“EVALUATION OF CORIANDER (*Coriandrum sativum* L.) GERMPLASM FOR GROWTH AND YIELD CHARACTERS UNDER *TARAI* CONDITIONS OF UTTARAKHAND”

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By

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CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF CORIANDER (*Coriandrum sativum* L.) GERMPLASM FOR GROWTH AND YIELD CHARACTERS UNDER *TARAI* CONDITIONS OF UTTARAKHAND"**, submitted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** with major in **VEGETABLE SCIENCE** and minor in **GENETICS AND PLANT BREEDING,** of the College of Post Graduate Studies, G. B. Pant University of Agriculture and Technology, Pantnagar, is a record of *bona-fide* research carried out by **MR. SUNIL KUMAR, Id. No. 39359,** under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been acknowledged.

(**J.P. Singh**)
Chairman
Advisory committee

CERTIFICATE

We, the undersigned, members of the Advisory Committee of **MR. SUNIL KUMAR, Id. No. 39359**, a candidate for the degree of **DOCTOR OF PHILOSOPHY** in Agriculture with major in **VEGETABLE SCIENCE** and minor in **GENETICS AND PLANT BREEDING,** and agree that the thesis entitled **"EVALUATION OF CORIANDER (*Coriandrum sativum* L.) GERMPLASM FOR GROWTH AND YIELD CHARACTERS UNDER *TARAI* CONDITIONS OF UTTARAKHAND"** may be submitted in partial fulfillment of the requirements for the degree.

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Introduction

Coriander (*Coriandrum sativum* L, 2n=2x= 22) is a plant belonging to family Umbelliferae (Apiaceae) which is a large family consisting 300 genera and more than 3,000 species. It is an annual herb with thin stem, bushy appearance and 90-100 cm in height. Leaves are alternate, compound and petiole has a pair of stipules sheathing the stem base. The lower leaves are broad, pinnate and have long petioles with crenately lobed margins. The upper leaves are cut with linear lobes and are bi or tri- pinnate. The flowers are pink or white. The seeds are green round (botanically fruit) attain greyish brown colour at maturity

The coriander seed is used as spice in the preparation of curry powder, pickling spices, sauces and seasoning. They are used for flavouring pastry, cookies, cakes etc. It is one of the important ingredient in the manufacture of food flavourings, bakery products, meat, fish and salads, soda and syrups, candy preserves. It is also used for flavouring liquor, particularly gin. The young tender plant is used in preparing chutneys and sauces and the leaves are used for flavouring curries and soups.

The coriander leaves have a pleasant aroma. and medicinal purpose. Hundred gram coriander seeds contain moisture 6.3g, iron 0.006g, carbohydrate 24.0g, potassium 1.2g, protein 1.3g, vitamin A 175U, fat 19.6g, riboflavin 0.26mg, fibre 31.5g ,thiamine 0.23mg, mineral matter 5.3g, niacin 3.2mg, calcium0.8g vitamin C12.0mg, phosphorus 0.44g, volatile oil 0.3g , sodium 0.82g and non-volatile oil 22.0g **(Pruthi, 1979).**

