VARIABILITY AND ASSOCIATION STUDIES FOR FOLIAGE YIELD COMPONENTS AND ITS QUALITY PARAMETERS IN CORIANDER (*Coriandrum sativum* L.)

M. Sc. (Hort.) Thesis

BY

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Thesis

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Rekha Thakur

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CERTIFICATE - I

This is to certify that the thesis entitled **"Variability and association studies for foliage yield components and its quality parameters in Coriander (*Coriandrum sativum* L.)** " submitted in partial fulfillment of the requirements for the degree of **"Master of Science in Horticulture"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur is a record of the bonafide research work carried out by **Rekha Thakur** 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 her.

Date: 12-01-2018

Chairman

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman:	Dr. Bhagwat Saran Asati	
Member:	Dr. Jitendra Singh	
Member:	Dr. Pooja Sahu	
Member:	Dr. R. R. Saxena	

CERTIFICATE – II

This is to certify that the thesis entitled **"Variability and association studies for foliage yield components and its quality parameters in Coriander (*Coriandrum sativum* L.)** " submitted by **Rekha Thakur** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of the requirements for the degree of **"Master of Science in Horticulture"** in the Department of Vegetable Science has been approved by the external examiner and Student's Advisory Committee after oral examination.

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(Name...3.3.2018...**)**

Major Advisor ....

Head of the Department ....

Dean/ Dean Faculty ....

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LIST OF ABBREVIATIONS

Abbreviations	Description
%	Per cent
@	At the rate of
^{O}C	Degree Celsius
CD	Critical difference
cm	Centimeter
CV	Coefficient of variation
df	Degree of freedom
et al	And others/Co-workers
Fig.	Figure
FYM	Farm yard manure
g	Gram
GA	Genetic advance
GCV	Genotypic coefficient of variation
PCV	Phenotypic coefficient of variation
ha	Hectare
hrs.	Hours
H^2	Heritability
i.e.	That is
kg	Kilogram
M^2	Square meter
MT	Million tons
mg	Milligram
No.	Number
NPK	Nitrogen, Phosphorus and Potassium

q/ha	Quintal per hectare
RBD	Randomized block design
RH	Relative Humidity
SEm±	Standard error of mean
var.	Variety
Via.	Through
Viz.	For example

THESIS ABSTRACT

a)	Title of the Thesis:	**"Variability and association studies for foliage yield components and its quality parameters in Coriander (*Coriandrum sativum* L.) "**
b)	Full Name of the Student:	Rekha Thakur
c)	Major Subject:	Vegetable Science
d)	Name and Address of the Major Advisor:	Dr. Bhagwat Saran Asati (Assistant Professor) Pt.KLS College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur(C.G.)
e)	Degree to be Awarded:	M.Sc. (Hort.) Vegetable Science

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Signature of the Student

Signature of Major Advisor

Signature of Head of the Department

Date: 12.01.2018

ABSTRACT

The present investigation entitled **"Variability and association studies for foliage yield components and its quality parameters in Coriander (*Coriandrum sativum* L.) "** was carried out at Pt. KLS College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur(C.G.) during 2016-17. The experiment was comprised of twenty eight genotype of coriander, laid out in Randomized Block Design (RBD) with three replications. The data were analyzed to work out the genetic variability, correlation coefficient and path analysis for the character *viz.*, Plant height, Number of branch per plant, Stem base diameter, Number of leaves per plant, Leaf length, Leaf width, Petiole length, Root length, Root weight, Plant fresh weight, Fresh leaf weight ,Leaf stem ratio, Fresh stem weight, Dry leaf weight, Dry stem weight,

Dry plant weight, Foliage yield (kg/plot), Foliage yield (q/ha), Fiber percentage, Dry matter percentage, K , Ca.

Analysis of variance revealed that the mean sum of square due to genotypes was highly significant for all characters except plant height and dry matter. Estimation of genetic parameters for various characters revealed that the high magnitude of genotypic as well as phenotypic coefficient of variation were recorded for leaf stem ratio, dry stem weight, root weight, fresh stem weight, foliage yield kg per plot, plant fresh weight, foliage yield q per ha, dry plant weight, fresh leaf weight, K mg per 100 g, dry leaf weight, stem base diameter, Ca mg per 100 g and number of leaves per plant.

In present investigation, COR- 07 was superior among all the genotype for most of the characters *viz.* Plant fresh weight, Fresh stem weight, Dry stem weight, Dry plant weight, leaf yield q per ha, Ca mg per 100 g, whereas COR-10 was superior among all the genotype for most of the characters *viz.* number of leaves per plant, number of branches per plant, stem base diameter.

Higher heritability estimates coupled with high genetic advance as percent of mean were observed for leaf stem ratio, dry stem weight, root weight, fresh stem weight, K mg per 100 g , foliage yield kg per plot, plant fresh weight, foliage yield q per ha, dry plant weight, fresh leaf weight, dry leaf weight, Ca mg per 100 g, stem base diameter, number of leaves per plant , fiber content and petiole length.

Correlation coefficient studies revealed that foliage yield kg per plot showed the highest positive and significant correlation with all the quantitative characters at both genotypic and phenotypic levels except leaf stem ratio.

The path analysis confined that direct effect of foliage yield kg per plot on fresh stem weight, fresh leaf weight, root weight, dry plant weight, leaf width, leaf stem ratio, plant height and petiole length should be considered simultaneously for amenability in foliage yield of coriander.

शोधग्रंथ का सारांश

(अ) शोध का शीर्षक	" धनिया का पत्ती उत्पादन एवं गुणवत्ता परीक्षण करते हुए उनके घटकों तथा विभिन्नताओं का अध्ययन "
(ब) विद्यार्थी का पूरा नाम	रेखा ठाकुर
(स) प्रमुख विषय	सब्जी विज्ञान
(द) मुख्य सलाहकार का नाम एवं पता	डॉ. भगवत शरण असाटी, (सहायक प्राध्यापक), पं. किशोरी लाल शुक्ला उद्यानिकी महाविद्यालय एवं अनुसंधान प्रक्षेत्र राजनांदगांव, इंदिरा गॉधी कृषि विश्वविद्यालय,रायपुर (छ.ग.)
(इ) उपाधि का नाम	एम.एस.सी.(उद्यानिकी) सब्जीविज्ञान

RThakur

मुख्य सलाहकार के हस्ताक्षर

विद्यार्थी के हस्ताक्षर

दिनॉक 12-01-2018

विभागाध्यक्ष के हस्ताक्षर

शोध सारांश

वर्तमान शोध शीर्षक ''धनिया का पत्ती उत्पादन एवं गुणवत्ता परीक्षण करते हुए उनके घटकों तथा विभिन्नताओं का अध्ययन'' पं. किशोरी लाल शुक्ला उद्यानिकी महाविद्यालय एवं अनुसंधान प्रक्षेत्र, राजनांदगांव, इंदिरा गांधी कृषि विश्वविद्यालय,रायपुर (छ.ग.) में वर्ष 2016–17 के दौरान किया गया।

शोध धनिया के 28 जीन प्रारूपों को तीन पुनरावृत्तियों में यादृछिक खण्ड अभिकल्पना में लगाया गया। विभिन्न लक्षणों जैसे–पौधें की लंम्बाई, प्रति पौध शाखाओं की संख्या, तना आधार व्यास, प्रति पौध पत्तियों की संख्या, पत्ती की लंम्बाई, पत्ती की चौड़ाई, डंठल की लंम्बाई, जड़ो की लंम्बाई, जड़ का भार, पौधों का ताजा भार, पत्ती का ताजा भार, पत्ती तना अनुपात, तने का ताजा भार, पत्ती का शुष्क भार, तने का शुष्क भार, पौधे का शुष्क भार, पत्तियो की उपज किग्रा. प्रति प्लॉट, पत्तियो की उपज क्विंटल प्रति हेक्टेयर, रेशा, शुष्क पदार्थ का प्रतिशत, पोटेशियम, कैल्शियम से आनुवंशिक विभिन्नता, सहसंबंध `गुणांक, एवं प्रसरण विश्लेषण का सांख्यिकी विश्लेषण किया गया।

विचलन का विश्लेषण से पता चला की जीन प्रारूपों के कारण वर्गो का मतलब योगफलों की पौध की ऊंचाई और शुष्क पदार्थ को छोड़कर सभी लक्षणों के लिये बहुत महत्वपूर्ण था । विभिन्न लक्षणों के लिये आनुवांशिक मापदंण्डो के अनुमान से पता चलता है कि पत्ती तना अनुपात, शुष्क तना भार, जड़ तना भार , तना का ताजा भार, पत्ती उपज (किग्रा. प्रति प्लॉट),पौधे का ताजा भार ,पत्ती उपज, (क्विटल प्रति हेक्टेयर), शुष्क पौध भार , पत्ती का ताजा भार, पोटेशियम एमजी प्रति 100 ग्राम, शुष्क पत्ती भार, तना आधार व्यास , कैल्शियम एमजी प्रति 100 ग्राम और पत्तियों की संख्या प्रति पौधा के लिये जीनोटीपिक और फिनोटीपिक गुणांक के उच्च परिणाम को दर्ज किया गया है ।

वर्तमान शोध से पता चला कि सीओ आर 07 सभी जीन प्रारूपों में अधिक लक्षणों के लिए सर्वोतम पाया गया जो पत्ती ताजा भार , तना ताजा भार , शुष्क तना भार , शुष्क पौध भार , पत्ती उपज (क्विटल प्रति हेक्टेयर), कैल्शियम एमजी प्रति 100 ग्राम के बीच बेहतर है। जबकि सी ओ आर 10 कई लक्षणों के लिये सर्वोतम पाया गया, जैसे– पत्तियों की संख्या प्रति पौध, प्रति पौध शाखाओं की संख्या , तना आधार व्यास आदि।

पत्ती तना अनुपात , शुष्क तना भार , जड़ का भार , तने का ताजा भार , पोटेशियम एमजी प्रति 100 ग्राम, पत्ती उपज किग्रा. प्रति प्लॉट , पौध ताजा भार , पत्ती उपज (क्विटल प्रति हेक्टेयर), शुष्क पौध भार , पत्ती ताजा भार, शुष्क पत्ती भार ,कैल्शियम एमजी प्रति 100 ग्राम, तना आधार व्यास ,प्रति पौध पत्तियों की संख्या, रेशा एवं डंठल की लंम्बाई में उच्च आनुवांशिकमता को उच्च आनुवांशिक अग्रिम के साथ पाया गया ।

सहसंबध गुणांक के अध्ययन से स्पष्ट है कि पत्ती उपज किग्रा. प्रति प्लॉट पत्ती तना अनुपात को छोड़कर सभी मात्रात्मक लक्षणों के साथ जीनोटीपिक एवं फिनोटीपिक स्तरों पर सबसे अधिक सकारात्मक और महत्वपूर्ण सहसंबध दिखाया है।

प्रसरण गुणांक विश्लेषण में पाया गया कि पत्तियों की उपज किग्रा. प्रति प्लॉट में तनों का ताजा भार , पत्तियों का ताजा भार , जड़ का भार , शुष्क पौध भार , पत्ती की चौड़ाई , पत्ती तना अनुपात , पौधे की लंम्बाई एवं डठल की लंम्बाई का सीधे उच्च धनात्मक प्रभाव पाया गया जो धनिया में पत्तियों के उपज में संयम के लिये एक साथ माना जाता है।

CHAPTER-I
INTRODUCTION

India is well-known for its vegetable growing areas and second largest producer of vegetable next to China. Vegetables are well-known for its higher nutritional, mineral and vitamins content and the major vegetables grown in India are Potato, Tomato, Cabbage, Cauliflower, Onion, Brinjal, Chilli, Legumes, and Cucurbits etc. Apart from the common vegetables the different vegetables which are generally recognized at local level are leafy vegetables. Leafy vegetables are major part of indian cuisine and it prefer due to its higher nutritional, mineral, low caloric value, higher fiber content and medicinal value.

Green coriander (also called cilantro or Chinese, Mexican or Japanese parsley) has been called the most commonly used flavoring agent in the world due to its usage across the Middle East into all of southern Asia as well as in most parts of Latin America (Perseglove *et al.,* 1981 and Singh and Singh, 1996).

Coriander (*Coriandrum sativum* L.), is an annual spice herb (2n=22), which belongs to the family Apiaceae and generally grown in winter season as main crop in India. It is a diploid cross pollinated crop. The plant is a native to Mediterranean and near eastern region (Bhandari and Gupta 1991) and is broadly cultivated in North Africa, Europe, India, China and Thailand. The main exporters of coriander are the Ukraine, Russia, India and Morocco, and the main importers are the USA, Sri Lanka and Japan.

India, being the land of spices, is the foremost country with regard to production of coriander and there is a good demand for this crop as seed and fresh leaves for international consumption (Kumar, 1997). India is world's largest producer of coriander although; the major quantity is consumed within the country (John, 1994).

India produced 178172.41 thousand MT of vegetable from 10237.93 thousand hectare area (NHB. 2016-17), in which coriander is cultivated in an area of 674 thousand hectares with an annual production of 883 thousand MT (NHB, 2016-17).Rajasthan, Gujarat, Madhya Pradesh, Tamil Nadu, U.P. are the major coriander producing states. The domestic marketing centres of coriander are Jodhpur, Pratapgarh, Nembhaheda, Bhawanimandi, Jhalarapatan, Ramganjmandi, Kota and Jaipur (Agasimani, 2014).

In Chhattisgarh, 489.23 thousand hectare area is under the vegetable cultivation and production is 6728 thousand MT. Area under coriander cultivation in Chhattisgarh is 18861 hectare and production is 87050 MT (Directorate of Horticulture, Govt. of Chhattisgarh, 2016-17).

Coriander is a thin- stemmed, small bushy herb, much branched, grows about 25 to 50 cm tall, with alternate and compound leaves become which highly segmented and linear as they reach upper extremities. The leaves are variable in shape, broadly lobed at the base of the plant, and slender and feathery higher on the flowering stems. Inflorescence is a compound umbel and usually comprises about five smaller umbellets. Fruits are globular, yellow brown when ripened and are 3 to 4 mm in diameter. The fruits consist of two halves, the single seeded mericarps (Nybe *et al*. 2007).

Coriander is an important spice crop having a prime position in flavorings food. Coriander is the most widely used favoring herb in the world, its fresh leaves are used in salads, soups, vegetables etc, due to its aromatic flavor. The leaves have a strong odour while its fruits have a warm and spicy aroma. Due to its pleasant aroma, tender shoots and leaves are used in chutney, soups and salads. Besides condiment, coriander also has medicinal values. Green leaves of coriander are used for culinary purposes. The content of essential oil in ripe fruit is comparably low (typically, less than 1 %); the oil consists mainly of linalool (50 to 60 %) and about 20 percent terpenes (pinenes, α-terpinene, myrcene, camphene, phellandrenes, α-terpinene, limonene, and cymene).

Coriander has been reported to have several potential health benefits like antioxidant activity, digestive stimulant, anti-hypertensive, cholesterol-lowering, anticancer effect and many more. This potential can further be explored and exploited to develop new formulations and coriander can be used as a complete and promising functional food (Chawla and Thakur, 2013).

Its leaves contain 88% water, 32 kcal, 6.0 g CHO, 2.7 protein, 0.5 g fat, 1.0 g fiber and 1.7 g ash , 150 mg C, 0.01 mg B1, 0.01 mg B2, 1.0 mg Niacin, 150 mg Ca, 55 mg P, 540 mg K, 6 mg Fe per 100 g fresh weight of leave and 10, 000 I.U. Vit. A (Rubatzky *et al*., 1999).

Volatile oils such as linalool are responsible for the aroma of coriander. The essential oil of coriander should contain 60-70 percent linalool. Immature seedlings of small seeded coriander (cilantro) are harvested as a spicy addition to salads or for flavoring of meats, soups and stews. The oil is one of the oldest spice extract known, as it is mentioned for flavoring gin and liquors, soft drink, pickle, sausages, cigarette and cosmetics (Shankaracharya and Natrajan 1971).

The crop is generally grown as rainfed crop, either pure or mixed with other crops in mid land situation. It can be grown on a fairly wide range of soils, but is best adapted to well drained loam and sandy loam soils. It is also cultivated in sandy loam soils of northern India and in red sandy loams of Chhattisgarh (Bala Shanmugam *et al.*, 1988). In certain areas, it is grown as irrigated crop (Sharma and Bhati, 1984). The time of sowing varies in different localities but in Chhattisgarh, it is often cultivated in winter (rabi) as pure crop from October to January. Coriander germinates very slowly, and may take as long as 21 days to emerge.

Despite the importance of the crops, very limited breeding work has been done. The starting point of any systematic breeding program is the collection of large germpalsm. The adequacy of the germpalsm is determined by the amount of genetic variability present in the germpalsm. Information on nature and magnitude of variability for different important characters is necessary to judge the potentiality of the germpalsm collection. The strength of any breeding programme depends on the strength of germpalsm collection because germpalsm collection and evaluations the starting point of any breeding programme.

The information on the genetic variability and its components and the correlation component characters with green leaf yield is required. It is a well known fact that the yield is a polygenic trait and greatly affected by environment. Thus the selections based on yield component have better chance of success. It is therefore, necessary to have knowledge of direct and indirect influences of yield attributing characters, which help to select best performing genotype. This can be determined by correlation coefficient of different characters and path coefficient analysis.

In spite of its wide cultivation in India, the average foliage yield of coriander is rather low because of lack of attention given to this crop. Use of improved varieties/cultivars is one of the strategies for increasing the production and productivity of the crop. A germplasm collection with a good variability for the desirable characters is the basic requirement of any crop improvement programme (Singhania *et al.* 2006). In addition, crop improvement is primarily based on extensive evaluation of germplasm (Ghafoor *et al*. 2001). As coriander is an important spice crop, it needs a great deal of critical evaluation of the available types for selection of the improved types with high yield potential. Therefore, the present investigation entitled **"Variability and association studies for foliage yield components and its quality parameters in Coriander (*Coriandrum sativum* L.)''**was carried out at Pt. KLS College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur(C.G.) during 2016-17 with the following objectives-

1. To evaluate genetic variability in coriander genotypes for foliage yield components and its quality parameters.
2. To find out association (correlation and path analysis) among the genotypes for foliage yield components and its quality parameters.
3. To select the best genotypes suitable for Chhattisgarh plains.

CHAPTER- II
REVIEW OF LITERATURE

The development of a variety in some crop species depends upon the magnitude of genetic variability for desired characters. Genetic variability is great interest to the plant breeder as it plays a vital role in forming a successful breeding programme. Studies of association among various characters and path coefficient analysis are also of significance to a plant breeder for initiating a selection breeding programme.

Coriander is the most important Indian condiment crop but very limited efforts have been made for the genetic improvement of this crop. The current status of genetic studies related to scope of present study have been reviewed and summarized under following heads:

2.1. Performance of genotypes

2.2 Genetic variability

2.3. Heritability and genetic advance

2.4. Correlation (characters association) studies

2.5. Path coefficient analysis

2.1. Performance of genotypes

Dixit (2007) reported that the coriander registered higher values of plant height (15.24 cm), number of leaves per plant (6.06), number of branches (2.07), length of leaves (4.94 cm), width of leaves (2.68) and average yield (2.34 kg/m^2) when grown in the greenhouse than in the open field (12.62 cm; 5.4; 1.66; 2.06 cm; 1.62 cm; and 1.68 kg/m^2).

Sahu, R.L. (2008) studied the influence of biofertilizers on growth, yield and quality of Coriander. The results indicated that vegetative growth contributing characters (plant height, number of primary and secondary branches and leaf area per plant), fresh and dry weight per plant were influenced by combination of 100%K and 75% NP along with Azotobacter, Azospirillum and PSB.

Thakur *et al*. (2010) surveyed at several places of district Durg (Chhattisgarh) and reported that the forty-two plant species which are being used as human food. Eighteen species were identified in the crop fields of rice, gram, soybean and arhar, as weeds and others were cultivated. All screened species belongs to twenty-one families.

Palanikumar *et al.*(2011) studied mean performance of genotypes, the biomass yield showed positive significant association with plant height, number of branches, number of leaves, weight of leaves, weight of stem and weight of root during all the three seasons. Significant correlation of the biomass yield suggests the scope of direct effective selections for further improvement.

Chaulagain *et al*. (2011) studied the green leaf production potential of ten coriander cultivars. Coriander Local, Marpha Local, Mallika, Surabhi and Kalmi Chhattedar showed better performance as compared to others on growth, yield and quality parameters. The highest green leaf yield (10.09 mt/ha) was recorded in Coriander Local followed by Mallika (9.54 mt/ha), Surabhi (9.40 mt/ha) and Kalmi chhattedar (9.24 mt/ha).

Jain, M. (2013) studied effect of seed treatment with organic and inorganic substances on germination and foliage yield of coriander in Rabi season under Chhattisgarh plains. The results indicated that, it can be concluded that soaking seeds in 2% leaf extract of *Calotropis sp*. for 12 hrs + *P. fluorescence* (10g kg-1 seed) have registered higher growth, yield attributes, yield and economics of Rabi coriander.

Moniruzzaman *et al*. (2013 a) studied fourteen genotypes of coriander as treatments were evaluated to determine the performances of coriander genotypes and select the promising genotype (s) for higher foliage yield. The highest foliage yield was recorded from the genotype CS003 (9.85 t/ha) followed by CS002 (6.69 t/ha) and CS 001 (6.47 t/ha) while the lowest from the genotype CS004 (2.75 t/ha). The variation in foliage yield was due to the variation of genetic inheritance. On the basis of foliage yield performance the genotypes CS001, CS002 and CS003, and based on yield and aroma CS008 genotypes were suitable.

Moniruzzaman *et al.* (2013 b) evaluated four genotypes of coriander (CS001, CS002, CS003, and CS004) were planted at twenty different dates to assess the genotypes for year round production of foliage of coriander. Result revealed that the number of plants/m^2 and foliage yield/ha decreased with the increase of temperature. The 01 January 2009 sowing gave the maximum foliage yield (6.38 t/ha) followed by 01 December 2008 sowing (6.05 t/ha). The genotype CS003 was the best yielder followed by CS001 and CS002. Performances of genotypes were the poorest during hot periods i.e. 01 April 2008 to 01 October 2008. The genotypes CS001, CS002 and CS003 performed better with regard to foliage production from 01 September 2008 to 15 February 2009 and in 15 March 2008, while the genotype CS008 gave better result from 15 October 2008 to 01 February 2009.

