Week No.	Temperature (°C)		Rain -fall (mm)	Relative Humidiy (%)		Wind velocity (kmph)	Evap- ration (mm)	Sun shine (Hours)
		Max.	Min.		I	II			
Jul. 2014	28	34.3	23.8	152.8	92	72	8.4	6.6	4.1
	29	28.5	24.6	260.2	95	88	12.1	2.8	0.5
	30	28.7	23.8	37.2	95	82	9.4	2.7	1.6
	31	29.8	24.8	136.0	95	86	9.7	4.0	1.9
Aug. 2014	32	30.2	24.8	42.1	91	71	9.1	3.6	2.8
	33	31.8	25.3	45.0	91	70	7.0	4.7	5.5
	34	32.3	25.1	25.8	92	73	4.0	3.7	3.4
	35	31.8	25.0	84.8	91	76	5.8	4.1	3.6
Sep. 2014	36	25.1	28.3	79.5	94	83	6.2	1.7	0.5
	37	30.5	24.3	41.0	95	79	5.8	3.3	3.4
	38	32.1	24.6	57.6	94	68	3.6	3.7	4.4
	39	33.4	24.0	0.0	93	57	2.1	4.1	8.3
Oct. 2014	40	33.2	24.0	0.0	91	57	2.5	3.9	8.3
	41	30.4	23.6	52.2	89	66	6.9	3.6	4.9
	42	31.5	22.5	1.2	91	56	2.6	3.4	8.4
	43	29.1	19.4	5.4	92	52	2.0	2.8	5.9
	44	30.1	16.9	0.0	94	37	1.9	3.0	8.0
Nov. 2014	45	30.7	17.6	0.0	88	44	3.0	3.4	7.8
	46	31.4	19.3	0.0	84	35	2.8	3.6	6.8
	47	29.3	11.9	0.0	91	28	1.9	2.9	8.5
	48	30.2	12.5	0.0	90	26	1.9	3.2	8.6
Dec. 2014	49	28.9	10.8	0.0	90	28	2.2	3.4	9.0

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