Coriander is a annual herb originating from the Mediterranean region between the eastern Mediterranean and Caucasus mountains (**Vaidya 2000).** The whole plant and especially the unripe fruit, is characterized by a strong disagreeable odour.Its name has been derived from the Greek word “Koris” meaning bed bug because of unpleasant,(**Gruenwalded 2004).** All part of the plants is edible but the fresh leaves and the dried seeds are the most common parts used in cooking In the Indian traditional medicine, a coriander is used in disorders of digestive, respiratory and urinary system, as it has diaphoretic, diuretic, carminative and stimulant. In Iranian traditional medicine, coriander has been indicated for a number of medical problems such as dyspeptic complaints, loss of appetite, convulsion and insomnia **(Abidhusen *et al*., 2012)**, coriander has been reported to exhibit several pharmacological effects such as antioxidant activity **(Wangensteen *et al*., 2004**, **Meloa *et al*., 2005)**, anti-diabetic activity (**Matasyoh *et al.*, 2009)**, anti-mutagenic activity **(Cortes *et al.*, 2004)**, anthelmentic activity (**Eyuale *et al*.,2007)**, sedative-hypnotic activity (**Emamghoreishi *et al*., 2006)**, anticonvulsant activety **(Hosseinzadeh and Madaniford, 2005)**, diuretic activity **(Abderahim *et al*., 2008)**, cholesterol lowering activity **(Dhanopakiam *et al*., 2008)**, protective role against lead toxicity (**Leena *et al.* 2011)**, antifungal activity (**Filomena *et al.*,2011)**, anti-feeding activity (**Ravi *et al*., 2011)**, anticancer activity (**Chithra and Leelamma, 2000)**, hepatoprotective activity (**Pandey *et al*., 2011)**, anti-protozoal activity **(Fernanda *et al*.,2011),** anti-ulcer activity (**Almofleha *et al*., 2011**), post-coital anti-fertility activity (**Mansoon *et al.*, 1987)**, heavy metal detoxification **(Karunasagar *et al*., 2005).**

India is a major seed spices producer in the world because of its favourable climatic and soil conditions for growing spices and other tropical herbs, therefore it is known as the "Home of Spices or land of Spices". The great Vasco De Gama discovered sea route to India with main aim for spices trade. International organization for Standardization (ISO) has listed 109 spices worldwide. In India around 63 spices are grown including seed spices. Out of 63 spices, 20 are classified as seed spices **(Anwer *et.al*., 2011)**. Out of 20 seed spices 10 are mandate and main seed spices of the National Research Centre on Seed Spices (NRCSS) Ajmer, India. These are coriander, cumin, fennel, fenugreek, dill, ajowain, celery, anise, nigella and caraway. From north of India, Jammu and Kashmir to South, Kerala (Spices State of India)., in West, Gujarat and Rajasthan (Seed Spices Bowl) to Eastern States.

Coriander is commercially cultivated in India, Bulgaria, Iran, Canada, China, Morocco, Syria, Romania, Egypt, Russia, Japan and Pakistan. In India coriander occupies the pride of place among the seed spices. This spices crop is grown in India during year 2008-09 was of 537327 hectares with a production 471515 tonnes seed. Its commercial cultivation is limited to a few states, which include Rajasthan, Madhya Pradesh, Tamil Nadu, Karnataka, Andhra Pradesh and Bihar.

. The total production of coriander in uttarakhand during year 2006-07 was 3771 tonnes out of 79 hectares sown area. (**Spice Board of India, 2009**).

For getting higher production selection of promising genotypes in a breeding programme is based on various criteria, most importantly final crop yield and its quality. Relationships among yield and yield-contributing traits also play an important role (**Diz *et al.*, 1994; Guler *et al.*, 2001; Mohammadi *et al.*, 2003; Rabiei *et al.*, 2004**). Selection may also be based on other plant and/or crop features, such as, early maturity (**Ahmad *et al.*, 1991**), industrial crop yield (*e.g.* oil yield), (**Baye & Becker 2005**), crop resistance (**Bridge, 2000 and Singh *et al.*, 2004**) and yield quality features (**Gravois 1998; Topal *et al.*, 2004**). Whatever criteria are used, there is always a final trait (seed yield) or several final traits (seed yield and quality) to which the most attention is paid.

To detect traits having influence on a final trait, *i.e.*, seed yield, path analysis is commonly applied. However, identifying traits determining yield is just the first step of a study; ultimately it is important to select genotypes that deliver maximum yield through optimizing yield-contributing traits. To group the genotypes and, in turn, to find the best group of the genotypes, cluster analysis (**Everitt *et al.*, 2001; Fraley and Raftery 1998**) may be applied.