Meena *et al.* (2013 a) evaluated to assess yield, quality and economics of coriander genotypes under irrigated condition. Results indicated that 'RKD-18' genotype was found most suitable and profitable in respect of seed yield, quality and economics than other genotypes for irrigated and prevailing agro-climatic conditions.

Agasimani (2014) studied on mean performance of genotypes, based on growth and yield attributing traits of genotypes *viz.*, DCC 37 (11.65 g), DCC 51 (11.63 g), DCC 49 (11.61 g), DCC 58 (11.52 g), DCC 59 (11.40 g) and DCC 8 (11.39 g) were identified as high yielding leafy types. Whereas, DCC 49 (4.24 g), DCC 51 (4.23 g), DCC 38 (4.16 g), DCC 8 (4.13 g), DCC 44 (4.12 g) and DCC 37 (4.11 g) recorded the maximum dry herbage yield during the whole season.

Kaium *et al.* (2015) studied yield and yield contributes of coriander as influenced by spacing and variety and observed that the highest seed yield (1.949 t/ha) was recorded from Faridpur local while BARI Dhonia 1 gave seed yield 1.903 t/ha. The highest plant height was obtained by BARI Dhonia 1 (81.853 cm) while for Faridpur local it was recorded 80.367 cm.

Katar *et al*. (2016) studied to determine the performance and stability of coriander genotypes for yield and yield components and essential oil content.

Results revealed that Arslan cultivar in Eskişehir location and Kudret in Isparta location had the highest seed yield. Besides Kudret cultivar and Gamze cultivar gave the highest seed yield as a means of locations; Eskisehir location had also higher seed yield.

Phurailatpam *et al.* (2016) studied nineteen cultivars of coriander from diverse sources were evaluated in semi-arid conditions of Gujarat for observing the various morphological and yield characters. The highest plant height was found in Pant Haritama (97.27 cm) which was at par with RCr 435, ACr 209, JD 1, Co 4, RCr 20 and Sadhana. There were no significant differences in number of primary and secondary branches in all the cultivars. Highest seed yield plant^{-1} were observed in JD 1 (10.78 g) which was at par with Sudha, Sindhu and RCr 41.

2.2. Genetic variability

The scope of the crop improvement depends on the foundation of genetic variability which is the pre-requisite for any breeding programme. There are two kinds of variability in crop plants, genetic and non genetic. The non genetic variability is the result of genetic and environmental interactions which is however, not of much use to breeders, since it cannot be perpetuated from generation to generation.

The study of genetic variability was made for the first time by great biologist Fisher (1918) and subsequently, the estimation of genotypic and phenotypic variations were used to predict the expected genetic response. Subsequently, a number of other workers have also discovered several techniques for the estimation of components of variance (Wright, 1921, Lush, 1940, Robinson *et al*., 1951 and Warner, 1952).

Tripathi *et al.* (2000) evaluated 40 genotypes of coriander and observed high estimates of PCV, GCV, heritability and genetic advance indicating substantial genetic variability and scope for selection for days to maturity, secondary branches, days to flowering and 1000 seed weight. There was little variability and scope for improvement through selection for number of umbellet per umbel, primary branches per plant and plant height.

Shrivastava *et al*. (2000) reported that forty genotypes of coriander in respect of plant height, primary branches, secondary branches, days to flowering, days to maturity, number of umbel per plant, number of umbellets per umbel, number of seeds per umbel, 1000 seed weight and seed yield. The assessment revealed considerable variability among the stock for all characters except primary branches per plant, umbellets per umbel and 1000 seed weight.

Jain *et al.* (2002) evaluated 196 accessions of coriander and reported that significant amount of variability was present in the germplasm for all the characters studied and also reported that umbels per plant followed by seed yield per plant exhibited high GCV as well as PCV. For umbellets per umbel, heritability and genetic advance were high, whereas, for days to 50 % flowering and 1000- seed weight, the heritability was high and genetic advance was low. The genetic advance was observed to be high for umbels per plant followed by seed yield per plant.

Megeji and Korla (2002) evaluated 30 genotypes of coriander and reported the analysis of variance which indicated significant differences in all the characters studied. Genotypic and phenotypic coefficients of variation were high for leaf yield, seed vigour and seed yield. Heritability was highest for 1000-seed weight followed by germination percentage. Seed vigour, leaf yield, 1000-seed weight, germination percentage and seed vigour recorded high genetic advance.

Rajput and Singh (2003) studied variability in 20 genotypes of coriander indicated higher estimates of genotypic coefficients of variation, PCV, heritability and genetic advance for seed yield, umbels per plant, seeds per umbel and plant height, suggesting probable role of additive gene effects on character expression.

Shah *et al.* (2003) evaluated 20 genotypes of coriander and reported that the PCV was generally higher than GCV. High estimates of heritability were recorded for oil content, 1000-seed weight, number of days of flowering, number of days to maturity and plant height, number of umbels per plant and seed grain per plant. Oil content, 1000-seed weight, plant height and number of days to flowering were characterized by high heritability coupled with high genetic gain.

Sharma *et al.* (2004) evaluated 120 genotypes of coriander and observed significant variability among the genotypes for all the character except seed yield per plant. GCV and PCV were moderate for umbels per plant, seeds per umbel, days to 50% flowering, plant height, branches per plant, umbellets per umbel and test weight.

Singh *et al*. (2005 a) studied a collection of 35 genotypes of coriander showing significant variability for plant height, number of primary and secondary branches per plant, days to 50 per cent flowering and maturity, number of umbels per plant, number of umbellets per umbel, number of seeds per umbellet, seed yield per plant, 1000-seed weight, essential oil content and harvest index.

Singh and Prasad (2006) evaluated 35 genotypes of coriander and reported genetic variation for plant height, number of primary branches per plant, number of secondary branches per plant, days to 50% flowering, days to maturity, number of umbels per plant, number of umbellets per umbel, number of grains per umbellet, 1000-grain weight essential oil content and harvest index.

Singh *et al*. (2006 a) carried out genetic variability and association studies involving 360 lines of coriander and resulted that high variability for seed yield (22.82%), umbels per plant, (28.65%) and seeds per umbel (21.63%) and low variability for days to 50% flowering (12.39%) and umbellets per umbel (13.30%).

Patel *et al*. (2008) carried out analysis of variability for 15 characters and 36 diverse genotypes of fennel. High genotypic and phenotypic variances were observed for days to 50% flowering, day to 50% maturity, plant height, plant height up to main umbel, total branches plant^{-1}, number of seeds main umbel^{-1}and seed yield plant^{-1}. The highest genotypic coefficient of variation was observed for volatile oil content in seed followed by total branches plant^{-1} and number of seeds main umbel^{-1}.

Singh *et al.* (2008) evaluated 70 germplasm lines of coriander and reported that a wide range of variability was noticed for plant height, branches per plant, umbels per plant, and seeds per umbel and seed yield. The high heritability coupled with high genetic advance and coefficients of variability was for plant height, inter-nodal distance, seed yield per plant, test weight and umbels per plant.

Idhal *et al.* (2009) evaluated 30 genotypes of coriander and reported that significant genotypic differences for all the nine characters. The genotypic coefficients of variation, heritability and genetic advance were higher for branches per plant, umbels per plant and 1000-seed weight.

Meena *et al*. (2010) studied on 30 diverse genotype of coriander and observed that days to maturity showed a wide arrange (103.10-121.60) followed by plant height (92.13-112.67) and no. of umbel plant-^{1} (59.85-88.07) while yield plot^{-1} showed least range (0.24-0.35). The PCV (%) were comparatively high for yield plot^{-1} followed by number of seed umbel^{-1}, no. of secondary branches plant^{-1} and test weight (g). GCV were comparatively high for yield plot^{-1} (kg) followed by number of umbel plant$^{-1,}$ yield plant^{-1} (g), number of seeds umbel^{-1}, test weight, number of umbellets umbel^{-1} and number of secondary branches plant-^{1}. The GCV is less than the corresponding PCV, indicating the role of environment in the expression of the traits under observation.

Mengesha and Alemaw (2010) evaluated the performance of 49 accessions of Ethiopian coriander and reported that the combined analysis of variance over locations, accessions varied significantly in all the traits except for basal leaf number, plant height and fatty oil contents. A range of seed yield (910-3099 kg ha-^{1}), essential oil (0.25-0.85 %) and fatty oil (11.11-16.53 %) content was obtained. Highest value of GCV, broad sense heritability and genetic advance as percent of mean was obtained for longest basal leaf length, days to start 50% flowering, umbels number per plant, number of umbellets per umbel, number of seeds per umbellets, number of seed per plant, seed yield per hac and essential oil content.

Pandey *et al.* (2012) evaluated thirty five coriander genotypes for 10 characters. Analysis of variance showed significant differences among genotypes for all the traits. The study showed highest phenotypic and genotypic coefficients of variation for number of secondary branches plant^{-1}, number of umbels plant^{-1} and seed yield plant^{-1}.

Abou El-Nasr *et al.* (2013) studied genetic variability, essential oil composition and ISSR molecular markers for seven characters in ten selected genotypes within three coriander cultivars. The analysis of variance revealed that there were highly significant ($p<0.01$) differences among and within coriander cultivars for all the characters, except total number of branches which showed significant ($p<0.05$) among the genotypes. Genotypes had highly significant variations at ($P> 0.01$) for all studied characters in both seasons except in case of total number of branches for Russian cultivar which was significant at ($P> 0.05$) in the 1st and 2nd seasons.

Dyulgerov and Dyulgerova (2013 a) observed that large genetic variability for most of the studied traits among 81 coriander accessions. Traits such as fruit weight per umbel, 1000 fruit weight and fruit weight per plant have major contribution to the induced genetic diversity.

Dyulgerova *et al.* (2013 b) studied the variation of some important yield components in a coriander collection. The experiment was laid out in randomised complete block design with three replications. Ten plants were randomly selected from each plot and data were collected for plant height, number of branches per plant. A large variation was observed for most of the characters studied in germplasm accessions. Suitable accessions for future use in coriander breeding program were identified. Plant height ranged from 48.67 to 101.67 cm and was the lowest variatied trait with a CV 13.77 percent.

Meena *et al*. (2013 b) reported highest genotypic and phenotypic variance for number of umbels plant^{-1}, plant height and days to harvesting. High genotypic and phenotypic coefficient of variance was observed for seed yield of coriander.

Rawat *et al*. (2013) studied genetic variability, PCV and GCV of 13 diverse genotype of fennel. The PCV was higher than GCV in all the characters. The maximum GCV was recorded for yield plant^{-1} (40.27), followed by seed yield (32.40 q ha^{-1}), weight of seed umbel^{-1} (27.12), number of umbellets umbel^{-1} (17.47) and number of seeds umbel^{-1} (16.88).

Singh and Singh (2013) evaluated nine genotypes with 11 traits in terms of genetic variability analysis in coriander. The PCV revealed that the days to maturity showed the maximum range of mean performance (134.33–142.33) followed by plant height (106.00–124.00) and minimum range of mean performance was obtained for umbellets umbel^{-1}(7.33-10.80).The maximum PCV was observed for number of umbels plant-^{1} (19.04) followed by primary branches (14.77) and number of umbellets umbel^{-1} (14.75). The maximum GCV was obtained for number of umbel plant^{-1} (18.39) followed by primary branches (13.35) and number of umbellets umbel^{-1} (11.50). The minimum GCV (0.81) and PCV were observed for days to maturity (1.03).

Meena *et al.* (2014 b) studied to assess the extent of genotypic and phenotypic coefficient of variation, expected genetic advance, heritability, genotypic and phenotypic correlation coefficients and path analysis for direct and indirect effect of yield components on yield of coriander**.** The highest genotypic and phenotypic variance was observed for number of umbels per plant, plant height and days to harvesting. High genotypic and phenotypic coefficients of variances were observed for seed yield.

Ameta *et al.* (2016) studied the variability, heritability and genetic advance in sixty accession of coriander along with five popular varieties. Analysis of variance revealed significant variability for most of the traits. High heritability (broad sense) coupled with high genetic advance as percent of mean was observed for the characters *viz.,* number of basal leaves, length of longest basal leaf and number of branches per plant.

Farooq, *et al.* (2017) studied the variability, heritability and genetic advance in 41 coriander genotypes. Result revealed that high phenotypic and genotypic coefficients of variation were observed for all the characters except plant height at harvest, 50 percent flowering, umbellets per umbel, seeds per umbellet and 1000 seed weight, which had moderate phenotypic and genotypic coefficients of variation.

2.3. Heritability and genetic advance

The term heritability in broad sense can be defined as the ratio of genetic variance to the total phenotypic variance (Lush, 1940). It is generally expressed in percentage. Thus the heritability is the heritable portion of phenotypic variance which is good index of the transmission of characters from parents to their offspring (Falconer, 1960). Depending upon the components of variance used as numerator in the calculation, heritability is of two types *viz.,* broad sense heritability and narrow sense heritability.

Heritability estimate provides the information regarding the amount of transmissible genetic variation to total variation and determines genetic improvement and response to selection. Johnson *et al.* (1955) emphasized that heritability estimates, when studied in conjunction with genetic advance would provide more appropriate information than the study of heritability alone.

Improvement in the mean genotypic value of selected plants over the parental population is known as genetic advance. The estimate of genetic advance in percentage of mean provides more reliable information regarding the effectiveness of selection in improving a trait. It is the measure of genetic gain under selection. The success of genetic advance under selection depends on three main factors *viz.* genetic variability, heritability, selection intensity (Allard, 1960). Estimates of genetic advance help in understanding the type of gene action involved in the expression of various polygenic characters. High values of genetic advance are indicative of additive gene action and low values are indicative of non additive gene action. Thus, the estimates of heritability and genetic advance are of great significance to the plant breeders for developing suitable selection strategy.

Tripathi *et al.* (2000) evaluated 40 genotypes of coriander to work out heritability and genetic advance for 10 metric traits which indicated substantial genetic variability and scope for selection for days to maturity, number of secondary branches^{-1}, days to flowering, and 1000-seed weight. There was little variability and scope for improvement through selection for number of umbellet per umbel, primary branches per plant and plant height.

Jain *et al.* (2002) evaluated 196 genotypes of coriander and found that high heritability was recorded in all the traits except umbellets per umbel. The genetic advance was observed to be high for umbels per plant followed by seed yield per plant. For umbellets per plant, heritability and genetic advance were high whereas, for days to 50% flowering and 1000-seed weight, the heritability was high and genetic advance was low.

Megeji and Korla (2002) studied thirty genotypes of coriander in a field experiment. Analysis of variance indicated significant differences in all the characters studied. Genotypic and phenotypic coefficients of variation were high for leaf yield, seed vigour and seed yield. Heritability was highest for 1000 weed weight followed by germination percentage and seed vigour. Leaf yield, 1000 seed weight, germination percentage and seed vigour recorded high genetic advance.

Rajput and Singh (2003) observed genetic variability in twenty genetically diverse genotypes of coriander for seven characters (days to flowering, plant height, branches per plant, umbels per plant, umbellets per umbel, seeds per umbel and seed yield). High estimates of GCV, PCV, heritability and genetic advance where recorded for seed yield, umbels per plant, seed per umbel and plant height, suggesting the probable role of additive gene effects on character expression. Superior genotypes for different characters were identified that could be exploited for intervarietal hybridization. Genetic advance was highest for seed yield followed by umbels plant^{-1} and seeds umbel$^{-1,}$ suggesting improvement in these characters by hybridization and selection. The traits seed yield, umbels plant^{-1}, seeds umbel^{-1} and plant height showed high heritability estimates coupled with high values of genetic advance suggests additive genes for the expression of these traits.

Sharma *et al.* (2004) evaluated 120 genotypes of coriander and reported that high heritability coupled with high genetic advance was observed only for seeds per umbel, days to 50% flowering, plant height, umbels per plant and 1000-seed weight showed high heritability and combined moderate genetic advance as percentage of mean.

Ali *et al*. (2004) reported that high heritability was observed for days to 50% flowering (98.90%), days to maturity (98.70%), number of umbellets per umbel (87.70%), and plant height (78.40%) The genetic advance was very high for number of seeds per plant with low magnitude of heritability.

Singh *et al*. (2005 a)The heritability estimates were high for days to maturity, essential oil content, number of secondary branches per plant, days to 50 percent flowering, 1000-seed weight, harvest index, number of umbellets per plant, plant height, number of primary branches per plant, number of seeds per umbellet and number of umbellets per umbel. While low heritability was observed for seed yield per plant. The genetic advance (expressed as percentage of mean) was high for number of primary branches per plant and harvest index, whereas, moderate for number of umbellets per plant, number of secondary branches per plant, 1000-seed weight, essential oil content, plant height, number of seeds per umbellet and grain yield per plant. Low genetic advance was observed for number of umbellets per umbel, days to 50 percent flowering and days to maturity.

Singh *et al*. (2005 b) evaluated 30 genotypes of coriander and found that high heritability for plant height, days to 50% flowering and days to maturity. Grain yield per plant was positively associated with number of umbellets per plant, number of grains per umbel, 1000 grain weight, number of primary branches per plant and harvest index in 85 genotypes of coriander.

Singh *et al.* (2006 a) evaluated 360 lines of coriander. High broad-sense heritability (91.94%) and genetic advance (56.55%) were obtained for number of umbels per plant and number of seeds per umbel. Whereas, high heritability and low genetic advance were observed for days to 50% flowering followed by plant height.

Katiyar *et al*. (2008) found the high heritability coupled with high genetic advance and coefficient of variability for plant height, inter-nodal distance, seed yield/plant, test weight and umbels/plant.

Patel *et al.* (2008) carried out analysis of variability for 15 characters and 36 diverse genotypes of fennel. Genetic advance as percent of mean and heritability estimates were high for seed yield plant^{-1}, days to 50% flowering, number of primary branches plant^{-1}, total branches plant^{-1}, test weight and volatile oil content. Genetic advance as percent of mean also highly observed for effective umbel plant^{-1}, number of umbellets umbel^{-1}, number of seeds main umbel^{-1}.

Singh *et al.* (2008) reported high heritability coupled with high genetic advance and coefficient of variation was observed for plant height, inter-nodal distance, seed yield plant^{-1}, test weight and umbels plant^{-1}.

Meena *et al*. (2010) evaluated 30 diverse genotypes of coriander and resulted high genetic advance coupled with high heritability was observed for number of umbel plant^{-1} followed by yield plant^{-1} and days to maturity. It indicated that additive gene effects were more important for these traits.

Mengesha and Alemaw (2010) investigated the performance of 49 accessions of coriander and found that highest value of genetic coefficient of variation, broad sense heritability and genetic advance as percent of mean was obtained for longest basal leaf length, days to start 50% flowering, umbels number plant^{-1}, umbellets number umbel^{-1}, seed number umbellets^{-1}, seed number plant^{-1}, seed yield ha^{-1} and essential oil content.

Pandey *et al*. (2012) High heritability coupled with high genetic advance for number of secondary branches per plant, number umbels per plant, seed yield per plant and test weight indicating the genetic variations in the above traits were due to additive gene effects. It suggested that the selection might be effective in the further improvement of these traits.

Abou El-Nasr *et al*. (2013) studied genetic variability, essential oil composition and ISSR molecular markers for seven characters in ten selected genotypes within three coriander cultivars and reported that heritability and genetic advance were high for fruit yield, linear growth and plant height in selected followed by Russian and Balady cultivars.

Al-Kordy M.A.A. *et al.* (2013) studied the genetic relationship among three cultivars of coriander which may further assist in developing and planning breeding strategies for crop improvement programs. Three coriander cultivars namely Russian, Balady (Egyptian), and Selected were used. The quantitative genetic studied characters were linear growth, plant height, number of primary branches/plant, number of total branches/plant, and fruit yield of plant. Ten promising genotypes were established within each cultivar. The individual plant selection procedure was practiced on inter and intra-cultivar populations. Analysis of variance, broad-sense heritability, genetic advance, genotypic and phenotypic correlation coefficients were estimated. Broad-sense heritability estimates were high in the three varieties ranging between 80.4 % to 99.8 %. Correlation coefficients among all studied traits were positive.

Meena *et al*. (2013 b) conducted an experiment on twenty four genotypes of coriander. High heritability coupled with high genetic advance as percent of mean was observed for test weight, plant height and number of seed umbel^{-1} indicating the importance of additive gene effects for these traits.

Singh and Singh (2013) studied variability analysis in coriander with 11 traits of nine genotypes. The maximum heritability value was obtained for number of umbels plant^{-1} (93.5%) followed by plant height (93.2%), number of seeds umbel^{-1} (89.2%). The genetic advance was maximum for number of umbels plant^{-1} (24.43%) followed by plant height (16.06%), number of seeds umbel^{-1} (7.26%), number of secondary branches (5.55%) and days to flowering (4.89%). Meanwhile, low genetic advance was obtained for number of umbellets umbel^{-1} followed by umbel diameter and test weight.

Meena *et al*. (2014 b) found that genotypic and phenotypic variance was higher for number of umbels per plant, pant height and days to harvesting. High genotypic and phenotypic coefficients of variance were observed for seed yield. High heritability coupled with high genetic advanced as percentage of mean was observed for test weight, plant height and number of seed per umbel indicating the important of additive gene effects for these traits. Heritability estimates were high for test weight, plant height, number of seed per umbel and chlorophyll content.

Ameta *et al.* (2016) studied the variability, heritability and genetic advance in sixty accession of coriander along with five popular varieties. The estimates of heritability in (broad sense) expressed in percentage was high for almost all the characters *viz.,* number of basal leaves, length of longest basal leaf (cm), plant height up to top (cm), plant height up to main umbel (cm), number of secondary branches per plant. High heritability (broad sense) coupled with high genetic advance as percent of mean was observed for the characters *viz.,* number of basal leaves, length of longest basal leaf and number of branches per plant.