The correlation gives the idea about the extent of association existing between yield and yield components. Moreover, the information related to the nature and extent of association among various yield attributes and direct and indirect influence of each component traits on the yield could prove helpful in formulating effective breeding strategy. Further, path analysis explores the relative contribution of both direct and indirect effects of yield components on the yield. **Wright (1921)** gave the theory of path coefficient for statistical analysis of cause and effects, which gives a critical examination of specific forces acting to produce correlation. Thus, it becomes imperative to get information on the nature and magnitude of association between different yield components and to resolve and quantify their mode of contribution towards yield. Principal component analysis (PCA) is a powerful tool for reducing a number of observed variables into a smaller number of artificial variables that account for most of the variance in the data set. It is particularly useful when we need a data reduction procedure that makes no assumptions concerning an underlying causal structure that is responsible for co-variation in the data.

Germplasm is a vital source in generating new plant types having desirable traits that help in increasing crop production with quality and thus improve the level of human nutrition. In order to maintain, evaluate and utilize germplasm efficiently and effectively, it is important to investigate the extent of genetic diversity, it contains (**Smith and Smith, 1989**). Keeping the facts in the view, the present investigation has been proposed under *Tarai* condition of Uttarakhand with the following objectives:

1. To evaluate the extent of genetic variability.
2. To study the nature and magnitude of association between different characters.
3. To identify the germplasm lines which may serve as potent donor for yield and quality characters.

Review of Literature

Chapter 2 REVIEW OF LITERATURE

In this chapter an attempt has been made to review the relevant literatures under the following sub-heads:

2.1 Genetic variability

2.2 Correlation and path-coefficient studies

2.3 Multivariate and cluster analysis for identification of superior germplasm lines.

2.1 Genetic variability

Sharma and Sharma (1989) studied of 200 lines of coriander (*Coriandrum sativum* L.) showed significant variability for plant height, branches per plant, days to flowering and maturity, umbels and umbellets per plant, grains per umbellet, 1000-grain weight, straw and grains yield per plant. The heritability estimate was high for 1000-grain weight, days to flowering and maturity, and low for umbels per plant, umbellets per plant, and grains yield per plant. Grains yield per plant had positive and significant correlation with plant height per plant, number of branches per plant , number of umbels per plant, and number of umbellets per plant, grains per umbellate, and straw yield per plant. Path coefficient analysis revealed that umbellets per plant. 1000-grain weight, and branches per plant were the most important characters for selection of high yielding genotypes, as they had direct positive effect as well as positive (except 1000-grain weight) association with grain yield per plant.

Shridhar *et al.* (1990) studied on genetic variability, heritability and genetic advance is derived from data on 13 characters in 19 indigenous and exotic genotypes grown in 1988-89. Considerable variation was noted for number of leaves, secondary branches, fresh weight of plant, days to 50% flowering, 1000-seed weight and seed yield per plant

Megeji and Korla (2002) evaluated 30 genotypes of coriander in a field experiment conducted in Solan, Himachal Pradesh, India. 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-seed weight, followed by germination per cent and seed vigour. Leaf yield, 1000-seed weight, germination per cent and seed vigour recorded high genetic advance

Kalra *et al*. (2003) studied the 120 Indian accessions of coriander (C. sativum) and these were screened under late planting conditions in Lucknow, Uttar Pradesh, India during 1998-99 for time taken before flowering and fruit maturity, seed yield, seed size, essential oil content of seeds, oil yield and susceptibility to powdery mildew and stem gall diseases. High levels of variability were observed for all the characters. In the same study, they found that a negative correlation between seed yield, and essential oil content and susceptibility to stem gall disease, and a significant positive relationship between days to flower and days to maturity, oil yield and late maturity. One of the accessions - CIMAP 2053 - was early maturing, high seed-yielding, had large fruits and exhibits a fair degree of tolerance to powdery mildew and stem gall diseases. The accession CIMAP 2096 was early maturing with a high degree of tolerance to major diseases and seeds rich in essential oil. It was concluded that these accessions would be suitable for cultivation under late sown conditions in Indo Gangetic plains for higher yield of seeds and essential oil.

Rajput and Singh (2003) studied the 20 genetically diverse genotypes of coriander during rabi 2001-02 in Jobner, Rajasthan, India. for genetic variability for 7 characters days to flowering , plant height, branches per plant, umbels per plant, umbellets per umbel, seeds per umbel and seed yield. In the same study estimates of genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance were recorded for seed yield, umbels per plant, seeds 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 (reciprocal recurrent selection) for developing a high-yielding cultivar with other desirable characters.

Shah *et al*. (2003) studied 20 *Coriander. sativum* cultivars grown in Udaipur, Rajasthan, India during the rabi season of 2000-2001 under 3 environments: E1 (early sowing; 23 October), E2 (optimum sowing; 4 November) and E3 (late sowing; 16 November).The genetic variation and correlation analyses for 11 traits were studied . The genotype x environment interaction was significant for days to flowering, plant height, 1000-seed weight, harvest index and oil content. The phenotypic coefficient of variation was generally higher than the genotypic coefficient of variation. High estimates of heritability were recorded for oil content, 1000-seed weight, number of days to flowering, number of days to maturity and plant height. Higher magnitude of genetic gain was recorded for oil content, 1000-seed weight, plant height, number of umbels per plant and seed yield per plant. Oil content, 1000-seed weight, plant height and days to flowering were characterized by high heritability coupled with high genetic gain. At the genotypic and phenotypic levels, 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 under all the three environments. The number of primary branches per plant and plant height was positively associated with seed yield under E2 only. The number of primary branches and number of umbels per plant had a negative association with seed yield. The significant positive direct effect on seed yield was exhibited by the 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.

Singh and Shah (2003) evaluated 20 genetically different genotypes of coriander for their stability with respect to their seed yield, its contributing traits and oil content. The genotypes were evaluated in 3 environments .The environments differed significantly as revealed by significant mean square due to environment, for all the traits studied. The genotype x environment interactions were significant for days to flowering, plant height, 1000-seed weight, harvest index and oil content. Whereas, non-significant mean square genotype x environment interaction for remaining traits showed linear response of genotypes to varying environments. Both linear and non-linear interactions were significant for plant height, 1000-seed weight, harvest index and oil content, whereas for seed yield only linear component was significant. The genotypes with good yield potential, average plant height and medium maturity were G.Cori-1, RCr-20, UD-262, RCr-446, UD-744, CS-2, RCr-41 and G.Cori-2 these germplasm suited for favourable environments, while Patan Mandi-1 and UD-447 with regression coefficient <1.0 were suitable for a low yielding environment.

Patel *et al.* (2008) carried out variability analysis for 15 characters in 36 diverse genotypes of fennel (*Foeniculum vulgare*) at Jagudan (Gujarat) which revealed highly significant differences among genotypes for all the characters studied. High genotypic and phenotypic variances were observed for days to 50 per cent flowering, days to 50 per cent maturity, plant height, plant height up to main umbel, total branches per plant, seeds per umbel and seed yield per plant. The highest genotypic coefficient of variation was observed for volatile oil content in seed followed by total branches per plant and number of seeds per main umbel. Heritability estimates were high for seed yield per plant, days to 50 per cent flowering, number of primary branches per plant, total branches per plant, test weight and volatile oil content. High genetic advance as per cent of mean was recorded for seed yield per plant, days to 50 per cent flowering, primary branches per plant, total branches per plant, effective umbels per plant, number of umbellate per umbel, number of seeds per main umbel, test weight and volatile oil content, suggesting that phenotypic selection for these traits would be effective. Overall, it is suggested that for improving yield in fennel, more emphasis should be given to plant height, primary branches per plant, total branches per plant and effective umbels per plant.

Selvarajan *et al.(*2008) Evaluated nine genotypes of coriander (*Coriandrum sativum* L.), i.e. CS 97, CS 102 and CS 123 from Jobner (Rajasthan, India); CS 12 and CS 203 from Coimbatore (Tamil Nadu, India); and CS 8, CS 101, CS 208 from Hissar (Haryana, India), were evaluated to identify the suitable types for cultivation in Tamil Nadu under irrigated conditions. The results of the pooled analysis of the 3-year (1998-2000) data indicated that CS 12 was the best with the highest yield of 579.3 kg per ha, followed by CS 102, recording yield of 561.0 kg per ha. The increase in yield for CS 12 was 10 per cent over the control cultivar CO3, which recorded yield of 529.6 kg per ha.