Farooq, *et al.* (2017) studied the variability, heritability and genetic advance in 41 coriander genotypes. Result revealed that high heritability estimates were of very high magnitude for all the characters. The highest heritability estimates were obtained for plant height at flower initiation (99.44) followed by plant height at harvest (99.07). The highest GAM was obtained for essential oil content (136.90) followed by essential oil yield per hectare (131.97) and seed yield per plant (109.67).

2.4. Correlation (characters association) studies

The original concept of correlation was given by Galton (1988) who suggested the need of coefficient of correlation to describe the degree of association between dependent and independent variables. Later, the formula for its quantitative estimation was developed by Pearson (1904), Fisher (1918) and Wright (1921). Thereafter, Searle (1961) described the mathematical implications of correlation coefficient at phenotypic, genotypic and environmental levels.

Correlation study gives the relationship of one character with the other. Yield, itself is not a unitary character but the end product of various component characters either jointly or singly. Therefore, knowledge of genetic association of yield and various component characters are of economic worth in formulating and executing the breeding programme. Hence, the prime requirement is to have precise and clear-cut information on the strength and direction of association of these traits with any worth character and also *inter se* relation among themselves. The selection efficiency is improved by making judicious combinations of the characters. The degree of associations between any character and its contributors can be estimated by correlation coefficient at genotypic and phenotypic levels. Correlation coefficient measure the association between any two characters.

Tripathi *et al.* (2000) investigated correlation in forty genotypes of coriander. Correlation studies indicated that plant height, number of secondary branches, days to flowering, days to maturity and number of umbel per plant were the major yield components. Whereas, number of primary branches per plant, number of umbellet per umbel and number of seeds per umbel, being negatively correlated with yield were less important.

Jain *et al.* (2003) evaluated one hundred ninety six genotypes of coriander excluding checks to work out correlation and path analysis for nine metric traits. The association studies indicated that all the characters (except days to 50% flowering) showed positive and significant correlation with seed yield per plant.

Shah *et al*. (2003) studied correlation analysis for eleven traits in twenty coriander. The genotype x environment interaction was significant for number of days to flowering, plant height, 1000 seed weight, harvest index and oil content. Seed yield per plant was highly correlated with harvest index. The number of seeds per umbel and number of umbels per plant were significantly correlated with seed yield per plant. The number of primary branches per plant and plant height was positively associated with seed yield.

Ali *et al*. (2004) reported that seed yield per plant was negatively correlated with days to 50% flowering and days to maturity while, it showed positive and significant association with umbellets per umbel, umbels per plant, seeds per plant and harvest index in coriander.

Vijayalatha and Chezhiyan (2005) studied correlation in coriander genotypes and indicated that the plant height, number of primary branches, number of umbels, number of umbellets per umbel and essential oil exhibited positive and significant association at phenotypic and genotypic levels with yield.

Singh *et al*. (2005 a) reported in coriander that seed yield per plant was positively and significantly correlated with plant height, number of primary branches per plant, number of secondary branches per plant, number of umbels per plant, number of umbellets per umbel, harvest index and number of seeds per umbellet. The correlation coefficient of remaining characters *viz.,* days to 50 percent flowering, days to maturity and essential oil content were positive and non-significant, whereas, for 1000-seed weight it was negative and non-significant with seed yield.

Singh *et al.* (2006 b) evaluated thirty-five genotype for correlation and path analysis to study the different qualitative and quantitative traits of coriander. Grain yield plant^{-1} was positively and significantly associated with plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of umbels plant^{-1}, number of umbellets umbel^{-1}, number of grains umbellets^{-1}, essential oil content and harvest index.

Singh *et al*. (2006 a) evaluated 360 lines of coriander at Jobner (Rajasthan). The association among characters revealed that seed yield was positively correlated with umbels per plant and branches per plant at genotypic level whereas, it showed negative and significant association with days to 50% flowering.

Singh and Prasad (2006) studied in coriander that grain yield per plant was positively and significantly associated with plant height, number of primary branches per plant, number of umbels per plant, number of umbellets per umbel, number of grains per umbellets, essential oil content and harvest index.

Katiyar *et al.* (2008) observed that branches per plant, leaves per plant, umbels per plant and seeds per umbel exhibited positively significant genotypic correlation with yield per plant. A positive significant correlation with seed yield per plant and its main components - seeds per umbel and umbels per plant were also noticed.

Singh *et al.* (2008) studied correlation coefficients of seed yield and its component characters in 70 germplasm of coriander. Branches plant^{-1}, leaves plant^{1}, umbels plant^{-1} and seeds umbel^{-1} exhibited positively significant genotypic correlation among them and all were positively and significantly associated with seed yield plant^{-1}. A positive significant correlation with seed yield plant^{-1} and its main components – seeds umbel^{-1} and umbels plant^{-1} were also noticed. .

Idhal *et al.* (2009) reported in coriander that seed yield was highly significant and positively correlated with umbellets per umbel, seed per umbel, plant height, and umbels per plant and biological yield per plant at genotypic and phenotypic level.

Meena *et al.* (2010) observed 30 diverse genotypes of coriander and reveals the value of correlation at phenotypic level were higher than the genotypic correlation indicating that there is strong inherent association between the various characters studied. The yield plant^{-1} showed positive and significant correlation with number of umbel plant^{-1}, number of umbellets umbel^{-1} at genotypic and phenotypic level.

Pandey *et al*. (2012) reported that seed yield per plant showed highly significant positive correlation with number of umbels per plant, number umbellets per umbel, test weight and days to maturity indicating that selection made on the basis of these traits will help for increasing the seed yield.

Kumar *et al.* (2017) reported that seed yield was significantly and positively associated with plant height, number of secondary branches per plant and number of fruits per umbel, which indicated that the traits might be directly selected for improving the seed yield in coriander.

Nair *et al.* (2013) reported that seed yield plant^{-1} exhibited a positive and significant correlation with number of fruits umbellet^{-1} (0.2333) but was negatively correlated with days to 50% flowering (-0.2869), days to 80% maturity (-0.2801) and vegetative yield plot^{-1} (-0.1415). Number of primary branches plant^{-1} exhibited a positive significant correlation with 1000 seed weight (0.5650), number of umbels plant^{-1}(0.4903), and number of fruiting nodes plant^{-1} (0.4751), number of fruits umbellet^{-1} (0.4113), number of umbellets umbel^{-1} (0.4015), number of fruits umbel^{-1} (0.3275) and diameter of fruits (0.3104).

Kassahun *et al.* (2013) studied correlation and path analysis with 15 agronomic and quality traits. More of the traits were found having high correlation coefficients at genotypic level than the phenotypic level, demonstrating intrinsic associations among the traits. Seeds per plant and thousand seeds weight were associated significantly and positively with seed yield per plant at phenotypic and genotypic levels. Essential oil and fatty oil contents were negatively associated with most of the traits studied. Path analysis revealed that days to end 50% flowering, longest basal leaf length, plant height, days to 50% maturity and seeds per umbellet exerted positive direct effect on seed yield per plant.

Fufa (2013) studied on nineteen land races of coriander with 9 component character and reveals that seed yield plant^{-1} was positively correlated with all traits except with the number of umbels per plant and oil content. On the other hand, oil content showed negative correlation with all traits studied except days to emergence.Biomass yield showed strong and highly significant positive correlation with plant height (r=0.68**), days to flower (r=0.74**), days to maturity (r=0.62**) and seed yield (r=0.92**) but a negative correlation (r=-0.05) with the number of umbels per plant.

Meena *et al.* (2013 b) evaluated 24 genotypes of coriander and found that the estimate of genotypic correlation coefficient was higher than corresponding phenotypic ones, thereby, suggesting strong inherent association among the characters studied. No. of umbels plant^{-1} (0.25*) and test weight (0.31*) exhibited positive and significant correlation with seed yield.

Singh and Singh (2013) studied genetic variability analysis in coriander and resulted that seed yield was positively associated with several characters such as plant height, number of primary branches per plant, number of secondary branches per plant, number of umbels per plant, number of umbellets per plant, number of seeds per umbel and umbel diameters.

Meena *et al.* (2014 b) to assess the extent of genotypic and phenotypic coefficient of variation, expected genetic advance, heritability, genotypic and phenotypic correlation coefficients and path analysis for direct and indirect effect of yield components on yield of coriander**.** The study was undertaken using 24 genotypes of coriander using randomized complete block design with 3 replications.

Meena *et al.* (2014 a) studied seed yield per plant was positively significant correlated with number of umbel per plant (0.25) and test weight (0.311) at genotypic and phenotypic level. Plant height showed positive and significant correlations with number of primary branches, number of secondary branches, leaf area, days to 50% flowering, number of umbel per plant, number of umbllete per umbel, number of seed per umbel, days to harvesting and chlorophyll content at both genotypic and phenotypic content.

Sravanthi *et al.* (2014) studied twenty-five coriander genotypes were evaluated to estimate the correlation coefficient and path analysis in randomized complete block design with three replications. Seed yield per plant exhibited positive and significant correlation with plant height, plant spread, fresh and dry weight of plant, days to 50 percent flowering, number of umbels per plant, number of seeds per umbellet, days to seed maturity and harvest index.

Singh *et al*. (2015) studied 64 coriander genotypes to identify the traits associated with seed yield and their attributes. Results revealed that seed yield plant^{-1} exhibited a positive and significant correlation with number of fruits umbel^{-1} but negative correlation with days to 50% flowering and days to 80% maturity, whereas number of fruits umbellet^{-1} expressed a positive significant correlation with number of fruits umbel^{-1} and 1000-seed weight. A positive correlation was also noted between 1000-seed weight and number of fruits umbel^{-1}. Almost all genotypes studied revealed diverse properties, making them suitable genetic materials for breeding homogenous coriander cultivars. Genotypic correlation coefficients were higher than the phenotypic ones because of the masking effect of genotypes for the expression of characters.

Kumar *et al*. (2017) evaluated ninety genotypes and three checks of coriander to study the genetic variation for their growth and yield characters namely, days to 50 percent flowering, plant height up to main umbel, plant height including main umbel, number of primary branches per plant, number of secondary branches per plant, number of umbels per plant, number of umbelletes per umbel, number of fruits per umbel, number of fruits per umbellate , seed yield per plot(g), seed yield per plant (g), seed yield kg per ha and 1000-seed weight (g).Character association indicate seed yield (kg per hectare) have significant and positive correlation with plant height up to main umbel (0.325), plant height including main umbels (0.331), number of fruits per umbel (0.290), seed yield per plot (0.743) and seed yield per plant (0.361).

2.5. Path coefficient analysis

Path coefficient analysis is a standardized regression coefficient which splits the correlation coefficients into the estimates of direct and indirect effects. Therefore, it helps in determining the casual factors of seeds yield.

The concept of path analysis was originally developed by Wright in 1921, but the technique was first used for better selection by Deway and Lu in 1959. Path coefficient analysis allows a detailed examination of specific force acting to produce a given correlation and measures the relative importance of such casual factor. It has been widely employed in selection work of many crop plants. Path coefficient analysis is used as an effective tool in finding out the direct and indirect effects of different contributing characters towards yield. Each component possesses a large direct effect on yield and its important indirect effects *via.* different yield components (Fonseca and Peterson, 1968).

Srivastava *et al.,* (2000) conducted path coefficient analysis in 40 genotypes of coriander, to determine the direct and indirect effect on seed yield of plant height, number of primary branches, days to flowering, days to maturity, number of umbels, number of umbellets per umbel, 1000-seed weight. About 70% of the characters had positive direct effect on seed yield. Days to flowering had highest direct effect on seed yield followed by day to maturity and number of umbels per plant. Plant height and number of primary branches had weak direct effect on seed yield.

Jain *et al*. (2003) studied path analysis for seed yield and yield components (number of days to 50% flowering height up to the base of the main umbel, total plant height, number of branches per plant, number of umbellets per umbel, number of umbellets per plant, number of seeds per umbel and 1000 seed weight) were conducted for 106 genotypes of coriander and 7 checks. The highest positive direct effects were recorded for essential oil and number of umbellets on the yield. This indicated that the yield in coriander was influenced by these traits and therefore selection should be exercised based on these traits.

Shah *et al.* (2003) reported that the maximum positive direct effect on seed yield was exhibited by number of primary branches per plant. The number of seeds per umbel showed a direct negative effect on seed yield, harvest index, 1000 seed weight and number of primary branches per plant comprised the major yield contributing characters.

Vijayalatha and Chezhiyan (2005) studied path analysis in ninety genotypes of coriander for 8 traits related to yield and quality the traits such as plant height, number of primary branches, number of umbels, number of umbellets, and essential oil. The positive direct effect of essential oil and number of umbellets was the highest on yield. This indicated that the yield in coriander was influenced by these traits and therefore selection should be exercised based on these traits.

Singh *et al*. (2005a) evaluated 35 genotypes of coriander which showed that number of grains per umbellets had the highest positive direct effects on seed yield per plant. However, its influence was reduced to a great extent due to appreciable negative indirect effects *via*., number of secondary branches per plant and plant height. The direct effect of number of primary branches per plant, number of umbels per plant, harvest index, days to 50 percent flowering and essential oil content were also positive and quite high.

Singh *et al*. (2005b) found that harvest index had highest positive direct effect on seed yield in coriander followed by number of primary branches per plant, essential oil content, number of umbellets per umbel. Number of umbels per plant, 1000-seed weight had week positive direct effect, whereas, negative indirect effect for number of secondary branches per plant, days to 50 per cent flowering, plant height, number of seeds per umbellet and days to maturity on seed yield.

Singh and Prasad (2006) reported in coriander that the maximum direct contribution to grain yield per plant was made by harvest index followed by primary branches per plant, days to maturity, number of secondary branches per plant, essential oil content, and number of umbellets per umbel, 1000-grain weight and harvest index showed high indirect effect *via* primary branches per plant.

Singh *et al.* (2006 a) reported that umbels per plant and branches per plant were the most important traits as they exerted positive direct effect on seed yield in coriander. Path analysis indicated highest positive direct effect of umbels plant^{-1} followed by branches plant^{-1}. The direct effect of days to 50% flowering was high and negative. Even though the correlation was significant and negative, this is the result of negative indirect effects of days to 50% flowering on seed yield particularly *via* umbels plant^{-1}.

Singh *et al.* (2006 b) reported that number of secondary branches per plant, harvest index, days to maturity and number of umbellets per umbel were the most important characters for selection of high yielding genotypes as they had high direct positive effects as well as positive association with grain yield per plant.

Idhal *et al.* (2009) reported through path coefficient analysis in coriander that plant height had highest positive direct effect on seed yield per plant followed by seed per umbel and 1000-seed weight.

Nair *et al*. (2013) reported that seed yield per plant exhibited a positive and significant correlation with number of fruits per umbel, number of fruits per umbellet expressed a positive significant correlation with number of fruits per umbel and 1000 seed weight. Days to 50 percent flowering had the highest positive direct effect on seed yield per plant followed by number of umbelllets per umbel, number of fruits per umbel and chlorophyll content at 60 days.

Kassahun *et al*.(2013) studied path analysis in coriander and result revealed that days to end 50% flowering, longest basal leaf length, plant height, days to 50% maturity and seeds umbellet^{-1} exerted positive direct effect on seed yield plant^{-1}, indicating that selection using these traits would be effective in improving seed yield in coriander.

Geremew awas *et al*. (2014) studied correlation and path coefficient analysis for seed yield and oil content of coriander genotypes for seed yield and yield related characters. Seed yield per plant was highly and positively correlated with number of umbel per plant, biomass yield per plant and number of seeds per plant, while it was negatively correlated with days to start of flowering, days to 50% flowering and plant height at flowering at both genotypic and phenotypic level. High positive indirect effect were exerted by fatty oil content *via* harvest index, days to maturity *via* plant height at flowering and thousand seed weight *via* days to start of flowering at both phenotypic and genotypic levels. The genotypic and phenotypic path coefficient analysis of fatty oil content showed that, seed yield per plant, thousand seed weight and number of primary branches are the major positive direct effect while harvest index per plant, plant height at flowering, umbel number per plant and days to 50% flowering exerts high negative direct effect on fatty oil content.

Meena *et al.* (2014 a) reported that path coefficient analysis shown days to 50% flowering (2.08) had highest direct effect on seed yield followed by number of seed per umbel (1.01), number of secondary branches (0.52), number of umbel per plant (0.49), test weight (0.28), plant height (0.23), leaf area (0.11) and chlorophyll content (0.11).

Meena *et al*. (2014 b) reported that path coefficient analysis revealed that secondary branches per plant had highest direct effect on seed yield followed by number of umbels per plant, test weight, days to 50% flowering and plant height.

Sravanthi *et al*. (2014) studied path analysis in coriander and revealed that the traits *viz.,* dry weight of plant and harvest index had higher direct and positive contribution towards seed yield. The days to first flowering, number of umbellets per umbel, number of secondary branches per plant, number of primary branches per plant, 1000 seed weight, number of seeds per umbellet and days to 50 percent flowering were the other characters which had direct positive contribution towards seed yield per plant.

Kumar *et al. (*2017) studied character association and path analysis in coriander. Path coefficient analysis revealed that the highest direct effect was shown by seed yield per plot (0.6975), toward on seed yield (kg per hectare) followed by number of fruits per umbels (0.2716), seed yield per plant (0.1143), 1000-seed weight (0.060), days to 50 percent flowering (0.0281), number of primary branches per plant (0.0734) and plant height upto main umbels.

CHAPTER-III
MATERIAL AND METHODS

This chapter deals with the description of the materials used and the methods or techniques adopted during the course of investigation. The present investigation entitled **"Variability and association studies for foliage yield components and its quality parameters in Coriander (*Coriandrum sativum* L.) "** was conducted during September 2016 to December 2016. The details of material and methods used in the present investigation are given below under separate heading:

3.1 Experimental Site

The experimental site was located at Pt. KLS College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) having with adequate facilities for irrigation and drainage are available.

3.2 Geographical Situation

Rajnandgaon district is situated in the western part of newly created Chhattisgarh state the district lies between latitude 20°70'- 22°29' North latitude and 80°23' to 81°29' East longitude covering an area of 8222 sq.kms. Its greatest length in the north-south is about 185 kms, while its width in the east-west extends about 80 kms. It is surrounded by Kawardha district in north, Durg district in the east; Bastar district is the south and Garchiroli, Bhandara (Maharashtra) and Balaghat (Madhya Prasesh) districts in the west.

3.3 Climate and weather condition

The Rajnandgaon has a tropical wet and dry climate throughout the year. However, the temperature during the summer (typically march to June) is hot to very hot. The maximum temperature during the summer month reaches as high as 45ºC and minimum as low as 8ºC during December to January. May is the hottest and December is the coolest month of the year. The city also receives hot wind during the summer season. The peak monsoon season is from July to October. The average rainfall in a year is about 1250 millimeters. Maximum of the rain is witnessed in the Monsoon and has great variation from year to year. The temperature however eases down from the month of November and continues till February. The duration is considered as the winter season of the year. Atmospheric humidity is high from June to October.

Maximum temperature during the crop growth periods 31.8^0C and the minimum temperature is $8\text{-}12^0C$. Average temperature remains around 23^0 to 24^0C.

Weekly average meteorological data during the span of experimentation, as recorded at Meteorological Observatory, meteorological center of Raipur are presented in Appendix A.

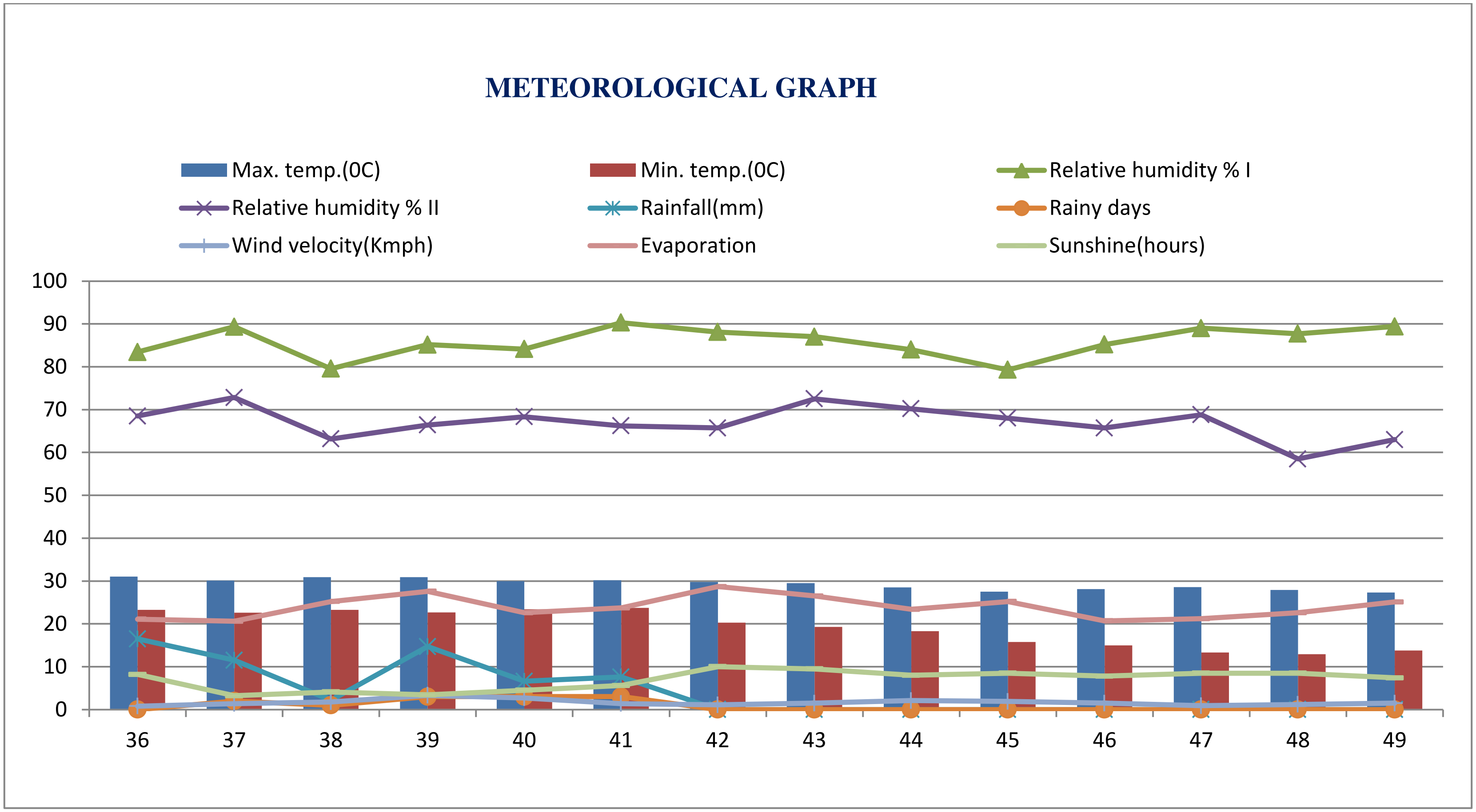


Fig 3.1: Weekly meteorological observation during the crop growth period of coriander (September 1, 2016) to December 09, 2016

3.4 Soil of the experimental field

The soil of the experimental field was sandy-loam. Soil samples from 20 cm depth were collected randomly from five different places before layout of the experiment. The collected soil samples were mixed thoroughly and a composite sample was made to determine the physio-chemical composition of the soil. The physiochemical analysis of the soil has been shown in Table- 3.1

Table 3.1: Physico-chemical properties of soils

S. No.	Particulars	Analytical Value	Classification	Methods
I	**Mechanical analysis**			
1.	Sand (%)	26.84		
2.	Silt (%)	24.68	Clay-loam (*Dorsa*)	International pipette method (Black, 1965)
3.	Clay (%)	42.24		
II	**Chemical analysis**			
1.	Organic carbon (%)	0.51	Medium	Walkley and Black's rapid titration method (Black, 1965)
2.	Available N (kg/ha)	321.27	Medium	Modified kjeldahl method (Piper, 1966)
3.	Available P_2O_5 (kg/ha)	30.83	Medium	Olsen method (Olsen, 1954)
4.	Available K_2O (kg/ha)	200.02	Medium	Flame Photometric method (Jackson,1973)
5.	Soil pH	7.43	Normal	Glass electrode pH meter method (Piper, 1966)

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 figure 3.2.