Bhagat *et al.* (2010) evaluated 13 genotype of coriander received from various centres under AICRP on spices. The experiment was laid in randomized block design with three replications. The ancillary data with yield were observed and recorded. Among the entries, maximum yield was recorded in COr-31 (950.35 kg/ha) followed by COr-28 (872.57 kg/ha) and COr-32 (865.63 kg/ha).

Bhagat *et al.* (2010) studied 14 genotype of fenugreek obtained from different coordinated centres of AICRP on spices during Rabi 2009 in randomized block design with 10 blocks and three replications. Data on plant height, number of pods per plant, seeds per pods, yield per plot and yield kg per ha were recorded. Among the entries, FGK-27 recorded maximum seed yield (618.06 kg per ha) followed by FGK-34 (375.00 kg per ha) and FGK-37 (348.61 kg per ha).

Meena *et al.* (2010) studied 13 diverse varieties of fennel (*Foeniculum vulgare* Mill.) at Ajmer experiment during 2006-08 on nature and variability with released varieties of fennel for yield and yield attributes character . Analysis of variability was carried out for 12 characters in showed highly significant differences among varieties for all the characters. High genotypic and phenotypic variances were observed for umbels per plant, umbellates per umbels and seed yield per plant. The highest genotypic coefficient of variation was observed for yield per plot, followed by umbels per plant , umbellate per umbel and test weight . High genetic advances as per cent of mean was recorded for seed yield per plot, umbels per plant, umbellates per umbel, test weight, number of branches per plant, angle of primary branche, seed per umbels and plant height suggesting that phenotypic selection for these traits would be effective.

Prajapati *et al.* (2010) evaluated 43 germplasm lines of Ajowain (*Trachyspermum ammi*) along with released varieties collected from different districts of Gujarat and studied eight quantitative and one qualitative traits during Rabi 2008-09. Wide variability existed among genotypes for all morphological and economic traits. Days to 50 per cent flowering, days to maturity, plant height, number of umbels, number of umbellates, number of seeds, 1000 seed weight and seed yield per plot are highly variable based upon range.

Prajapati *et al.* (2010) evaluated 50 germplasm of dill (*Anethum sowa* Kurtz) consisting released varieties and local entries, collected from different districts of Gujarat. The study was based on eight quantitative and two qualitative traits. Wide variability existed among the genotypes for all the morphological and economic traits. Days to 50 per cent flowering, days to maturity, plant height number of umbellates, number of seeds, 1000 -seed weight and yield per plot are highly variable based on the variance. The correlation coefficients of the grains yield and some of yield attributing character *viz.*, number of branches, number of umbels, number of umbellates and 1000-seed weight revealed that high positive correlation. Number of seeds showed high positive correlation with number of umbels and number of umbellats.

Shoba *et al.* (2010) studied 22 coriander accessions for drought tolerance at Tamil Nadu Agriculture University,Coimbatore . The study revealed that out of 22 genotypes evaluated under three phase vegetative phas, reproductive phase and non stress condition , the genotype CS-127 registered the highest plant height, higher root length and earliness in flowering irrespective of moisture stress at vegetative phase, reproductive phase and non-stressed condition. In case of total dry matter production, number of umbels per plant and number of umbellates were high in non-stress condition followed by stress during vegetative growth phase and stress during the reproductive phase, respectively. Whereas, in the case of seed yield, and harvest index, CS-127 registered the highest value under non-stressed condition followed by stress at reproductive growth phase and stress during the vegetative growth phase respectively.

2.2 Correlation and Path coefficient analysis

Yield in coriander, as in other crops is a very complex character and is dependent on many other traits. A study of correlation between different quantitative characters provides us with an idea of association that could be effectively utilized in selecting a better plant type in coriander breeding programme. Path coefficient analysis measures direct influence of a variable upon another and permits separation of correlation coefficient into component of direct and indirect effect. The studies done on these aspects are given below

Arumugam and Muthurkrishnan (1979) studied five agronomic traits in 42 lines selected from among 244, estimates of heritability and genetic advance were shown to be high for plant height and number of mericarps per plant. These characters together with number of umbellates per umbel were positively correlated with seed yield.

Suthanthirapandian *et al.(*1980) evaluated in 60 types from the germplasm collected from the Tamil Nadu Agriculture University Coimbatore. Height and number of umbels per plant showed wide variation. High heritability estimates were observed for all the characters studied, ranging from 66.48 per for number of primary branches to 84.93 per cent for yield per plant. Genetic advance was high for all characters except number of secondary umbels per umbel.

Rao *et al.* (1981) studied 52 varieties of coriander for the number of secondary branches, number of umbels per plant and number of fruits per umbel had high genotypic and phenotypic coefficients of variation. High heritability and high genetic advance were noticed for number of secondary branches and number of umbels per plant. Yield had a significant positive association with height and number of umbels per plant. Path analysis indicated that height, number of umbels per plant and seed weight had the most important direct effect on yield

Jindla *et al.*(1985) carry out and recorded the observation on days to flowering, plant height, umbels per plant, umbellate per umble, seeds per umblet and seed yield per plot. Plant height, umbels per plant and seeds per umblet exhibited high heritability and genetic advance. Almost all the characters studied were positively correlated with each other. Path-coefficient analysis indicated that days to flowering, plant height and umblets per umble were important characters in making selection for seed yield.

Bhandari and Gupta 1991 evaluated 200 genotypes of *Coriandrum sativum* L. exhibited genetic variation for plant height, primary branches per plant and effective branches per plant, days to flowering and maturity, umbels and umbellates per plant, grains per umbellates, 1000 seed weight, straw yield and grain yield per plant and harvest index. Heritability estimates were high for days to flowering, 1000 seed weight and days to maturity; moderate for plant height, straw yield, umbels per plant, umbellate per plant and number of primary branches per plant and low for harvest index, effective branches, grain yield per plant and grains yield per umbellate. Phenotypic correlations of grain yield per plant were highly significant and positive with umbellate per plant, umbels per plant, number of effective branches per plant , straw yield per plant, number of primary branches per plant, plant high per plant, number of grains per umbellate and harvest index. Maximum direct contribution to grain yield per plant was made by umbellate per plant, followed by straw yield per plant, umbels per plant and grains per umbellate, Umbellate per plant made sizeable indirect effect via straw yield per plant. Straw yield per plant made sizeable indirect contribution via umbellate per plant.

Srivastava *et al.*(2000) studied path coefficient analysis for 40 genotypes of coriander to determine the direct and indirect effects on seed yield of plant height, number of primary branches, number of secondary branches, days to flowering, days to maturity, number of umbels, number of umbellate per umbel number of seed per plant.

Tripathi *et al.* (2000) studied forty genotypes of coriander including controls and reported phenotypic and genotypic coefficient of variations (PCV, GCV), heritability, genetic advance (GA) and correlation coefficients for 10 matric traits. High estimates of PCV, GCV, heritability and GA indicated 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 umbellets per umbel, primary branches per plant and plant height. 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, number of umbellates per umbel and number of seeds per umbel, being negatively correlated with yield were less important.

Gurbuz (2001) studied correlation and path analysis among yield components in 25 winter resistant lines of coriander (*Coriander. sativum*). The highest correlations were found between single plant yield and single plant weight, and number of branches with seeds yield. Path analysis indicated the highest direct and positive effect of single plant weight on single plant yield. Plant height had the highest negative effect on single plant yield.