3.5 Experimental Details

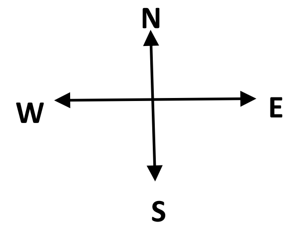
3.5.1 Experimental details and layout

1. Crop	: Coriander (*Coriandrum sativum L.*)
2. Family	: Apiaceae
3. Treatments/ genotypes	: 28
4. Design of Experiment	: Randomized Block Design (RBD)
5. Number of Replications	: 03
6. No. of Plot	: 84
7. Plot Size	: 1 x 1 m^2
8. Spacing	: 15(Row to row) x 5 (Plant to plant) cm^2
9. No. of Plants/plot	: 120
10. Date of sowing	: 06/Sep/2016

3.5.2 Experimental material

Twenty eight genotypes of coriander along with one check variety were grown in a randomized block design with three replications. The sowing of experimental material was done on 6 September 2016. Recommended dose of fertilizers, Seed Treatment Gibberellic acid (Plant Growth Regulater) 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.

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



Treatment Details:-

T1-COR-01
T2-COR-02
T3-COR-03
T4-COR-04
T5-COR-05
T6-COR-06
T7-COR-07
T8-COR-08
T9-COR-09
T10-COR-10
T11-COR-11
T12-COR-12
T13-COR-13
T14-COR-14
T15-COR-15
T16-COR-16
T17-COR-17
T18-COR-18
T19-COR-19
T20-COR-20
T21-COR-21
T22-COR-22
T23-COR-23
T24-COR-24
T25-COR-25
T26-COR-26
T27-COR-27
T28-Pant Haritama

Fig. 3.2: -Layout plan of Experiment Field

Experimental materials

The twenty eight genotypes of Coriander were collected from different part of Chhattisgarh and list of all the genotypes with the sources is given in Table. 3.2.

Table: 3.2 Treatment Details: -

The following twenty-eight genotypes of coriander were included in trial-

S. No.	Treatments/Genotypes	Source
01	COR-01	Collection from Banglore CO-1
02	COR-02	Collection from Nagpur
03	COR-03	Collection from Aurangabad
04	COR-04	Collection from Jodhpur CO-1
05	COR-05	Collection from Jodhpur CO-2
06	COR-06	Collection from Delhi CO-1
07	COR-07	Collection from Banglore CO-2
08	COR-08	Collection from Faizabad
09	COR-09	Collection from Delhi CO-2
10	COR-10	Collection from Rajnandgaon CO-1
11	COR-11	Collection from Rajnandgaon CO-2
12	COR-12	Collection from Rajnandgaon CO-3
13	COR-13	Collection from Rajnandgaon CO-4
14	COR-14	Collection from Maharashtra
15	COR-15	Collection from Raipur
16	COR-16	Collection from Chandigarh
17	COR-17	Collection from Mahasamund
18	COR-18	Collection from Bemetara
19	COR-19	Collection from Balod CO-1
20	COR-20	Collection from Durg CO-1
21	COR-21	Collection from Durg CO-2
22	COR-22	Collection from Balod CO-2
23	COR-23	Collection from Balod CO-3
24	COR-24	Collection from Balod CO-4
25	COR-25	Collection from Kanker
26	COR-26	Collection from Balod CO-5
27	COR-27	Collection from Dhamtari
28	Pant Haritama	Check variety

Seed treatment

Before seed treatment, the seeds of coriander were splited into two parts by rubbing. Then required seed of different coriander genotypes was treated with Gibberellic acid @ 50ppm. Treated seeds were dried in shade for 30 minutes.

Sowing

Treated seeds were sown at the depth of 1 to 2 cm on 6 September 2016.

Fertilizer application

Nitrogen, phosphorus, potassium played an important role in increasing growth and seed yield of coriander. After final preparation of land, FYM @ 10 t/ha was mixed thoroughly in soil where as chemical fertilizers *viz*., N, P and K were applied in furrow at the time of sowing. The recommended dose of fertilizer was 30:30:20 kg NPK/ha. Half amount of N with full amount of P and K were given per plot as basal dose. The remaining quantity of N was given as top dressing after 30 days of sowing. Nitrogen was given in the form of urea. P and K were applied through single super phosphate and muriate of potash, respectively. It was applied in ridges and furrows were immediately sowing in the field at spacing of 15cm X 5cm.

Thinning

Thinning of the crop was done 25-30 days after germination of crop in order to maintain proper spacing and plant population in plots.

Irrigation

First irrigation was given just after sowing followed by light irrigation at 10 days after sowing to facilitate proper germination and establishment of the crop seedling. Subsequent irrigation was given at 2-3days intervals to maintain the soil moisture till crop maturity.

Weed Management

The experimental plots were kept weed free. Hand weeding was done to control the seasonal weeds and when needed.

Harvesting

The crop was harvested after 45-50 Days after sowing.

Table : 3.3 Schedule of various cultural operations

S.No.	PARTICULARS	DATE
1.	Field Preparation	2 September 2016
	Ploughing by MB plough	2 September 2016
	Rotavator and pata	2 September 2016
2.	Layout of Field	4 September 2016
3.	Sowing and basal dose of fertilizers	6 September 2016
4.	No. of Irrigation (ten)	6 September 2016
		9 November 2016
5.	Split application of Urea	4 October 2016
6.	Thinning	10 October 2016
7.	Weeding	18 September 2016
		2 October 2016
		15 October 2016
8.	Harvesting	9 November 2016

3.6 Observations procedure

The observations on different growth parameters and leaf yield attributes were recorded on five randomly selected competitive plants from each plot of all replications. The method adapted to record different observations on growth as well as leaf yield contributing traits are given below in details.

3.7 Quantitative characters

3.7.1 Plant height (cm)

From each plot, five plants were randomly selected and stakes were fixed nearby each selected plants for recording observations. The height of the plant was measured with meter scale from ground level to the top of the plants at different stages of crop growth. The average height was calculated.

3.7.2 Number of branches per plant

Total numbers of branches per plant were also recorded from five already tagged plants in each plot at the time of harvest. Total numbers of branches were counted on each of five plants and averaged.

3.7.3 Stem base diameter (cm)

Stem base diameter of five randomly selected plants from each plot of all three replications was measured in cm using vernier calipers at just above the soil surface after 50 days and their mean was estimated.

3.7.4 Number of leaves per plant

Total numbers of leaves were also recorded on randomly selected five tagged plants in each plot at different intervals. Total numbers of leaves were counted on each of five plants and averaged.

3.7.5 Leaf length (cm)

The randomly five plants per plot was selected for length of leaves per plant and five leaves was recorded at 50 days after sowing from the base to tip of the apical portion of leaf by scale and averages was calculated.

3.7.6 Leaf width (cm)

The randomly five plants per plot was selected and the breadth of leaves per plant was recorded at 50 days after sowing from upper, middle and lower portion of the leaf by scale and averages was calculated.

3.7.7 Petiole length (cm)

Length of petiole of five randomly selected plants from each plot of all three replications was measured at 50 days after sowing. Length was measured in centimeter from the base of the stem to the petiole of leaf with the help of meter scale.

3.7.8 Root length (cm)

The length of root from plant of the each treatment was measured (cm) from color region to root tip with the help of scale and mean was recorded.

3.7.9 Root weight (g)

After measuring the length, all the stem roots of five randomly selected plants were collected by cutting them with the help of sharp blade at the stem surface. The weight of roots of each plant in the treatment was measured and expressed in grams. The mean was calculated for each treatment and recorded in grams.

3.7.10 Plant fresh weight (g)

Fresh weight of five random selected plants was taken just after harvesting and weighing by electric balance from each plot of all replication and average value was calculated.

3.7.11 Fresh leaf weight (g)

After harvesting of the plant the leaf portion was separated and weighed with the help of electronic balance from five randomly selected plants of each plot in each replication and then average leaf weight was calculated.

3.7.12 Leaf stem ratio

Ratio between leaf weight and stem weight calculated by the following formula:

$$\text{Leaf stem ratio} = \frac{\text{Leaf weight}}{\text{Stem weight}}$$

3.7.13 Fresh stem weight (g)

After harvesting of the plant the stem portion was separated and weighed with the help of electronic balance from five randomly selected plants of each plot in each replication and then average stem weight was calculated.

3.7.14 Dry leaf weight (g)

After taking fresh weight of leaf just after harvesting then, it was kept in the electric oven at 60°C for 8 hours; finally dry weight of leaf was recorded and average value was calculated.

3.7.15 Dry stem weight (g)

After taking fresh weight of separated stem, it was kept in the electric oven at 60°C for 8 hours; finally dry weight of stem was recorded and average value was calculated.

3.7.16 Dry plant weight (g)

After taking fresh weight of plant just after harvesting then, it was kept in the electric oven at 60°C for 8 hours; finally dry weight of plant was recorded and average value was calculated.

3.7.17 Foliage yield (kg/plot)

Foliage yield kg/plot was recorded by uprooting the plants and weighing it by electronic balance.

3.7.18 Foliage yield (q ha^{-1})

Foliage yield from each plot was noted down, then calculated in quintal $hectare^{-1}$ with appropriate multiplication factor.

3.8 Qualitative characters

3.8.1 Fiber Content (%)

Fiber content is estimated through fibra plus automatic Fiber estimation system, Model FES 6 R: fibra plus Six Place Automatic Fiber Estimation System.

Principle:

Crude Fiber refers to the residue of a feed that is insoluble after successive boiling with dilute acid and alkali. When the sample is subjected to acid and alkali digestion, we obtain a residue comprising ash (mineral matter) of the feed and the resistant fraction of carbohydrate. When the residue is ignited the organic matter gets oxidized leaving the inorganic residue or ash. Thus the difference in weight of the residue before and after ashing gives the weight of crude Fiber.

Procedure:

- Weigh the samples accurately and note down the weight (W)
- Transfer the weighed samples into oven dried crucibles
- Place the crucibles into the metal adapters of Fibra Plus hot exraction unit and ensure proper sealing of crucibles against the adapter rubber.

Acid Wash:

- Pour 150 ml of 1.25% H_2SO_4 into the extractors from the top for each samples.
- Don’t leave any place without crucibles.

- Switch on the instrument and set the initial temperature to 500°C.
- After boiling start, reduce the temperature to 400°C.
- Allow the samples to boil for 45 minutes in acid.
- After 45 minutes boiling, drain and acid wash the samples twice or thrice with distilled water.
- During draining, ensure that the knob is in vacuum mode.
- If the draining is not effective that the knob is in vacuum mode.
- If the draining is not effective due to clogging of sample in the crucible, then keep the knob in pressure mode, press the pressure button twice or thrice and immediately turn the knob to vacuum mode.

Alkali Wash:

- Pour 150 ml of 1.25% NaOH into the extractors from the top for each samples.
- Don't leave any place without crucibles.
- Switch on the instrument and set the initial temperature to 500°C.
- After boiling starts, reduce the temperature to 400°C.
- Allow the samples to boil for 45 minutes in base.
- After 45 minutes boiling, drain the alkali wash the samples twice or thrice with distilled water.
- During draining, ensure that the knob is in vacuum mode.
- If the draining is not effective that the knob is in vacuum mode.
- If the draining is not effective due to clogging of sample in the crucible, then keep the knob in pressure mode, press the pressure button twice or thrice and immediately turn the knob to vacuum mode.
- After alkali wash take out crucibles and dry them in hot air oven @ 100°C until the crucibles are free from moisture.
- Cool down the hot crucibles to room temperature using a desicator.
- Weigh the crucibles and record the reading (CWBA=W1)
- Place all the crucibles in the muffle furnace at 400°C for ashing.

Cool down the hot crucibles after ashing to room temperature using a dedicator. Now weigh the crucibles and record the readings (CWAA=W2).

Calculation-

Sample weight = W

CWBA = W1

CWAA = W2

W3 = (W1-W2)

% of Crude Fiber = (W3/W) X 100

3.8.2 Estimation of Potassium

The most common method for K determination is through Flame photometer. The plant sample for K estimation can be digested in diacid or in triacid. In addition digest obtained from dry ash is also taken for K determination.

Principle

The determination is based on measurement of the spectral line intensities of potassium atoms excited when passing through a flame. Atoms of some specific element take energy from flame and get excited to the higher orbit, such atoms release energy of a wavelength and give spectral lines which is specific for that element and is proportional to the concentration of atoms of that element.

Reagents

Standard stock solution:

To prepare a stock solution, 1.9069 g of analytical grade KCI is dissolved in deionized water and volume made upto 1 liter. This solution contains 1000ppm K. prepare 100 ppm K solution by diluting the 1000 ppm K solution 10 times (10 ml in 100ml final volume)Final standard solutions of 0,5 and 10 ppm are prepared from 100 ppm K.

Method

1. Digestion

Digest the plant samples in diacid (HNO_3-$HCIO_4$) mixture or triacid (HNO_3-H_2SO_4- $HCIO_4$) mixture or dry ashed as described on forgoing pages.

2. Determination of K in plant digest

- For determination of K in plant digest first set the instrument with standard solution and prepare standard curve.
- Standard curve instrument is set at full scale with highest concentration of 5 ppm using a standard filter. The specify the linear range of K (normaly 5 ppm) and suitable factor is calculated for finding out : The K in plant samples.

3. K in plant digest

The digest is diluted to the suitable concentration range so that final concentration lies between 0 to 5 ppm. The samples are than read in flame photometer at 548 nm wavelength or using filter for K.

Calculations

Calculate percent Kin plant sample as follows:

Calculate from direct flame photometer Reading:

Weight of plant sample = 0.5 g

Total volume of plant digest = 50 ml

(in case digestion is carried out in 100 ml Kijdahl flask the volume would be 100 ml and weight of plant sample would be 1.0 g)

Reading on flame photometer = R

$$\text{Percent K} = R \times \frac{5}{100} \times \frac{50}{0.5} \times \frac{100}{10000000}$$

$$\text{Reading} = \frac{5}{100} \times \frac{\text{Volume of digest}}{\text{Wt. of sample}} \times \frac{100}{1000000}$$

Where 5 ppm K = 100 reading

If further dilution is made, the dilution is to be multiplied in the calculation.

Calculation with the help of standard curve

In case concentration of K in aliquot which has been read out from the standard curve is C, the calculation will be:

$$\%\ K = C\ (\text{ppm}) \times \frac{\text{Volume of digest}}{\text{Wt. of sample}} \times \frac{100}{1000000}$$

Here also dilution factor if any may be considered.

3.8.3 Dry matter (%)

The dry matter content of plant was calculated by using the following formula:

$$\text{DM (\%)} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100$$

3.8. 4 Estimation of Calcium

Principle

Ca in plant test solution is determined by complexometric titration with 01N EDTA solution in the presence of murexide or calcon indicator.

Digestion process

0.5g of oven dried sample was digested by 10 ml of diacid mixture HNO_3: $HClO_4$ (Chapman and Pratt, 1961) using Kjeldahl unit. Volume of digested samples made up to 100 ml for the estimation of calcium.

Reagents

1. Standard EDTA-disodium solution
2. Hydroxylamine hydrochloride
3. Triethanolamine solution
4. Sodium hydroxide solution
5. Murexide indicator or calcon indicator
6. Potassium cyanide solution

Procedure

- Transfer 10 ml aliquot of plant digested sample in 250 ml conical flask. Then distilled water is add to obtain a volume of about 100 ml.

- Then 10 drop of each potassium cyanide or 2-5 crystal of carbamate hydroxylamine hydrochloride and trithanolamine solutions ,5 ml of sodium hydroxide solution(NaOH) and 50 mg of murexide indicator or 5 drops of calcon indicator is added and the solution is titrated with standard EDTA disodium solution till the calcon changes reddish violet or purple.
- Repeat the titration until the difference between two sample titre dose not exceed by more than .05ml. Similarly run a blank titration taking an aliquot of the blank test solution.

Calculations

$$\text{meq Ca/100g plant sample} = \frac{(S-B) \times T \times N \times 100}{A \times W}$$

% Ca in plant sample = meq Ca/100 g plant sample × ME

Where

S is EDTA titre for the aliquot of plant sample test solution

B is EDTA titre for the aliquot of blank test solution

T is total volume of plant test solution prepared

N is normality of EDTA solution as against standard $CaCl_2$ using Ca indicator

ME is milligram equivalent weight of Ca *i.e.*0.02.

A is the aliquot of plant sample test solution in ml taken for EDTA titration

W is the mass of plant sample in gram used for the preparation of plant test solution.

3.9 Morphological parameters

Growth habit	Branching index	Stem pubescence	Stem pubescence	Leaf pigmentation	Leaf pigmentation	Leaf shape	Prominence of leaf veins
Erect	Branches all over the stem	Absent	Absent	Absent	Absent	Lobed	Smooth
		Present	Present	Present	Present		Rugose
Semi Erect	Only at top						
Bushy	Only at base						

Petiole pigmentation	Leaf colour	Petiole colour	Leaf curliness	Stem colour	Leaf roughness
Absent	Light green	Light green	Curled	Deep violet	Smooth
Present	Green	Green	Medium curled	Light green	Rough
	Dark green	Dark green	Absent	Light violet	
	Bluish green	Reddish tinge		Greenish violet	
		Bluish green		Green	

Source- MINIMAL DESCRIPTIORS OF AGRI-HORTICULTURAL CROPS
PART II: VEGETABLE CROPS
National Bureau of Plant Genetic Resources Pusa Campus, New Delhi-110012, India

3.10 Statistical analysis and interpretation of data

The experimental data obtained on various selected variables was analyzed by the standard method of statistical analysis of RCBD. Statistical analysis was done by taking the mean value of five plants from each genotype in each replication.

3.10.1 Analysis of variance

Analysis of variance for randomized complete block design (RCBD) was done by the method described by Panse and Sukhatme (1978) method. The skeleton of analysis of variance used is given below:

Analysis of variance of twenty eight genotypes replicated thrice in a randomized block design was done for all the characters

The following linear model was used for analysis of variance

$Yij = \mu + Li + Bj + eij$

Where,

i = number of treatments (1, 2, 3….. 23)

j = number of replications (3)

Yij = value of i^{th} treatment in j^{th} block

μ= general mean

Li = effect of i^{th} treatment

Bj = effect of j^{th} block

Eij = random error with restrictions that eij = N (0, 02) has normal distribution.

Statistical analysis was done by using method suggested by Panse and Sukhatme (1978).

The skeleton of ANOVA used is given below:

Source of variation	**Degree of freedom**	**Sum of squares**	**MSS**	**F ratio**	**Expected mean square**
Replications	r-1	SSr	Mr	Mr/ Me	-
Treatments	t-1	SSt	Mt	Mt/ Me	$\sigma^2 e + \sigma^2 g$
Error	(r-1) (t-1)	SSe	Me	-	$\sigma^2 e$
Total	rt-1				

Where, r = Number of replication

t = Number of treatment

$\sigma^2 e$ = Expected error mean square

$\sigma^2 g$= Expected genotype mean square

The significance of difference among treatment means were tested by F test at 5% level of significance. If significant F value was found, critical difference was calculated to test the significance of difference between any two treatment mean as follows:

a. Critical difference

CD = S Ed x t value at 5 % at error degree of freedom

$$\text{S Ed} = \frac{\sqrt{2\,EMS}}{r}$$

Where,

S Ed = standard error of difference between two treatment means

EMS = Error mean of square

r = Number of replications

b. Standard error of mean

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

c. Coefficient of variation (CV) (%)

Coefficient of variation is standard deviation expressed as percentage of mean

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

Where,

SD = standard deviation

$\overline{X}$ = Mean of character

3.10.2 Studies on Variability, heritability and genetic advance

A. Variability

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated by the method suggested by Singh and Choudhary (1985).

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

Where,

$\sigma^2 g$ = Genotype variance,

Mg = Treatment mean square,

Me = Error mean square.

a. Phenotypic coefficient of variation (PCV)

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

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

Where,

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

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

$\sigma^2 e$ = Environmental variance,

$\bar{x}$ = General mean.

b. Genotypic coefficient of variation (GCV)

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

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

< 10 % = Low

10-12% = Moderate, and

> 20% = High

B. Heritability:

Heritability estimates (Broad sense) for fruit yield and its components of hybrids were worked out by Singh and Choudhary (1985) as follows:

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

The broad sense heritability estimates were classified as low, moderate and high as follows:

0 - 30 % = Low

31 - 60% = Moderate, and

> 60% = High

C. Genetic advance

Genetic advance was estimated by using the method suggested by Johnson *et al.* (1955) and the formula is:

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

Where, GA = Genetic advance,

K = Selection differential (at 5%, k= 2.06),

h^2bs = Heritability in broad sense,

σp = Phenotypic standard deviation.

GA was reported as percentage of mean and it was calculated as follows:

$$\text{Genetic advance as percentage of mean} = \frac{\text{Genetic advance}}{\bar{x}} \times 100$$

The GA was categorized as, >20% = High,

10 - 20% = Moderate, and

< 10% = Low.

3.10.3 Coefficient of correlation

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

i. Phenotypic correlation between characters x and y

$$r_{xy(p)} = \frac{Cov_{xy(p)}}{\sqrt{var_{x(p)} \times var_{y(p)}}}$$

ii. Genotypic correlation between characters x and y

$$r_{xy(g)} = \frac{Cov_{xy(g)}}{\sqrt{var_{x(g)} \times var_{y(g)}}}$$

iii. Environmental correlation between characters x and y

$$r_{xy(e)} = \frac{Cov_{xy(e)}}{\sqrt{var_{x(e)} \times var_{y(e)}}}$$

Where

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

Var x(p), Var x(g), Var x(e) = phenotypic, genotypic & environmental variance of character x, respectively.

Var y(p), Var y(g), Var y(e) = phenotypic, genotypic & environmental variance for character y, respectively.

The significance of correlation coefficients was tested, against Fisher's table value (1963) for (g-2) degrees of freedom at 5 per cent and 1 per cent level of significance, where g is the number of genotypes.

3.10.4 Path coefficient analysis

The path analysis was originally developed by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient analysis splits the genotypic correlation coefficients into the measures of direct and indirect effects. It measures the direct and indirect contribution of independent variables to dependent variable.

Path coefficients were obtained by simultaneous equations, which express basic relationship between correlation and path coefficient.

$r_1y = P_{1y} + P_{2y}\, r_{12} + P_{3y}\, r_{13} + \ldots\ldots p\ (n\text{-}1)\ y\ r_1\ (n\text{-}1)$

$r_2y = P_{2y} + P_{1y}\, r_{21} + P_{3y}\, r_{23} + \ldots\ldots p\ (n\text{-}1)\ y\ r_2\ (n\text{-}1)$

$r_3y = P_{3y} + P_{2y}\, r_{32} + P_{1y}\, r_{31} + \ldots\ldots\ p\ (n\text{-}1)\ y\ r_3\ (n\text{-}1)$

|

|

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Similarly for (n-1)

$r\ (n\text{-}1)y = P\ (n\text{-}1)y + P(n\text{-}2)y\ r\ (n\text{-}1)\ (n\text{-}2)\ldots\ldots\ldots\ldots,$

$P\ \{n\text{-}(n\text{-}1)\ y\ r\ (n\text{-}1)\ \{n\text{-}(n\text{-}1)\}$

Where,

y = the dependent variable

r = genotypic or phenotypic correlation coefficients between a pair of characters

n = total number of characters

Path coefficient analysis includes 3 different steps:

(i) Estimation of direct effects of individual independent character (cause of dependent character effect)

(ii) Estimation of indirect effects of each independent character via all other independent character

(iii) Estimations of residual effects

(i) Estimation of direct effects (P_{iy}):

Direct effects can be estimated as follows in the form of matrix notation:

(B) x (A) = (C)

(A) = $(B)^{-1}$ x (C)

Where,

A = column vector of direct effects (unknown)

i.e.

$$(A) = \begin{array}{c} P_{1y} \\ P_{2y} \\ | \\ | \\ | \\ | \\ P_{(n-1)y} \end{array}$$

(B) The correlation matrix (genotypic or phenotypic) of all possible character combinations among independent variable only, *i.e.*

$$B = \begin{array}{l} r_{11}, r_{12} \ldots\ldots\ldots\ldots\ldots\ldots r_{1(n-1)} \\ r_{21}, r_{22} \ldots\ldots\ldots\ldots\ldots\ldots r_{2(n-1)} \\ | \\ | \\ | \\ | \\ | \\ r_{(n-1)1}, r_{(n-1)2} \ldots\ldots r_{(n-1)(n-1)} \end{array}$$

$(B)^{-1}$ is the inverse matrix

(C) Matrix is the column vector correlation coefficient between independent characters and dependent one

$$(C) = \begin{bmatrix} r_{1y} \\ r_{2y} \\ | \\ | \\ | \\ | \\ r(n-1)\,y \end{bmatrix}$$

Direct effect was obtained by simple multiplication, *i.e.* multiplying elements of inverted correlation matrix $(B)^{-1}$ with corresponding elements of column vector (C), *e.g.*

$P_{1y} = r_{11}\, r_{1y} + r_{12}\, r_{2y} + \ldots\ldots. r_1(n-1)\ r(n-1)\ y$

Where,

$r_{11}\ r_{12} \ldots..r_1\ (n-1)$ are the inverted values of correlation matrix (B)

(ii) Estimation of indirect effects:

The indirect effects of any independent trait *via* all other independent traits were obtained by multiplying the direct effects of that independent variable with the corresponding correlation coefficients *e.g.,*

P_1y = direct effect of 1^{st} independent character on dependent trait (y)

Indirect effects:

1^{st} trait *via* 2^{nd} – $r_{12}\ p_2y$

1^{st} trait *via* 3^{rd} – $r_{13}\ p_3y$

1^{st} trait *via* (n-1) – $r1(n-1)\ p(n-1)_y$

Similarly, all positive indirect effects for other independent variables were worked out,

(iii) Estimation of residual effect:

The residual effects were estimated by following formula:

$$1 = p^2{}_{1y} + p^2{}_{2y} + \ldots\ldots\{P_{(n-1)y}\}^2 + 2\ \{P_{1y}\, P_{2y}\, r_{12} + P_{1y}P_{3y}\, r_{13} + \ldots + P_{(n-2)y}\, P_{(n-1)y}\ r\ (n-2)\ (n-1) + R^2$$

or

$1 = \{x + R^2\}$

Where, X is the sum of all the terms in right hand side of the equation except R^2

or

$R^2 = (1\text{-}x)$

$R = (1\text{-}x)^{y}{}_{2}$

Plate I : A view of experimental field

CHAPTER-IV
RESULTS AND DISCUSSION

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

4.1. Analysis of variance and mean performance

4.2. Genetic variability

4.3. Correlation coefficient

4.4. Path coefficient analysis

4.5. Morphological traits recorded as per coriander descriptor.

4.1. Analysis of variance and mean performance

The analysis of variance of all the characters under study is presented in table 4.1. This analysis of variance revealed that mean sum of square due to genotypes was highly significant for all the studied character except plant height and dry matter. This is an indication of existence of sufficient variability among the genotypes for leaf yield and its component traits. Which revealed existence of considerable variability in material studied for improvement of various traits.

4.1.2 Mean performance of genotype for different characters

Observation was recorded on the five randomly selected plants, for different genotypes and was used for calculating the mean performance for different traits. The mean performances of all the traits for the twenty eight genotypes are shown in the **Table: 4.2** and result is described as below:

4.1.2.1 Plant height (cm)

Plant height ranged from 17.35 cm to 24.90 cm with an overall mean of 21.20 cm. Maximum plant height was recorded in the genotype COR-26 (24.90 cm) followed by COR-25 (24.64 cm), COR-10 (23.88 cm) and COR-21 (23.213 cm). However, minimum plant height was noticed in genotype COR-23 (17.35cm).

Table: 4.1 Analysis of variance for foliage yield and its component characters in coriander

S No.	Characters (df)	Mean sum of square Replication 2	Treatment 27	Error 54
01	Plant height (cm)	1.279	11.168	9.033
02	No. of branches per plant	0.863	4.676 **	1.826
03	Stem base diameter (cm)	0.011	0.069**	0.008
04	No. of leaves per plant	11.33	381.143**	65.194
05	Leaf length (cm)	0.072	0.159**	0.049
06	Leaf width (cm)	0.168	0.171**	0.080
07	Petiole length (cm)	0.080	5.170**	1.078
08	Root length (cm)	5.542	4.066**	1.215
09	Root weight (g)	0.001	0.094**	0.003
10	Plant fresh weight (g)	0.382	15.891**	0.696
11	Fresh leaf weight (g)	0.004	2.698**	0.136
12	Leaf stem ratio	0.002	2.895**	0.041
13	Fresh stem weight (g)	0.272	5.713**	0.346
14	Dry leaf weight (g)	0.002	0.066**	0.007
15	Dry stem weight (g)	0.001	0.053**	0.003
16	Dry plant weight (g)	0.001	0.206**	0.010
17	Foliage yield (kg/plot)	0.005	0.229**	0.010
18	Foliage yield (q/ha.)	110.8	4509.91**	197.56
19	Fiber (%)	0.321	3.521**	0.487
20	Dry matter (%)	0.077	3.172	2.061
21	K (mg/100 g)	5890.47	411129.93**	2021.34
22	Ca (mg/100 g)	603.57	1479580.37**	2857.89

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

4.1.2.2 Number of branches per plant

Highest number of branches per plant recorded in genotypes COR-10 (12.13) followed by COR-11 (11.40), COR-05 (11.00), COR-17 (10.93) and COR-04 (10.33), whereas, minimum number of branches per plant recorded in COR-14 (6.60) with overall mean of 9.28.

4.1.2.3 Stem base diameter (cm)

Stem base diameter ranged from 0.25 cm to 0.72 cm with an average mean of 0.51cm. Maximum stem base diameter recorded in genotype COR-10 (0.72 cm), followed by COR-11 (0.72 cm), COR-22 (0.69 cm) and COR-02 (0.68 cm), COR-

21(0.67 cm) , COR-03 (0.64 cm).While genotype COR-27 (0.25 cm) was noted for minimum stem base diameter.

4.1.2.4 Number of leaves per plant

Number of leaves per plant ranged between 22.60 to 68.67 with an average mean of 47.02. Maximum number of leaves per plant recorded in genotype COR-10 (68.67) followed by COR-04 (67.93), COR-17 (65.26) and COR-11 (63.13), COR-05 (56.86). While genotype COR-14 (22.60) was noted for minimum number of leaves per plant.

4.1.2.5 Leaf length (cm)

Leaf length varied from 2.28 cm to 3.07 cm with an overall mean of 2.71 cm. The highest leaf length 3.07 cm was recorded in genotype COR-01 followed by COR-06 (2.97 cm) and COR-03 (2.95 cm). However, genotype COR-04 (2.28 cm) was noted for minimum leaf length.

4.1.2.6 Leaf width (cm)

Leaf width ranged from 2.75 cm to 3.66 cm with an overall mean of 3.14 cm. The highest leaf width 3.66 cm was recorded in genotype COR-25. However, it was found statistically *at par* with genotypes *viz.,* COR-22 (3.51 cm), COR-10 (3.40 cm), COR-06 (3.37 cm), whereas the lowest leaf width 2.75 cm was recorded in genotypes COR-04.

4.1.2.7 Petiole length (cm)

The range of petiole length lies between 5.61cm to 11.31cm with an overall mean of 7.81 cm. The highest petiole length 11.31 cm was recorded in genotype COR-14. Whereas, it was found statistically *at par* with genotypes COR-20 (9.60 cm) and COR-09 (9.60 cm). Genotype COR-26 (5.61cm) was noted for minimum petiole length.

4.1.2.8 Root length (cm)

Maximum root length was recorded in genotype COR-03 (10.35 cm), and it was statistically *at par* with genotype COR-09 (10.29 cm). While minimum root length recorded in COR-12 (5.98 cm) with overall mean of 8.29 cm.

4.1.2.9 Root weight (g)

The range for root weight varied from 0.14 g to 0.76 g with overall mean of 0.42 g. Maximum root weight recoded in genotype COR-01 (0.76 g). However, it was found statistically *at par* with genotypes *viz*., COR-07 (0.73 g), COR-03 (0.69 g), COR-25 (0.68 g), COR-19 (0.64 g). Whereas, minimum root weight 0.14 g was recorded in genotypes COR-14.

4.1.2.10 Plant fresh weight (g)

Fresh weight of plant ranged from 2.19 g to 10.76 g with overall mean of 6.21g. Maximum fresh weight recorded in genotypes COR-07 (10.76 g) followed by COR-22 (9.85 g) and COR-21 (9.55 g) whereas, the minimum fresh weight of plant recorded in COR-12 (2.19 g).

4.1.2.11 Fresh leaf weight (g)

Leaf weight is ranged from 0.92 g to 4.38 g with overall mean of 2.59 g. Maximum leaf weight 4.38 g was recorded in genotype COR-15 followed by COR-22 (4.14 g), COR-02 (3.84 g) and COR-11 (3.72 g).Whereas, minimum leaf weight was recorded in genotype COR-12 (0.92g).

4.1.2.12 Leaf stem ratio

Leaf stem ratio ranged from 0.60 to 5.87 with an overall mean of 1.08. Maximum leaf stem ratio 5.87 was recorded in genotype COR-15. However, it was found statistically at par with genotypes *viz.,* COR-28 (1.81), COR-23 (1.61) and COR-26 (1.21).Whereas, minimum leaf stem ratio 0.60 was recorded in genotype COR-08.

4.1.2.13 Fresh stem weight (g)

Fresh stem weight is ranged from 1.03 g to 6.37 g with overall mean of 3.19 g. Maximum fresh stem weight 6.37 g was recorded in genotype COR-07 however, it was found statistically *at par* with genotypes *viz.,* COR-21 (5.33 g) and COR-22 (5.16 g).Whereas, minimum stem weight found in COR-12 (1.03 g).

4.1.2.14 Dry leaf weight (g)

Dry leaf weight is ranged from 0.15 g to 0.64 g. Maximum dry leaf weight recorded in COR-02 (0.64 g) followed by 0.63 g (COR-15) and 0.61 g (COR-22) with an overall mean of 0.41 g. Whereas, minimum dry leaf weight recorded in COR-14 (0.15 g).

4.1.2.15 Dry stem weight (g)

Dry stem weight is ranged from 0.12 g to 0.56 g with an overall mean of 0.30 g. Maximum dry stem weight 0.56 g was recorded in genotype COR-07, followed by COR-01 (0.50 g), COR-22 (0.49 g), COR-21 (0.47 g) and COR-25 (0.47 g). Whereas, minimum dry stem weight was noticed in COR-12 (0.12 g).

4.1.2.16 Dry plant weight (g)

Dry plant weight ranged from 0.28 g to 1.11g with an overall mean of 0.71 g. Maximum dry plant weight 1.11 g was recorded in genotype COR-07, followed by COR-22 (1.10 g), COR-21 (1.09 g) and COR-01 (1.08 g).Whereas, minimum dry plant weight recorded in COR-12 (0.28 g).

4.1.2.17 Foliage yield (kg/plot)

Leaf yield per plot ranged from 0.26 kg to 1.29 kg with an overall mean of 0.74 kg. Maximum leaf yield per plot 1.29 kg was recorded in genotype COR-07, followed by COR-22 (1.18 kg), COR-21(1.14 kg) and COR-11(1.05 kg). Whereas, minimum leaf yield per plot found in COR-12 (0.26 kg).

4.1.2.18 Foliage yield (q/ha)

Leaf yield ranged from36.88 q/ha to 181.36 q/ha with an overall mean of 104.62 q/ha. Maximum leaf yield 181.36 q/ha was recorded in genotype COR-07 followed by COR-22 (166.0 q/ha), COR-21 (160.99 q/ha) and COR-11 (148.21 q/ha).Whereas, minimum leaf yield noticed in COR-12 (36.88 q/ha).

4.1.2.19 Fiber content (%)

Maximum fiber content recorded in genotype COR-11 (8.14 %). However it was found statistically *at par* with genotype *viz.,* COR-27 (7.90 %), COR-08 (7.61%),

COR-19 (7.60 %), COR-02 (7.50 %), COR-03 (7.50 %) and COR-21 (7.40 %). While, minimum fiber content noticed in COR-10 (4.07 %) with an overall mean of 6.55 %.

4.1.2.20 Dry matter (%)

The dry matter percentage of plant ranged from 9.79 % to 14.10 % with an overall mean of 11.66 %. The maximum dry matter percentage found in COR-12 (14.10 %), however, it was found statistically *at par* with genotypes *viz.,* COR-23 (13.26 %), COR-02 (12.87 %) and COR-01 (12.79 %) minimum dry matter percentage of plant found in COR-19 (9.79 %).

4.1.2.21 K (mg/ 100 g)

Maximum K content recorded in genotype COR-20 (1936.6 mg) followed by COR-06 (1746.6 mg), COR-21 (1620 mg), COR-22 (1423.3 mg), and COR-25 (1420 mg). Minimum K content recorded in genotype COR-28 (520 mg) with an overall mean of 1070.83 mg.

4.1.2.22 Ca (mg/ 100 g)

Maximum Ca content recorded in genotype COR-07 (4800.00 mg) followed by COR-10 (4386.6 mg), COR-20 (3296.6 mg), and COR-21 (3193.3 mg). Minimum Ca content recorded in genotype COR-26 (1673.3 mg) with an overall mean of 2621.07 mg.

These findings are in close proximity with the results of Chaulagain *et al*. (2011), Moniruzzaman *et al*. (2013), Agasimani *et al*. (2014), Phurailatpam *et al.* (2016), Dyulgerova *et al.* (2013), Palanikumar *et al.* (2011).

Table 4.2: Mean performance for foliage yield and its components characters in coriander.

Characters	Plant height (cm)	No. of branches per plant	Stem base diameter (cm)	No. of leaves per plant	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Root length (cm)	Root weight (g)	Plant fresh weight (g)	Fresh leaf weight (g)
COR-01	22.100	8.733	0.647	49.067	3.073	3.253	8.693	8.387	0.763	8.748	3.585
COR-02	21.887	10.333	0.680	52.600	2.700	3.360	7.807	9.640	0.556	8.373	3.842
COR-03	21.947	8.733	0.647	45.067	2.953	3.287	8.267	10.353	0.695	8.704	3.309
COR-04	19.960	10.333	0.533	67.933	2.280	2.753	7.440	9.660	0.317	6.147	2.711
COR-05	21.207	11.000	0.613	56.867	2.727	3.073	7.473	8.233	0.408	6.860	3.087
COR-06	19.687	8.533	0.587	37.333	2.973	3.373	8.707	8.880	0.494	6.546	2.447
COR-07	22.047	9.400	0.567	55.467	2.907	3.300	8.707	8.907	0.737	10.763	3.653
COR-08	21.347	9.600	0.587	53.867	2.760	3.253	8.347	9.147	0.453	6.873	2.441
COR-09	21.647	7.867	0.573	35.800	2.940	3.220	9.607	10.293	0.320	5.804	1.948
COR-10	23.880	12.133	0.727	68.667	2.847	3.400	7.620	9.447	0.356	7.233	2.788
COR-11	21.327	11.400	0.720	63.133	2.753	3.267	7.978	8.287	0.516	8.799	3.727
COR-12	18.320	8.067	0.280	32.800	2.573	2.907	5.760	5.980	0.233	2.191	0.924
COR-13	22.640	9.067	0.320	46.667	2.347	2.793	7.807	6.693	0.258	3.679	1.424
COR-14	22.233	6.600	0.360	22.600	2.727	2.913	11.313	7.687	0.141	2.867	0.967
COR-15	18.447	10.133	0.640	46.800	2.720	3.220	6.953	8.027	0.511	6.906	4.382
COR-16	19.940	8.733	0.600	34.467	2.927	3.160	8.400	7.833	0.419	5.577	2.125
COR-17	18.927	10.933	0.553	65.267	2.307	2.787	7.087	7.427	0.391	5.705	2.293
COR-18	19.493	10.067	0.300	49.200	2.667	3.060	6.153	6.727	0.280	4.375	2.096
COR-19	23.093	9.600	0.393	49.667	2.767	3.247	8.360	7.820	0.647	6.281	2.888
COR-20	20.840	7.933	0.507	31.067	2.847	3.220	9.607	8.360	0.239	4.453	1.629
COR-21	23.213	9.533	0.673	50.600	2.953	3.367	9.080	9.300	0.516	9.556	3.704
COR-22	22.787	9.800	0.693	48.133	2.953	3.513	8.587	8.633	0.548	9.853	4.141
COR-23	17.353	8.333	0.333	39.000	2.587	3.007	6.220	6.473	0.279	3.761	2.061
COR-24	19.027	9.333	0.347	44.400	2.633	3.167	6.607	9.393	0.319	4.151	1.817
COR-25	24.647	7.533	0.453	37.067	2.867	3.660	7.133	9.027	0.688	7.973	2.759
COR-26	24.907	8.267	0.287	40.067	2.507	3.033	5.613	7.073	0.315	4.503	2.233
COR-27	21.180	9.467	0.253	45.533	2.347	2.767	5.753	7.533	0.231	3.043	1.247
PH(CV)	19.587	8.467	0.467	47.533	2.320	2.807	7.613	7.020	0.152	4.215	2.545
Grand Mean	21.202	9.28	.512	47.02	2.71	3.14	7.81	8.29	.420	6.21	2.59
SEm±	1.735	0.780	0.051	4.662	0.127	0.163	0.600	0.636	0.033	0.482	0.213
C.D.(p=0.05)	N/A	2.218	0.146	13.254	.362	.465	1.705	1.809	0.093	1.370	.605
C.V. (%)	14.175	14.555	17.405	17.171	8.132	8.992	13.296	13.288	13.472	13.431	14.174