Choudhary and Ramkrishna (2003) carried out mutagenic studies on polygenic variation for yield and yield components (plant height, number of primary branches per plant, number of umbels per plant, number of umbellets per plant, 1000-seed weight, seed set per umbel and number of seeds per umbel was studied in the M_4 progenies of 3 *Coriander sativum* cultivars (RCr-41, RCr-436 and RCr-20). The M_2 progenies were developed through intermating the progenies of the M_2 and M_2 generations. However, only the M_2 progenies recording higher yields that their parents were advanced to the M_4 generation without evaluating the M_3 generation. A total of

63, 64 and 23 M_4 progenies were obtained from RCr-41, RCr-436 and RCr-20, respectively. The between-progeny component of the genetic variance was significant, whereas the within-progeny component of the genetic variance was not significant for all the traits. For yield per plant, none of the progenies of RCr-20 was superior to their parent. However, 1 progeny of RCr-41 and 8 progenies of RCr-436 were superior in 5 of the 7 traits. Most of the progenies of RCr-20 and RCr-41 had undergone inbreeding depression, whereas those of RCr-436 frequently out yielded the control. In RCr-436, the parent and M_4 progenies showed high coefficients of variation for yield per plant and number of umbels per plant.

Jain *et al.* (2003) studied correlation and path analyses for seed yield and yield components number of days to 50 per cent 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 *(Coriandrum sativum)* and 7 controls (selected from the germplasm collection maintained in Jobner, Rajasthan, India) grown during the rabi season of 2001. Seed yield was positively and significantly correlated with all the traits except number of days to 50% flowering. Total plant height was positively associated with number of umbels per plant, height up to the base of the main umbel, number of branches per plant, number of umbellets per umbel, number of seeds per umbel, and 1000-seed weight. Path analysis revealed that total plant height had the greatest positive direct effect on seed yield, followed by number of umbels per plant and 1000-seed weight. The number of days to 50 per plant flowering had a significant negative correlation with seed yield. The results suggest that selection for greater total plant height, number of umbels per plant and 1000-seed weight, earliness, and less height up to the base of the main umbel will be effective for the improvement of the seed yield of coriander.

Davila *et al*. (2004) evaluated 4 genotypes of vegetable coriander under 5 environments in Coahuila, Mexico with an objective to generate models of prediction of flowering using regression, correlation and path analysis. The results showed that the methodologies utilized had capacity to generate models with a high predictive value for each environment of production. The models derived from the variables leaf area at

24 days after sowing , dry weight at 38 days after sowing , relative rate of leaf area at 24 days after sowing , relative rate of leaf growth at 52 days after sowing and duration of leaf area at 38 days after sowing successfully estimated the days to flowering in coriander

Singh *et al.* (2008) studied of 70 germplasm lines of coriander *(Coriandrum sativum L.)* grown on sodic soil for variability, heritability and correlation coefficients of seed yield and its component characters. A wide range of variability was noticed for plant height, branches per plant, umbels per plant, seeds per umbel and seed yield. Ten genotypes were identified more promising for sodic soil yielding above 30 g seed per plant. The high heritability coupled with high genetic advance and coefficient of variability was for plant height, inter-nodal distance, seed yield per plant, test weight and umbels per plant. Branches per plant, leaves per plant, umbels per plant and seeds per umbel exhibited positively significant genotypic correlation among themselves and all were positively and significantly associated with seed 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. Considering the direct and indirect selection parameters of major contributors a plant ideotype has been discussed to enhance seed yield on one hand and leafy vegetable on the other.

Datta (2006) studied of 15 coriander genotypes for Correlation coefficients of different growth and yield attributing characters with respect to yield revealed that primary branches per plant, secondary branches per plant, umbellate per umbel and seeds per umbel were positively and significantly correlated with yield.