Characters	Leaf stem ratio	Fresh stem weight (g)	Dry leaf weight (g)	Dry stem weight (g)	Dry plant weight (g)	Foliage yield (kg/plot)	Foliage yield (q/ha.)	Fiber (%)	Dry matter (%)	K (mg/100g)	Ca (mg/100g)
COR-01	0.888	4.400	0.574	0.506	1.080	1.049	147.373	6.3	12.791	1,033.3	2,600.0
COR-02	1.201	3.975	0.648	0.414	1.062	1.002	140.723	7.5	12.876	686.6	2,143.3
COR-03	0.731	4.701	0.583	0.442	1.025	1.044	146.577	7.5	11.679	1,150.0	2,886.6
COR-04	0.793	3.119	0.417	0.291	0.707	0.738	103.600	7.3	11.505	803.3	2,076.6
COR-05	0.955	3.365	0.521	0.321	0.842	0.823	115.537	6.5	12.213	880.0	2,123.3
COR-06	0.679	3.605	0.418	0.327	0.745	0.785	110.247	6.13	11.375	1,746.6	2,320.0
COR-07	0.677	6.373	0.558	0.561	1.119	1.291	181.363	5.9	10.355	536.6	4,800.0
COR-08	0.608	3.979	0.392	0.347	0.739	0.824	115.773	7.61	10.773	783.3	2,023.3
COR-09	0.687	3.536	0.315	0.306	0.621	0.696	97.747	6.97	10.737	1,293.3	1,953.3
COR-10	0.776	4.089	0.523	0.353	0.876	0.867	121.813	4.07	12.465	1,216.6	4,386.6
COR-11	0.815	4.556	0.603	0.467	1.070	1.055	148.213	8.14	12.163	843.3	3,100.0
COR-12	0.897	1.034	0.167	0.122	0.289	0.263	36.887	7.17	14.109	1,196.6	2,326.6
COR-13	0.813	1.997	0.249	0.199	0.448	0.441	61.933	4.45	12.321	1,133.3	2,906.6
COR-14	0.637	1.759	0.154	0.185	0.339	0.344	48.265	6.7	12.177	626.6	2,456.6
COR-15	5.875	2.013	0.635	0.178	0.813	0.828	116.333	4.45	11.881	926.6	2,196.6
COR-16	0.703	3.032	0.367	0.272	0.639	0.669	93.910	6.3	11.346	840.0	2,473.3
COR-17	0.869	3.021	0.373	0.290	0.663	0.684	96.060	6.7	11.951	1,263.3	3,146.6
COR-18	1.075	1.999	0.335	0.179	0.514	0.525	73.733	7.31	11.728	763.3	2,040.0
COR-19	1.119	2.747	0.398	0.219	0.617	0.753	105.803	7.6	9.794	610.0	2,466.6
COR-20	0.679	2.585	0.258	0.189	0.447	0.534	74.997	6.9	10.017	1,936.6	3,296.6
COR-21	0.742	5.336	0.613	0.479	1.092	1.146	160.997	7.4	11.460	1,620.0	3,193.3
COR-22	0.799	5.164	0.615	0.491	1.107	1.182	166.003	4.63	11.255	1,423.3	2,843.3
COR-23	1.616	1.421	0.348	0.143	0.491	0.451	63.337	6.14	13.260	1,333.3	2,636.6
COR-24	0.990	2.015	0.322	0.183	0.505	0.498	69.940	6.9	12.071	1,410.0	2,393.3
COR-25	0.609	4.527	0.348	0.477	0.825	0.956	134.287	6.9	10.203	1,420.0	2,626.6
COR-26	1.214	1.956	0.305	0.204	0.509	0.540	75.840	6.7	10.683	1,163.3	1,673.3
COR-27	1.047	1.565	0.223	0.153	0.377	0.365	51.260	7.9	12.685	823.3	2,483.3
PH(CV)	1.819	1.518	0.326	0.127	0.453	0.505	70.920	5.6	10.682	520.0	1,816.6
Grand Mean	1.08	3.19	.413	.300	.714	.744	104.624	6.55	11.66	1070.83	2621.07
SEm±	0.117	0.339	0.048	0.030	0.058	0.058	8.115	0.403	0.829	25.957	30.865
C.D.(p=0.05)	.332	.965	.136	0.085	.166	.164	23.073	1.146	N/A	73.801	87.754
C.V. (%)	18.706	18.417	19.959	17.126	14.137	13.434	13.435	10.643	12.311	4.199	2.040

4.2 Genetic variability

Variability is the base for any breeding programme. It is a complex phenomenon which is measured by the estimation of range, mean, genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation.

In present investigation variability parameters for foliage yield and its components are present in **Table- 4.3**

4.2.1 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 10%), moderate (10-20%) and high (more than 20%) as suggested by Sivasubramanian and Madhavamenon (1973).

Genotypic and phenotypic coefficients of variation of different characters are presented in **Table 4.3.** High magnitude of genotypic as well as phenotypic coefficient of variations were recorded for traits *viz.*, leaf stem ratio (90.48 and 92.40 %), dry stem weight (43.86 and 47.11 %), root weight (41.97 and 44.12 %), fresh stem weight (41.94 and 45.81 %), foliage yield kg per plot (36.37 and 38.79 %), plant fresh weight (36.25 and 38.66 %), foliage yield q per ha (36.23 and 38.64 %), dry plant weight (35.82 and 38.56 %), fresh leaf weight (35.61 and 38.33 %), K mg per100 g (34.48 and 34.74%), dry leaf weight (34.07 and 39.65 %), stem base diameter (27.89 and 32.88 %), Ca mg per100 g (26.76 and 26.84 %), and number of leaves per plant (21.82 and 27.77 %), suggested that substantial improvement on coriander through selection for these traits. Moderate GCV and PCV were recorded for fiber content

(15.33 and 18.66 %), petiole length (14.95 and 20.01 %), root length (11.75 and 17.74 %) and number of branches per plant (10.50 and 17.95 %). Suggested existence of considerable variability in the population. Selection for these traits may also be given the importance for improvement programme. Low GCV and PCV were recorded for leaf length (7.08 and 10.78 %), leaf width (5.53 and 10.56 %), dry matter % (5.21 and 13.37 %), and plant height (3.98 and 14.72 %). Similar findings were also reported earlier by Tripathi *et al.* (2000), Megeji and Korla (2002), Singh *et al.* (2008), Rawat *et al.* (2013) and Meena *et al.* (2013).

Phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the traits indicating that environmental factors were influencing their expression. 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.

Table: 4.3 Genetic parameter of variability for foliage yield and its component characters in coriander

S. No.	Parameter	Range			Coefficient of Variation (%)		Heritability	Genetic	G.A. as %
	Character	Min.	Max.	Mean	GCV	PCV	(h^2%)	Advance	of mean
1	Plant height(cm)	17.35	24.9	21.2	3.98	14.72	7.3	0.47	2.21
2	No. of branches per plant	6.6	12.13	9.28	10.5	17.95	34.22	1.17	12.6
3	Stem base diameter(cm)	0.25	0.72	0.51	27.89	32.88	72	0.25	49.01
4	No. of leaves per plant	22.6	68.67	47.02	21.82	27.77	61.8	16.61	35.32
5	Leaf length (cm)	2.28	3.07	2.71	7.08	10.78	43.11	0.26	9.59
6	Leaf width (cm)	2.75	3.66	3.14	5.53	10.56	27.5	0.19	6.05
7	Petiole length (cm)	5.61	11.31	7.81	14.95	20.01	55.83	1.8	23.04
8	Root length (cm)	5.98	10.35	8.29	11.75	17.74	43.9	1.33	16.04
9	Root weight (g)	0.14	0.76	0.42	41.97	44.12	90.5	0.34	80.95
10	Plant fresh weight (g)	2.19	10.76	6.21	36.25	38.66	87.92	4.35	70.04
11	Fresh leaf weight (g)	0.92	4.38	2.59	35.61	38.33	86.3	1.77	68.33
12	Leaf stem ratio	0.6	5.87	1.08	90.48	92.4	95.9	1.97	182.4
13	Fresh stem weight (g)	1.03	6.37	3.19	41.94	45.81	83.81	2.52	79
14	Dry leaf weight (g)	0.15	0.64	0.41	34.07	39.65	73.82	0.25	60.97
15	Dry stem weight (g)	0.12	0.56	0.3	43.86	47.11	86.7	0.25	83.33
16	Dry plant weight (g)	0.28	1.11	0.71	35.82	38.56	86.3	0.49	69.01
17	Foliage yield (kg/plot)	0.26	1.29	0.74	36.37	38.79	87.9	0.52	70.27
18	Foliage yield (q /ha)	36.88	181.36	104.62	36.23	38.64	87.91	73.23	69.99
19	Fiber (%)	4.07	8.14	6.55	15.33	18.66	67.48	1.7	25.95
20	Dry matter (%)	9.79	14.1	11.66	5.21	13.37	15.22	0.48	4.11
21	K (mg/100g)	520	1936.6	1070.83	34.48	34.74	98.53	755.14	70.51
22	Ca (mg/100g)	1673.3	4800	2621.07	26.76	26.84	99.42	1441.11	54.98

GCV-Genotypic coefficient of variation, PCV- Phenotypic coefficient of variation,G.A.-Genetic Advance.

4.2.2 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 formulate concrete breeding programme, genetic advance along with heritability help to as certain 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 (<50 %), moderate (50 %- 70 %) and high (>70 %) as suggested by Robinson (1966).

In the present investigation high magnitude of heritability was recorded for most of the characters. The highest heritability was recorded for the characters Ca mg per 100 g (99.42 %), K mg per100 g (98.53 %), leaf stem ratio (95.9 %), root weight (90.5 %), plant fresh weight (87.92 %), foliage yield q per ha (87.91 %), foliage yield kg per plot (87.9 %), dry stem weight (86.7 %), fresh leaf weight (86.30 %). dry plant weight (86.3 %), fresh stem weight (83.81 %), dry leaf weight (73.82 %) and stem base diameter (72 %). Similar results reported by Singh and Singh (2013) for plant height, number of branches per plant and leaf weight. Similar results were also reported by Ali *et al*. (2005), Singh *et al.* (2005), Meena *et al*. (2013), Ameta *et al*. (2016) and Farooq *et al.* (2017). The moderate heritability was observed for the characters fiber content (67.48 %), number of leaves per plant (61.80 %) and petiole length (55.83 %).Low heritability was observed for leaf length (43.11 %), root length (43.9 %), number of branches per plant (34.22 %), leaf width (27.50 %), dry matter (15.22 %), and plant height (7.30 %), similar result was also reported by Singh *et al.* (2005).

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 (>20 %), moderate (20- 10 %) and low (<10 %) as suggested by Johnson *et al*. (1955).

Genetic advance as percentage of mean was observed high for leaf stem ratio (182.40 %), dry stem weight (83.33 %), root weight (80.95 %), fresh stem weight (79 %), K mg per 100 g (70.51 %), foliage yield kg per plot (70.27 %), plant fresh weight (70.04 %), foliage yield q per ha (69.99 %), dry plant weight (69.01 %), fresh leaf weight (68.33 %), dry leaf weight (60.97 %), Ca mg per 100 g (54.98 %), stem base diameter (49.01 %), number of leaves per plant (35.32 %), fiber content (25.95 %) and petiole length (23.04 %). Root length (16.04 %) and number of branches per plant (12.60 %) showed moderate genetic advance as percentage of mean. Leaf length (9.59 %), leaf width (6.05 %), dry matter % (4.11 %) and plant height (2.21 %) 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 such 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 were observed for characters *viz.*, leaf stem ratio, dry stem weight, root weight, fresh stem weight, K mg per 100 g, foliage yield kg per plot, plant fresh weight, foliage yield q per ha, dry plant weight, fresh leaf weight, dry leaf weight, Ca mg per 100 g, stem base diameter, number of leaves per plant, fiber content, petiole length indicating that most likely the heritability is due to additive gene effects and selection may be effective. Therefore, selection based on phenotypic performance of these traits would be effective to select desirable plant type. Similar results were also reported by Singh and Singh (3013), Ali *et al*. (2005), Singh *et al.* (2005), Meena *et al*. (2013), Ameta *et al*. (2016) and Farooq *et al.* (2017). Rest of the traits showed moderate to low heritability estimates coupled with moderate to low genetic advance as percentage of mean indicated the role of non additive genetic variance in their expression.

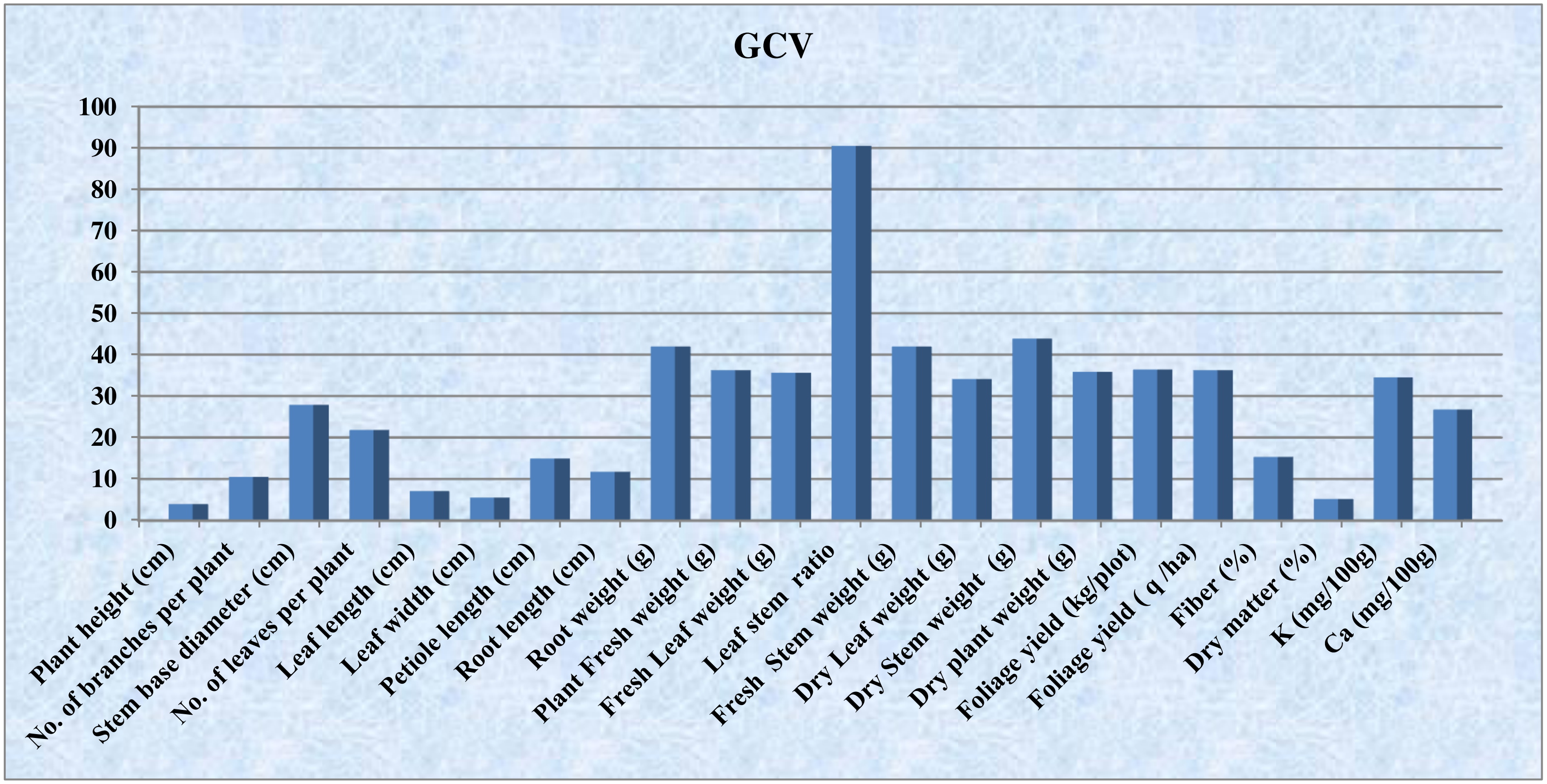

Fig. 4.1: Graphical presentation of genotypic coefficient of variation (GCV) of leaf yield and its components of coriander

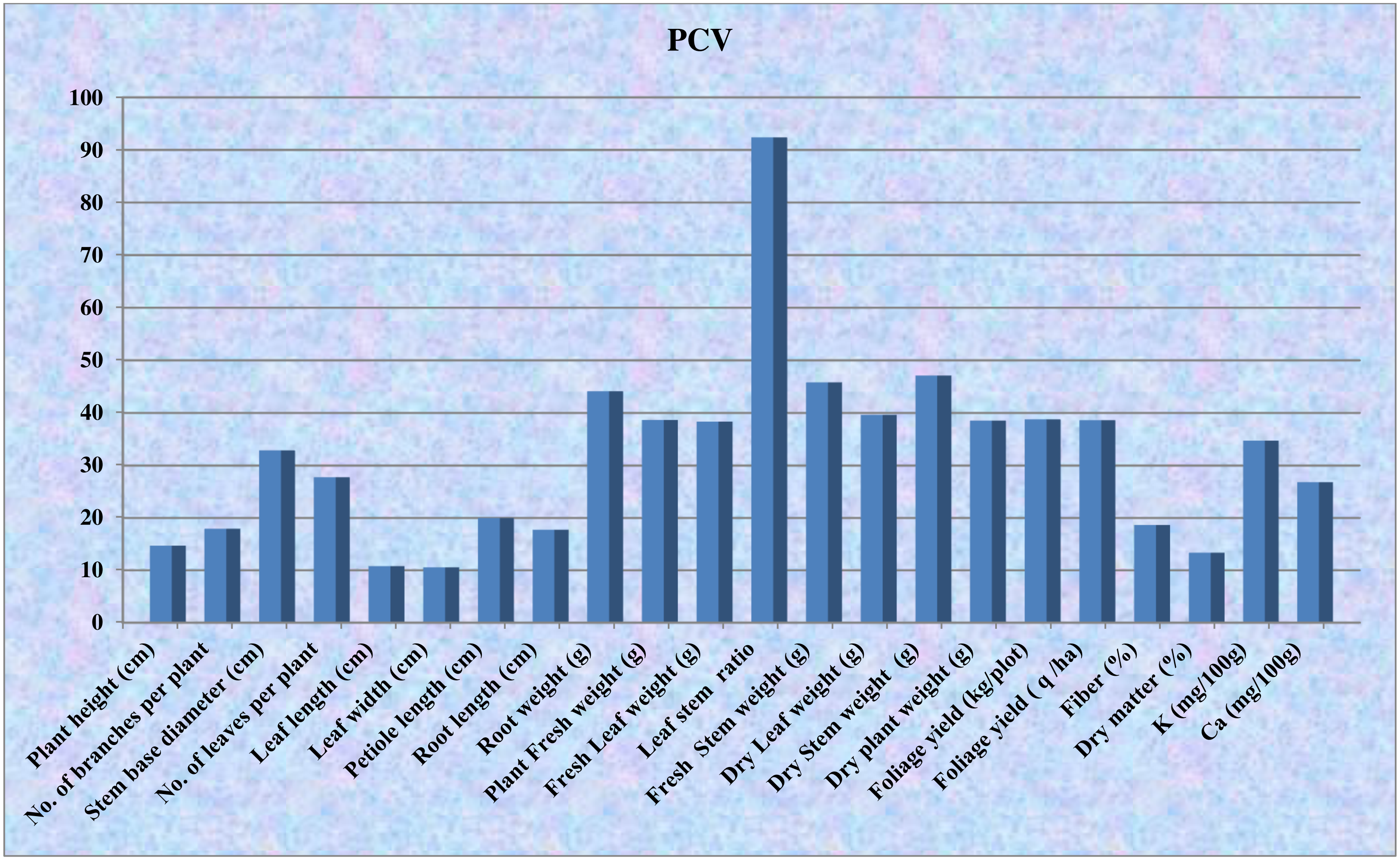

Fig. 4.2: Graphical presentation of phenotypic coefficient of variation (PCV) of leaf yield and its components of coriander

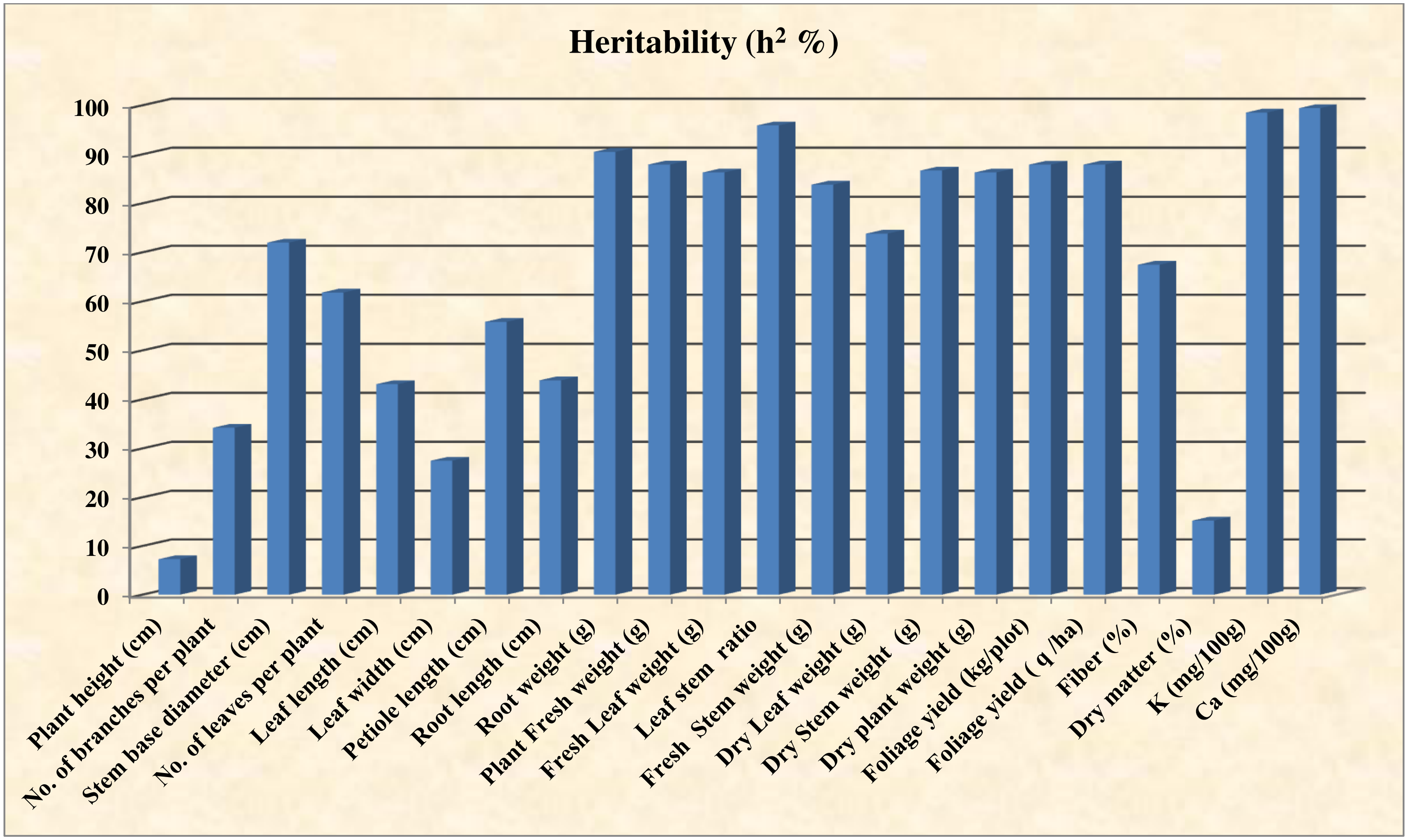

Fig. 4.3: Graphical presentation of heritability (h^2b) of leaf yield and its components of coriander

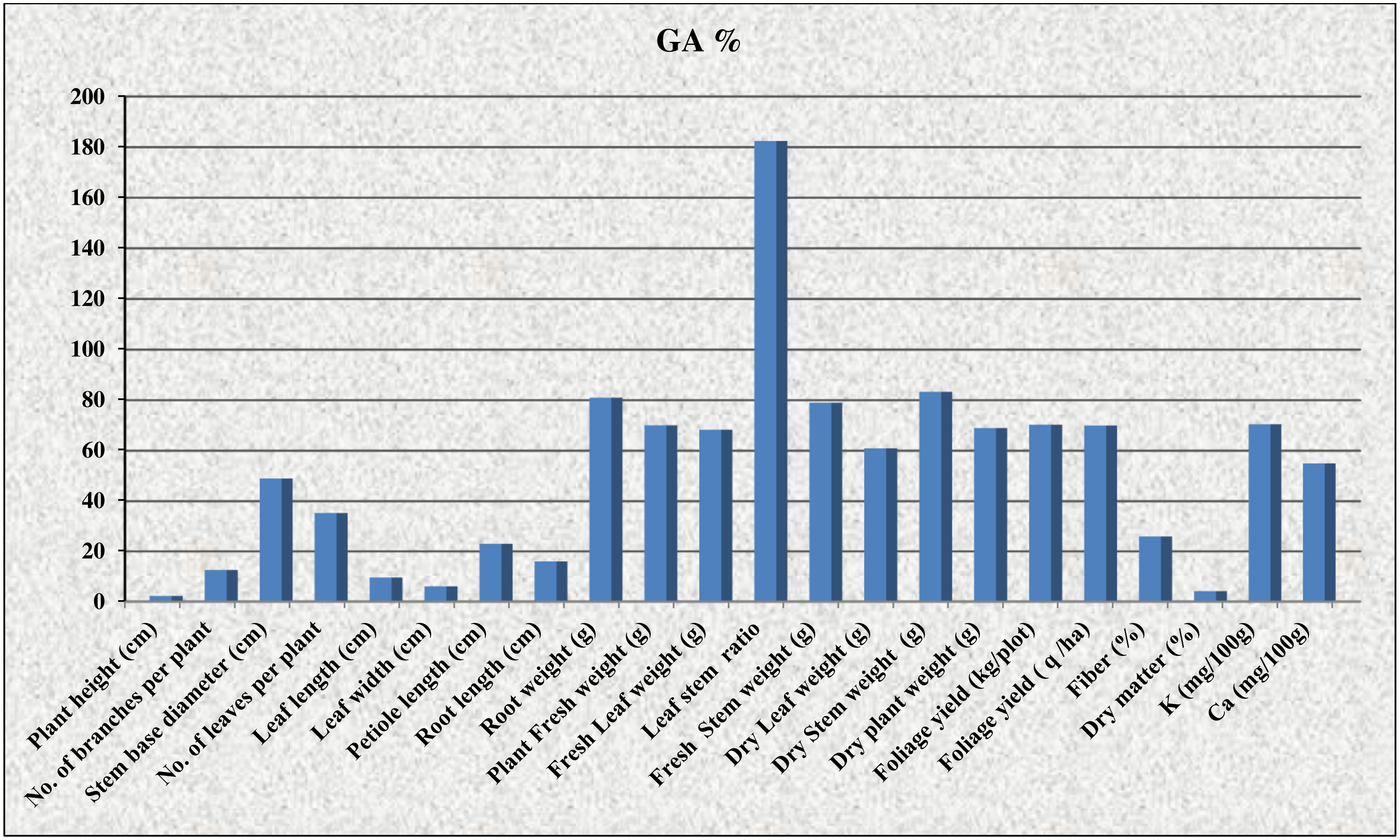

Fig. 4.4: Graphical presentation of genetic advance (GA %) of leaf yield and its components of coriander

4.3 Correlation coefficient

Association analysis is an important approach in a breeding 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 foliage 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) 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. The phenotypic correlations were normally of genetic and environmental interaction which provided information about the association between the two 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 genotypes plays a great role in achieving higher yield combined with better quality.

The genotypic and phenotypic correlation for foliage yield and its component in coriander are presented in Table: **4.4** and only significant correlations are discussed here.

Plant height showed positive and highly significantly correlation with leaf width, plant fresh weight, fresh stem weight, dry stem weight, dry plant weight, and foliage yield kg per plot at both genotypic and phenotypic level and with root length, root weight and fresh leaf weight at genotypic level only and with leaf length and petiole length at phenotypic level only. While, it is significantly positively correlated with stem base diameter, number of leaves per plant and root weight at phenotypic level only and also leaf length and petiole length at genotypic level only. Whereas, it is highly significant negative correlation with number of branches per plant and leaf stem ratio at genotypic level were significant negative correlation with number of leaves per plant at genotypic level and leaf stem ratio at phenotypic level only.

Number of branches per plant showed highly significant positive correlation with stem base diameter, number of leaves per plant, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry plant weight, foliage yield kg per plot at both genotypic and phenotypic levels and also it is positive and significant correlation with root length, root weight and dry stem weight at genotypic level only and also significant positive correlation with leaf width and dry stem weight at phenotypic level only. Whereas, it is highly significantly negative correlation with leaf length and petiole length at genotypic level and significant negative correlation with leaf width at genotypic level only.

Stem base diameter showed highly significant positive correlation with number of leaves per plant, leaf length, leaf width, petiole length, root length, root weight, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Number of leaves per plant showed highly significant positive correlation with plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic levels and also positive and significant correlation with root length and root weight at both genotypic and phenotypic levels. Whereas, it is highly significant negative correlation with leaf length and petiole length at genotypic level only.

Leaf length showed positive and highly significant correlation with leaf width, petiole length, root length, root weight, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Leaf width showed positive and highly significant correlation with root length, root weight, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both phenotypic and genotypic level, it also showed positive and significant correlation with petiole length at phenotypic level only.

Petiole length showed positive and highly significant correlation with root length, plant fresh weight, fresh stem weight, dry stem weight and foliage yield kg per plot at both genotypic and phenotypic level while, it is highly significantly positively correlated with dry plant weight at genotypic level and significant positive correlation with dry plant weight at phenotypic level only. Whereas, petiole length showed highly significantly negative correlation with leaf stem ratio at genotypic level only and significant negative correlation with leaf stem ratio at phenotypic level only.

Root length showed highly significant positive correlation with root weight, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both phenotypic and genotypic level.

Root weight showed positive and highly significant correlation with plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Plant fresh weight showed highly significant positive correlation with fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Fresh leaf weight showed highly significant and positive correlation with leaf stem ratio, fresh stem weight, dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Leaf stem ratio showed significant positive correlation with dry leaf weight at both genotypic and phenotypic level. While, it is highly significant negative correlation with fresh stem weight and dry stem weight at both phenotypic and genotypic levels.

Fresh stem weight showed highly significant positive correlation with dry leaf weight, dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Dry leaf weight showed positive highly significant correlation with dry stem weight, dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Dry stem weight showed positive highly significant correlation with dry plant weight and foliage yield kg per plot at both genotypic and phenotypic level.

Dry plant weight showed positive highly significant correlation with foliage yield kg per plot at both genotypic and phenotypic level.

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 plant height, number of branches per plant, stem base diameter, number of leaves per plant, leaf length, leaf width, petiole length, root length, root weight, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight and dry plant weight exhibited the significant positive correlation with foliage yield (kg/ plot) at both genotypic and phenotypic level. Hence, direct selection for these traits may lead to the development of high yielding genotypes of coriander.

Similar results were also reported by Singh *et al.* (2005), Singh and Prasad (2006), Idhal *et al.*(2009), Meena *et al.*(2014) and Kumar *et al.* (2017).

Table 4.4: Genotypic and phenotypic correlation coefficient between foliage yield and its quantitative characters in coriander

No	Characters	01. Plant height (cm)	02. No. of branches per plant	03. Stem base diameter (cm)	04. No. of leaves per plant	05. Leaf length (cm)	06. Leaf width (cm)	07. Petiole length (cm)	08. Root length (cm)	09. Root weight (g)	10. Plant fresh weight (g)	11. Fresh leaf weight (g)	12. Leaf stem ratio	13. Fresh stem weight (g)	14. Dry leaf weight (g)	15. Dry stem weight (g)	16. Dry plant weight (g)	17. Foliage yield kg/plot)
1	P	1.000	0.213	0.230*	0.221*	0.373**	0.442**	0.360**	0.204	0.236*	0.336**	0.214	-0.228*	0.377**	0.213	0.341**	0.300**	0.337**
	G	1.000	-0.793**	0.144	-0.277*	0.272*	0.573**	0.224*	0.823**	0.819**	0.796**	0.351**	-0.813**	0.991**	0.207	0.909**	0.675**	0.796**
2	P		1.000	0.462**	0.851**	0.106	0.233*	-0.102	0.117	0.160	0.367**	0.408**	0.078	0.305**	0.532**	0.242*	0.439**	0.368**
	G		1.000	0.510**	0.981**	-0.453**	-0.241*	-0.477**	0.252*	0.223*	0.429**	0.596**	0.191	0.280**	0.657**	0.276*	0.501**	0.430**
3	P			1.000	0.447**	0.548**	0.548**	0.415**	0.527**	0.505**	0.761**	0.706**	0.023	0.707**	0.755**	0.653**	0.782**	0.760**
	G			1.000	0.466**	0.581**	0.643**	0.484**	0.775**	0.597**	0.845**	0.807**	0.072	0.786**	0.885**	0.771**	0.879**	0.844**
4	P				1.000	-0.040	0.123	-0.090	0.238*	0.265*	0.460**	0.478**	-0.008	0.397**	0.557**	0.354**	0.510**	0.461**
	G				1.000	-0.415**	-0.201	-0.343**	0.267*	0.269*	0.475**	0.538**	0.021	0.392**	0.568**	0.390**	0.510**	0.476**
5	P					1.000	0.847**	0.515**	0.433**	0.493**	0.555**	0.400**	-0.128	0.578**	0.461**	0.494**	0.525**	0.555**
	G					1.000	0.842**	0.583**	0.587**	0.753**	0.675**	0.460**	-0.155	0.719**	0.485**	0.740**	0.645**	0.674**
6	P						1.000	0.382**	0.447**	0.489**	0.573**	0.449**	-0.070	0.574**	0.474**	0.511**	0.541**	0.574**
	G						1.000	0.210	0.766**	0.982**	0.933**	0.779**	-0.053	0.903**	0.734**	0.921**	0.876**	0.932**
7	P							1.000	0.369**	0.145	0.313**	0.112	-0.233*	0.419**	0.115	0.315**	0.228*	0.312**
	G							1.000	0.516**	0.206	0.330**	0.123	-0.295**	0.444**	0.146	0.416**	0.290**	0.327**
8	P								1.000	0.417**	0.533**	0.358**	-0.170	0.579**	0.441**	0.494**	0.512**	0.532**
	G								1.000	0.547**	0.732**	0.538**	-0.205	0.789**	0.599**	0.752**	0.711**	0.731**
9	P									1.000	0.820**	0.716**	-0.002	0.734**	0.683**	0.749**	0.787**	0.821**
	G									1.000	0.877**	0.772**	0.005	0.812**	0.759**	0.851**	0.851**	0.878**
10	P										1.000	0.877**	-0.049	0.943**	0.856**	0.881**	0.955**	0.900**
	G										1.000	0.894**	-0.041	0.950**	0.912**	0.968**	0.993**	0.900**
11	P											1.000	0.333**	0.670**	0.925**	0.649**	0.879**	0.877**
	G											1.000	0.349**	0.713**	0.987**	0.735**	0.916**	0.895**
12	P												1.000	-0.307**	0.219*	-0.305**	-0.024	-0.050
	G												1.000	-0.311**	0.271*	-0.315**	-0.011	-0.041
13	P													1.000	0.690**	0.911**	0.872**	0.943**
	G													1.000	0.753**	0.909**	0.927**	0.950**
14	P														1.000	0.645**	0.921**	0.856**
	G														1.000	0.787**	0.950**	0.911**
15	P															1.000	0.892**	0.881**
	G															1.000	0.941**	0.968**
16	P																1.000	0.955**
	G																1.000	0.993**
17	P																	1.000
	G																	1.000

4.4 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, foliage 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 foliage yield per plot in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation as presented in **Table 4.5.** Data revealed that fresh stem weight of plant showed the highest positive direct effect (0.767) on foliage yield kg per plot followed by fresh leaf weight (0.500), root weight (0.104), dry plant weight (0.067), leaf width (0.003), leaf stem ratio (0.001), plant height (0.001) and petiole length (0.000) whereas, the characters namely plant fresh weight (-0.287), dry stem weight (-0.036), leaf length (-0.006), stem base diameter (-0.005), dry leaf weight (-0.005), number of leaves per plant (-0.002), root length (-0.002) and number of branches per plant (-0.001) showed maximum negative direct effects on foliage yield kg per plot.

Plant height showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.760), fresh leaf weight (0.176), root weight (0.085), dry plant weight (0.045), plant height (0.001), number of branches per plant (0.001), leaf width (0.001).

Number of branches per plant showed positive indirect effect on foliage yield *via.,* fresh leaf weight (0.298), fresh stem weight (0.215), dry plant weight (0.034), root weight (0.023), leaf length (0.003).

Stem base diameter showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.603), fresh leaf weight (0.404), root weight (0.062), dry plant weight (0.059), leaf width (0.002).

Number of leaves per plant showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.301), fresh leaf weight (0.269), dry plant weight (0.034), root weight (0.028), leaf length (0.003).

Leaf length showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.552), fresh leaf weight (0.230), root weight (0.078), dry plant weight (0.043), leaf width (0.002), number of branches per plant (0.001), number of leaves per plant (0.001).

Leaf width showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.692), fresh leaf weight (0.389), root weight (0.102), dry plant weight (0.059), plant height (0.001).

Petiole length showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.341), fresh leaf weight (0.062), root weight (0.021), dry plant weight (0.020), number of branches per plant (0.001), number of leaves per plant (0.001), leaf width (0.001).

Root length showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.605), fresh leaf weight (0.269), root weight (0.057), dry plant weight (0.048), leaf width (0.002), plant height (0.001).

Root weight showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.623), fresh leaf weight (0.386), dry plant weight (0.057), leaf width (0.003), plant height (0.001).

Plant fresh weight showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.729), fresh leaf weight (0.447), root weight (0.091), dry plant weight (0.067), leaf width (0.002), plant height (0.001).

Fresh leaf weight showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.547), root weight (0.080), dry plant weight (0.062), leaf width (0.002).

Leaf stem ratio showed positive indirect effect on foliage yield *via.,* fresh leaf weight (0.175), plant fresh weight (0.012), dry stem weight (0.011), root weight (0.001), leaf length (0.001).

Fresh stem weight showed positive indirect effect on foliage yield *via.,* fresh leaf weight (0.357), root weight (0.084), dry plant weight (0.062), leaf width (0.002), plant height (0.001).

Dry leaf weight showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.578), fresh leaf weight (0.494), root weight (0.079), dry plant weight (0.064), leaf width (0.002),

Dry stem weight showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.774), fresh leaf weight (0.367), root weight (0.088), dry plant weight (0.063), leaf width (0.002), plant height (0.001).

Dry plant weight showed positive indirect effect on foliage yield *via.,* fresh stem weight (0.711), fresh leaf weight (0.458), root weight (0.088), dry plant weight (0.067), leaf width (0.002),), plant height (0.001).

The effect of residual factor (0.000) on foliage yield per plot was negligible, thereby, suggested that no other major yield component is left over.

In present investigation, fresh stem weight followed by fresh leaf weight and root weight showed high positive and direct effect had significant positive correlation with foliage yield kg per plot. Therefore, the higher fresh stem weight and fresh leaf weight should be considered in selection criteria for increasing foliage yield kg per plot.

The present study suggested that more emphasis should be given to selecting genotypes with high fresh stem weight, fresh leaf weight and root weight. Directly or indirectly all characters showed positive effect on foliage yield kg per plot, which is in

Table 4.5 : Direct and indirect effect of component character on foliage yield in coriander (*Coriandrum sativum* L.)

Characters	Plant height (cm)	No. of branches per plant	Stem base diameter (cm)	No. of leaves per plant	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Root length (cm)	Root weight (g)	Plant fresh weight (g)	Fresh leaf weight (g)	Leaf stem ratio	Fresh stem weight (g)	Dry leaf weight (g)	Dry stem weight (g)	Dry plant weight (g)	Foliage yield kg/ plot
Plant height (cm)	**0.001**	0.001	-0.001	0.000	-0.002	0.001	0.000	-0.001	0.085	-0.228	0.176	-0.001	0.760	-0.001	-0.040	0.045	0.796
No. of branches per plant	-0.001	**-0.001**	-0.002	-0.002	0.003	-0.001	0.000	0.000	0.023	-0.123	0.298	0.000	0.215	-0.003	-0.010	0.034	0.430
Stem base diameter (cm)	0.000	-0.001	**-0.005**	-0.001	-0.004	0.002	0.000	-0.001	0.062	-0.242	0.404	0.000	0.603	-0.004	-0.028	0.059	0.844
No. of leaves per plant	0.000	-0.001	-0.002	**-0.002**	0.003	-0.001	0.000	0.000	0.028	-0.136	0.269	0.000	0.301	-0.003	-0.014	0.034	0.476
Leaf length (cm)	0.000	0.001	-0.003	0.001	**-0.006**	0.002	0.000	-0.001	0.078	-0.193	0.230	0.000	0.552	-0.002	-0.027	0.043	0.674
Leaf width (cm)	0.001	0.000	-0.003	0.000	-0.005	**0.003**	0.000	-0.001	0.102	-0.267	0.389	0.000	0.692	-0.004	-0.033	0.059	0.932
Petiole length (cm)	0.000	0.001	-0.002	0.001	-0.004	0.001	**0.000**	-0.001	0.021	-0.095	0.062	0.000	0.341	-0.001	-0.015	0.020	0.327
Root length (cm)	0.001	0.000	-0.004	0.000	-0.004	0.002	0.000	**-0.002**	0.057	-0.210	0.269	0.000	0.605	-0.003	-0.027	0.048	0.731
Root weight (g)	0.001	0.000	-0.003	0.000	-0.005	0.003	0.000	-0.001	**0.104**	-0.251	0.386	0.000	0.623	-0.004	-0.031	0.057	0.878
Plant fresh weight (g)	0.001	-0.001	-0.004	-0.001	-0.004	0.002	0.000	-0.001	0.091	**-0.287**	0.447	0.000	0.729	-0.004	-0.035	0.067	0.900
Fresh leaf weight (g)	0.000	-0.001	-0.004	-0.001	-0.003	0.002	0.000	-0.001	0.080	-0.256	**0.500**	0.000	0.547	-0.005	-0.027	0.062	0.895
Leaf stem ratio	-0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.012	0.175	**0.001**	-0.239	-0.001	0.011	-0.001	-0.041
Fresh stem weight (g)	0.001	0.000	-0.004	-0.001	-0.005	0.002	0.000	-0.001	0.084	-0.272	0.357	0.000	**0.767**	-0.004	-0.037	0.062	0.950
Dry leaf weight (g)	0.000	-0.001	-0.004	-0.001	-0.003	0.002	0.000	-0.001	0.079	-0.261	0.494	0.000	0.578	**-0.005**	-0.029	0.064	0.911
Dry stem weight (g)	0.001	0.000	-0.004	-0.001	-0.005	0.002	0.000	-0.001	0.088	-0.277	0.367	0.000	0.774	-0.004	**-0.036**	0.063	0.968
Dry plant weight (g)	0.001	-0.001	-0.004	-0.001	-0.004	0.002	0.000	-0.001	0.088	-0.285	0.458	0.000	0.711	-0.005	-0.034	**0.067**	0.993

confirmation to the finding of Singh *et al.(*2006), Mengesha *et al.(*2013), Meena *et al.(*2014), Sravanthi *et al.(*2014) and Kumar *et al.*(2017).

Overall the path analysis confined that positive direct effect of fresh stem weight, fresh leaf weight, root weight, dry plant weight, leaf width, leaf stem ratio, plant height and petiole length, whereas, indirect effect of fresh stem weight, fresh leaf weight, root weight, dry plant weight, plant height, number of branches per plant, leaf width, leaf length and number of leaves per plant.

4.5 Various morphological characters observed in different genotypes of Coriander

Morphological characters recorded in all the genotypes as per the minimum descriptors for leafy vegetables for the cultivated coriander during the peak of crop growth presented in Table: 4.6 and findings are described as below:

Growth habit

All the 28 genotypes of coriander were evaluated for the growth habit were categorized into various distinct groups *viz.,* thirteen genotypes had semi erect (COR-01, COR-03, COR-06, COR-07, COR-08, COR-09, COR-15, COR-16, COR-19, COR-20, COR-21, COR-22, COR-23), eight had erect (COR-12, COR-13, COR-14, COR-18, COR-24, COR-25, COR-26, COR-27) and seven had bushy (COR-02, COR-04, COR-05, COR-10, COR-11, COR-17, COR-28).

Stem pubescence

All the 28 genotypes of coriander were evaluated for the stem pubescence

Absent COR-01, COR-02, COR-03, COR-04, COR-05, COR-06, COR-07, COR-08, COR-09, COR-10, COR-11, COR-12, COR-13, COR-14, COR-15, COR-16, COR-17, COR-18, COR-19, COR-20, COR-21, COR-22, COR-23, COR-24, COR-25, COR-26, COR-27, COR-28.

Stem pigmentation

All the 28 genotypes of coriander were evaluated for the stem pigmentation were categorized into various distinct groups *viz.,* twenty genotypes present (COR-01,

COR-04, COR-05, COR-07, COR-08, COR-12, COR-13, COR-15, COR-16, COR-17, COR-18, COR-19, COR-21, COR-22, COR-23, COR-24, COR-25, COR-26, COR-27, COR-28) and eight genotypes absent (COR-02, COR-03, COR-06, COR-09, COR-10, COR-11,COR-14, COR-20)

Leaf pubescence

All the 28 genotypes of coriander were evaluated for the leaf pubescence

Absent COR-01, COR-02, COR-03, COR-04, COR-05, COR-06, COR-07, COR-08, COR-09, COR-10, COR-11, COR-12, COR-13, COR-14, COR-15, COR-16, COR-17, COR-18, COR-19, COR-20, COR-21, COR-22, COR-23, COR-24, COR-25, COR-26, COR-27, COR-28.

Leaf pigmentation

All the 28 genotypes of coriander were evaluated for the leaf pigmentation

Absent COR-01, COR-02, COR-03, COR-04, COR-05, COR-06, COR-07, COR-08, COR-09, COR-10, COR-11, COR-12, COR-13, COR-14, COR-15, COR-16, COR-17, COR-18, COR-19, COR-20, COR-21, COR-22, COR-23, COR-24, COR-25, COR-26, COR-27, COR-28.

Leaf shape

All the 28 genotypes of coriander were evaluated for the leaf shape

Lobed COR-01, COR-02, COR-03, COR-04, COR-05, COR-06, COR-07, COR-08, COR-09, COR-10, COR-11, COR-12, COR-13, COR-14, COR-15, COR-16, COR-17, COR-18, COR-19, COR-20, COR-21, COR-22, COR-23, COR-24, COR-25, COR-26, COR-27, COR-28.

Prominence of leaf veins

All the 28 genotypes of coriander were evaluated for the prominence of leaf veins were categorized into various distinct groups *viz.,* twenty seven genotypes Smooth (COR-01, COR-02, COR-03, COR-04, COR-05, COR-06, COR-07, COR-08, COR-09, COR-10, COR-11, COR-12, COR-13, COR-14, COR-15, COR-16, COR-17, COR-18, COR-19, COR-20, COR-21, COR-22, COR-23, COR-24, COR-25, COR-27, COR-28) and one genotype rugose (COR-26).

Petiole pigmentation

All the 28 genotypes of coriander were evaluated for the petiole pigmentation were categorized into various distinct groups *viz.,* twenty-one genotypes had present pigmentation (COR-01, COR-02, COR-03, COR-04, COR-05, COR-07, COR-08, COR-10, COR-12, COR-13, COR-15, COR-16, COR-17, COR-18, COR-19, COR-21, COR -22, COR-23, COR-24, COR-26, COR-27) and seven genotypes had absent pigmentation (COR-06, COR-09, COR-11, COR-14, COR-20, COR-25, COR-28).

Leaf colour

All the 28 genotypes of coriander were evaluated for the leaf colour were categorized into various distinct groups *viz.,* eighteen genotypes green colour (COR-01, COR-02, COR-03, COR-04, COR-05, COR-07, COR-08, COR-10, COR-11, COR-12, COR-16, COR-17, COR-18, COR-21, COR -22, COR-23, COR-26, COR-28) and six genotypes recorded for light green colour (COR-06, COR-09, COR-14, COR-19, COR-20, COR-25) and four genotypes recorded for dark green colour (COR-13, COR-15, COR-24, COR-27).

Petiole colour

All the 28 genotypes of coriander were evaluated for the petiole colour were categorized into various distinct groups *viz.,* thirteen genotypes had green colour (COR-01, COR-04, COR-05, COR-07, COR-08, COR-12, COR-13, COR-16, COR-17, COR-19, COR-21, COR-22, COR-28) nine genotype had light green colour (COR-02, COR-03, COR-06, COR-09, COR-10, COR-11, COR-14, COR-20, COR-25), one genotype had dark green colour (COR-15) and five genotype had reddish tinge colour (COR-18, COR-23, COR-24, COR-26, COR-27).

Leaf curliness

All the 28 genotypes of coriander were evaluated for the leaf curliness were categorized into various distinct groups *viz.,* twenty four genotypes absent (COR-02, COR-03, COR-04, COR-06, COR-07, COR-09, COR-10, COR-11, COR-12, COR-13, COR-14, COR-15, COR-16, COR-17, COR-18, COR-19, COR-20, COR-21, COR-23, COR-24, COR-25, COR-26, COR-27, COR-28) and four genotypes present (COR-01, COR-05, COR-08, COR -22).

Stem colour

All the 28 genotypes of coriander were evaluated for the stem colour were categorized into various distinct groups *viz.,* fifteen genotypes had greenish violet (COR-01, COR-04, COR-05, COR-07, COR-08, COR-12, COR-13, COR-15, COR-16, COR-17, COR-19, COR-21, COR-22, COR-25, COR-28), one genotype had light green (COR-14), seven genotype had green colour (COR-02, COR-03, COR-06, COR-09, COR-10, COR-11, COR-20) and five genotype had deep violet (COR-18, COR-23, COR-24, COR-26, COR-27).

Leaf roughness

All the 28 genotypes of coriander were evaluated for the leaf roughness were categorized into various distinct groups *viz.*, twenty-six genotypes had smooth (COR-01, COR-02, COR-03, COR-04, COR-05, COR-06, COR-07, COR-08, COR-09, COR-10, COR-11, COR-12, COR-13, COR-14, COR-15, COR-16, COR-17, COR-18, COR-19, COR-20, COR-21, COR-22, COR-24, COR-26, COR-27, COR-28) and two genotype had rough (COR-23, COR-25).

Table 4.6: Various morphological characters observed in different genotypes of coriander

Morphological traits Genotypes	Growth habit	Stem pubescence	Stem pigmentation	Leaf pubescence	Leaf pigmentation	Leaf shape	Prominence of leaf veins	Petiole pigmentation	Leaf colour	Petiole colour	Leaf curliness	Stem colour	Leaf roughness
COR-01	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Present	Greenish violet	Smooth
COR-02	Bushy	Absent	Absent	Absent	Absent	Lobed	Smooth	Present	Green	Light green	Absent	Green	Smooth
COR-03	Semi Erect	Absent	Absent	Absent	Absent	Lobed	Smooth	Present	Green	Light green	Absent	Green	Smooth
COR-04	Bushy	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Absent	Greenish violet	Smooth
COR-05	Bushy	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Present	Greenish violet	Smooth
COR-06	Semi Erect	Absent	Absent	Absent	Absent	Lobed	Smooth	Absent	Light green	Light green	Absent	Green	Smooth
COR-07	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Absent	Greenish violet	Smooth
COR-08	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Present	Greenish violet	Smooth
COR-09	Semi Erect	Absent	Absent	Absent	Absent	Lobed	Smooth	Absent	Light green	Light green	Absent	Green	Smooth
COR-10	Bushy	Absent	Absent	Absent	Absent	Lobed	Smooth	Present	Green	Light green	Absent	Green	Smooth
COR-11	Bushy	Absent	Absent	Absent	Absent	Lobed	Smooth	Absent	Green	Light green	Absent	Green	Smooth
COR-12	Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Absent	Greenish violet	Smooth
COR-13	Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Dark green	Green	Absent	Greenish violet	Smooth
COR-14	Erect	Absent	Absent	Absent	Absent	Lobed	Smooth	Absent	Light green	Light green	Absent	Light green	Smooth
COR-15	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Dark green	Dark green	Absent	Greenish violet	Smooth
COR-16	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Absent	Greenish violet	Smooth
COR-17	Bushy	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Absent	Greenish violet	Smooth
COR-18	Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Reddish tinge	Absent	Deep violet	Smooth
COR-19	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Light green	Green	Absent	Greenish violet	Smooth
COR-20	Semi Erect	Absent	Absent	Absent	Absent	Lobed	Smooth	Absent	Light green	Light green	Absent	Green	Smooth
COR-21	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Absent	Greenish violet	Smooth
COR-22	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Green	Present	Greenish violet	Smooth
COR-23	Semi Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Green	Reddish tinge	Absent	Deep violet	Rough
COR-24	Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Dark green	Reddish tinge	Absent	Deep violet	Smooth
COR-25	Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Absent	Light green	Light green	Absent	Greenish violet	Rough
COR-26	Erect	Absent	Present	Absent	Absent	Lobed	Rugose	Present	Green	Reddish tinge	Absent	Deep violet	Smooth
COR-27	Erect	Absent	Present	Absent	Absent	Lobed	Smooth	Present	Dark green	Reddish tinge	Absent	Deep violet	Smooth
PH(CV)	Bushy	Absent	Present	Absent	Absent	Lobed	Smooth	Absent	Green	Green	Absent	Greenish violet	Smooth

COR-01

COR-02

COR-03

COR-04

COR-05

COR-06

COR-07

COR-08

Plate II:- Morphological variability in Coriander (*Coriandrum sativum* L.) genotypes

COR -09

COR -10

COR -11

COR -12

COR -13

COR -14

Plate III:- Morphological variability in Coriander (*Coriandrum sativum* L.) genotypes

COR -15

COR -16

COR -17

COR -18

COR -19

COR -20

Plate IV:- Morphological variability in Coriander (*Coriandrum sativum* L.) genotypes

COR -21

COR -22

COR -23

COR -24

COR -25

COR -26

Plate V:- Morphological variability in Coriander (*Coriandrum sativum* L.) genotypes

COR -27

COR -28

Plate VI:- Morphological variability in Coriander (*Coriandrum sativum* L.) genotypes

CHAPTER-V
SUMMARY AND CONCLUSIONS

The present investigation entitled **"Variability and association studies for foliage yield components and its quality parameters in Coriander (*Coriandrum sativum* L.) "** was carried out at Pt. KLS College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during 2016-17. The experiment was comprised of twenty eight genotype of coriander was laid out in Randomized Complete Block Design (RCBD) with three replications to estimate the parameter of genetic variability, correlation coefficient and path analysis.

Five randomly selected plants were considered for observations of different characters *viz*., plant height (cm), number of branches per plant, stem base diameter (cm), number of leaves per plant, leaf length (cm), leaf width (cm), petiole length (cm), root length(cm), root weight (g), plant fresh weight (g), fresh leaf weight (g), leaf stem ratio, fresh stem weight (g), dry leaf weight (g), dry stem weight (g), dry plant weight (g), foliage yield (kg/plot), foliage yield (q/ha), fiber (%), dry matter (%), K (mg /100g), Ca (mg /100g).

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

The highest foliage yield (kg/plot) was recorded in genotype COR-07 (1.29 kg) followed by COR-22 (1.18 kg) and COR-21 (1.14 kg). Maximum number of leaves per plant recorded in genotype COR-10 (68.67) followed by COR-04 (67.93) and COR-17 (65.26). Highest number of branches per plant recorded in genotypes COR-10 (12.13) followed by COR-11 (11.40) and COR-05 (11.00).Maximum plant height was recorded in the genotype COR-26 (24.90 cm) followed by COR-25 (24.64 cm), COR-09 (23.88 cm) and COR-21 (23.213 cm.).

Maximum stem base diameter recorded in genotype COR-10 (0.72 cm), followed by COR-11 (0.71 cm), COR-22 (0.69 cm) and COR-02 (0.68 cm), COR-21 (0.67 cm), COR-03 (0.64 cm). Highest leaf length 3.07 cm was recorded in genotype COR-01 followed by COR-06 (2.97 cm) and COR-03 (2.95 cm). Maximum leaf width recorded in genotype COR-25 (3.66 cm) followed by COR-22 (3.51 cm), COR-10 (3.40 cm) and COR-06 (3.37cm). Maximum petiole length recorded in genotype COR-14 (11.31 cm) followed by COR-20 (9.60 cm) and COR-09 (9.60 cm). Maximum root length was recorded in genotype COR-03 (10.35 cm), followed by COR-09 (10.29 cm). Maximum root weight recoded in genotype COR-01 (0.76 g) followed by COR-07 (0.73 g), COR-03 (0.69 g), COR-25 (0.68 g) and COR-19 (0.64 g). Maximum plant fresh weight recorded in genotypes COR-07 (10.76 g) followed by COR-22 (9.85 g) and COR-21 (9.55 g). Maximum leaf weight 4.38 g was recorded in genotype COR-15 followed by COR-22 (4.14 g), COR-02 (3.84 g) and COR-11 (3.72 g). Maximum leaf stem ratio 5.87 was recorded in genotype COR-15 followed by COR-28 (1.81), COR-23 (1.61) and COR-26 (1.21). Maximum fresh stem weight 6.37 g was recorded in genotype COR-07 followed by COR-21 (5.33 g) and COR-22 (5.16 g). Maximum dry leaf weight recorded in genotype COR-02 (0.64 g) followed by COR-15 (0.63 g) and COR-22 (0.61 g). Maximum dry stem weight 0.56 g was recorded in genotype COR-07, followed by COR-01 (0.50 g), COR-22 (0.49 g), COR-21 (0.47 g) and COR-25 (0.47 g). Maximum dry plant weight 1.11 g was recorded in genotype COR-07, followed by COR-22 (1.10 g), COR-21 (1.09 g) and COR-01(1.08 g).

Maximum foliage yield q per ha 181.36 q/ha was recorded in genotype COR-07 followed by COR-22 (166.0 q/ha), COR-21 (160.99 q/ha) and COR-11 (148.21 q/ha). Maximum fiber content recorded in genotype COR-11 (8.14 %) followed by COR-27 (7.90 %), COR-08 (7.61%), COR-19 (7.60 %), COR-02 (7.50 %), COR-03 (7.50%) and COR-21 (7.40 %). Maximum dry matter percentage found in COR-12 (14.10 %) followed by COR-23 (13.26 %), COR-02 (12.87 %) and COR-01 (12.79 %).Maximum K content recorded in genotype COR-20 (1936.6 mg) followed by

COR-06 (1746.6 mg), COR-21 (1620 mg), COR-22 (1423.3 mg), and COR-25 (1420 mg). Maximum Ca content recorded in genotype COR-07 (4800.00 mg) followed by COR-10 (4386.6 mg), COR-20 (3296.6 mg) and COR-21 (3193.3 mg).

The highest genotypic and phenotypic coefficient of variation was recorded for leaf stem ratio (90.48 and 92.40 %), dry stem weight (43.86 and 47.11 %), root weight (41.97 and 44.12 %), fresh stem weight (41.94 and 45.81 %), foliage yield kg per plot (36.37 and 38.79 %), plant fresh weight (36.25 and 38.66 %), foliage yield q per ha (36.23 and 38.64 %), dry plant weight (35.82 and 38.56 %), fresh leaf weight (35.61 and 38.33 %), K mg per100 g (34.48 and 34.74 %), dry leaf weight (34.07 and 39.65 %), stem base diameter (27.89 and 32.88 %), Ca mg per100 g (26.76 and 26.84 %) and number of leaves per plant (21.82 and 27.77 %). The phenotypic coefficients of variation were higher than the genotypic coefficient of variation. The highest heritability was recorded for the characters Ca mg per 100 g (99.42 %), K mg per100g (98.53 %), leaf stem ratio (95.9 %), root weight (90.5 %), plant fresh weight (87.92 %), foliage yield q per ha (87.91 %), foliage yield kg per plot (87.9 %), dry stem weight (86.7 %), fresh leaf weight (86.30 %), dry plant weight (86.3 %), fresh stem weight (83.81 %), dry leaf weight (73.82 %) and stem base diameter (72 %). Whereas, highest heritability coupled with highest genetic advance were observed for leaf stem ratio (182.40 %), dry stem weight (83.33 %), root weight (80.95 %), fresh stem weight (79 %), K mg per 100 g (70.51 %), foliage yield kg per plot (70.27 %), plant fresh weight (70.04 %), foliage yield q per ha (69.99 %), dry plant weight (69.01 %), fresh leaf weight (68.33 %), dry leaf weight (60.97 %), Ca mg per 100 g (54.98 %), stem base diameter (49.01 %), number of leaves per plant (35.32 %), fiber content (25.95 %) and petiole length (23.04 %). Hence, these characters might be improved by simple selection.

Foliage yield kg per plot showed positive and significant correlation with plant height, number of branches per plant, stem base diameter, number of leaves per plant, leaf length, leaf width, petiole length, root length, root weight, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight and dry plant weight at both genotypic and phenotypic level but with leaf length and petiole length only at genotpic level. It indicated that major emphasis should be given on these components for increasing the foliage yield kg per plot.

Path coefficient analysis revealed that fresh stem weight (0.767) and fresh leaf weight (0.500) and root weight (0.104) showed the highest positive and direct effect on foliage yield kg per plot whereas, negative direct effects on foliage yield kg per plot *viz.,* plant fresh weight (-0.287) for quantitative characters.

On the other hand, the positive and indirect effect of plant height, stem base diameter, number of leaves per plant, leaf length, leaf width, petiole length, root length, root weight, plant fresh weight, fresh leaf weight, fresh stem weight, dry leaf weight, dry stem weight and dry plant weight.

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 coriander.

In present investigation, COR- 07 was superior among all the genotype for most of the characters *viz.,* plant fresh weight, fresh stem weight, dry stem weight, dry plant weight, foliage yield q per ha., Ca mg /100 g, whereas COR-10 was superior among all the genotype for most of the characters *viz.*, number of leaves per plant, number of branches per plant, stem base diameter. These two genotypes can be utilized for further breeding programme for selection of variety in Chhattisgarh plains.

Similarly in case of foliage yield most of the genotypes were found to be better yielder in comparison to check variety (0.505 kg $plot^{-1}$) except few varieties (COR-12, COR-13, COR-14, COR-23, COR-24, COR-27) gave comparatively lower foliage yield.

Higher heritability estimates coupled with high genetic advance as percent of mean were observed for leaf stem ratio, dry stem weight, root weight, fresh stem weight, K mg per 100 g , foliage yield kg per plot, plant fresh weight, foliage yield q per ha , dry plant weight, fresh leaf weight, dry leaf weight, Ca mg per 100 g, stem base diameter, number of leaves per plant , fiber content and petiole length. Whereas, higher heritability estimates coupled with high genetic advance as percent of mean were observed for K and Ca indicating that the these characters are controlled by additive gene.

Correlation coefficient studies revealed that foliage yield kg per plot showed the highest positive and significant correlation with all the quantitative characters at both genotypic and phenotypic levels except leaf stem ratio.

The path analysis confined that positive direct effect of foliage yield kg per plot on fresh stem weight, fresh leaf weight, root weight, dry plant weight, leaf width, leaf stem ratio, plant height and petiole length should be considered simultaneously for amenability in foliage yield of coriander.

SUGGESTIONS FOR FUTURE RESEARCH WORK

On the basis of present study, the following suggestions could be made to plan out further improvement programme on coriander

1. The experiment may be conducted during different seasons also to find out whether the genotypes give same effect over season or not.
2. More number of genotypes may be collected from different untouched places of India and included in further studies.
3. In addition to present study large number of genotypes should be collected and evaluated to realize the actual genetic variability available in coriander for Chhattisgarh state.
4. There is need to screen the genotypes against biotic (disease and insect pests) and abiotic stresses (drought tolerant/ resistant).
5. In present investigation, COR- 07 was superior among all the genotype for most of the quantitative characters *viz.,* plant fresh weight, fresh stem weight, dry stem weight, dry plant weight, foliage yield q per ha., Ca content, whereas COR-10 was

superior among all the genotype for most of the characters *viz*., number of leaves per plant, number of branches per plant, stem base diameter can be utilized for multilocational trials in different location in Chhattisgarh.

6. Biochemical and nutritional analysis of Coriander should be done.

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Appendix-A .Table: Weekly meteorological observation during the crop growth period (September 1, 2016) to December 09, 2016

Standard week No.			Temperature		Relative Humidity (%)		Rain fall(mm)	Rainy days	Wind Velocity (Kmph)	Evapo-ration (mm)	Sun Shine (hours)
			Max(^{0}c)	Min(^{0}c)	I	II					
35		**27-02**	31.8	23.2	84	62	2.6	0	1.2	21.9	7.5
36	**Sep**	**03-09**	31.0	23.3	83.42	68.5	16.5	0	0.8	21.1	8.2
37		**10-16**	30.1	22.6	89.33	72.8	11.5	2	1.4	20.6	3.2
38		**17-23**	30.9	23.3	79.54	63.16	2.2	1	1.8	25.2	4.1
39		**24-30**	30.9	22.7	85.14	66.4	14.7	3	3.3	27.6	3.4
40	**Oct**	**01-07**	30.0	23.4	84.14	68.34	6.6	3	2.7	22.6	4.5
41		**08-14**	30.2	23.7	90.3	66.2	7.6	3	1.4	23.7	5.6
42		**15-21**	29.8	20.3	88.1	65.7	0	0	1.1	28.7	10.0
43		**22-28**	29.5	19.3	87	72.5	0	0	1.5	26.5	9.5
44		**29-04**	28.5	18.3	84	70.2	0	0	2.1	23.4	8.0
45	**Nov**	**05-11**	27.5	15.8	79.3	68	0	0	1.9	25.2	8.5
46		**12-18**	28.1	15.0	85.2	65.7	0	0	1.5	20.7	7.8
47		**19-25**	28.6	13.3	89.0	68.8	0	0	0.9	21.2	8.5
48		**26-02**	27.9	12.9	87.7	58.5	0	0	1.2	22.6	8.5
49	**Dec**	**03-09**	27.3	13.8	89.4	63.0	0	0	1.5	25.1	7.4

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