Singh *et al*. (2006) evaluated of 360 lines of coriander (*Coriandrum sativum* L.) at Jobnor (Rajasthan) indicated high variability for seed yield (22.2%), umbels per plant·, (28.65%) and seeds umbel' (21.63%) and low variability for days to 50 per cent flowering (12.39%) and umbellates per umbel" (13.30%). High broad sense heritability (91.94%) and genetic advance (56.55%) were obtained for umbels per plant and seeds per umbels. Correlation and path coefficient analysis indicated that umbels per plant and branches per plant were the most important traits as they exerted positive direct effect on seed yield**.**

Singh *et al.* (2011) evaluation on nine genotypes namely 2007, 8918, 2002, 9903, 9106, 9807, 2015, 2108 (germplasm lines) including check variety Azad Dhania-1 of coriander (*Coriandrum sativum* L.). The materials were evaluated in an augmented Randomized Block Design with three replications during the rabi season of 2009–10. Efforts have been made to study the association of component traits with seed yield. It came into account that seed yield was significantly and positively correlated with its component characters like the number of primary branches per plant (rg = 0.750** and rp = 0.581**), number of secondary branches per plant (rg = 0.471* and rp = 0.431*), number of umbels per plant (rg = 0.932** and rp = 0.801**), number of umbellates per plant (rg = 0.806** and rp = 573**), number of seeds per umbels (rg = 667** and rp = 0.569**) and umbel diameter (rg = 851** and rp = 0.703**) both at the genotypic and phenotypic levels. Thus, the data revealed that the highest positive correlation (0.932) was appeared between number of umbels per plant and seeds yield (gm) whereas the lowest positive correlation (0.031) was expressed between number of umbellates per plant and 1000-seeds weight. Hence, the study will help the breeder to know the degree of association between traits, which can be used for crop improvement through selection of component traits.

2.3 Multivariate and cluster analysis for identification of superior germplasm lines.

Principal component analysis is appropriate when you have obtained measures on a number of observed variables and wish to develop a smaller number of artificial variables (called principal components) that will account for most of the variance in the observed variables. The principal components may be used as predictor or criterion variables in subsequent analyses

Principal component analysis is a variable reduction procedure. It is useful when you have obtained data on a number of variables (possibly a large number of variables), and believe that there is some redundancy in those variables. In this case, redundancy means that some of the variables are correlated with one another, possibly because they are measuring the same construct. Because of this redundancy, you believe that it should be possible to reduce the observed variables into a smaller number of principal components (artificial variables) that will account for most of the variance in the observed variables.

Patel ***et al*****. 2000** studied of Forty eight genotypes of (*Coriandrum sativum* L.) were collected from different villages of an important and major coriander growing district-Guna (Madhya Pradesh). Data were recorded on 10 different characters. D^2 values between pairs of genotypes ranged from 2.50 to 96.96. By using D^2 analysis the genotypes were grouped into nine clusters. The clustering was at random and without any relationship between genetic diversity and geographic diversity. Seed yield per plant had highest contribution towards genetic divergence followed by secondary branches and umbellets per plant

Ali ***et al.*** **(2000)** evaluated twenty genotypes of coriander grown for three consecutive seasons. The pooled data for yield and its attributes were subjected to study the genetic divergence using Mahalanobis D^2 statistics. Twenty genotypes were classified into seven clusters. The cluster I contained the maximum of 13 genotypes belonging to different geographical origins. Cluster II contained two genotypes. The clusters III, IV, V, VI and VII contained one genotype each. Genotypes CS-193 and Tikamgarh Local were quite divergent and appeared promising for further improvement.

Srivastava ***et al*****.(2000)** studied 40 genotypes of coriander was subjected to multivariate analysis using D^2 statistics. The characters studied were plant height, primary branches, secondary branches, days to flowering, days to maturity, number of umbel, 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, umbellate per umbel and 1000-seed weight. The 40 genotypes were grouped into four clusters depending on similarities of their D^2 values. Cluster number I had 12 genotypes, III retained 11. Cluster numbers II and IV captured 10 and 7 genotypes. The inter-cluster D^2 values ranged from 0.62 to 30.7, suggesting considerable diversity among the groups of the genotypes. Based on cluster means, characters such as days to flowering, days to maturity and number of secondary branches were major factors of differentiation among genotypes, which may be taken into account while selecting parents for hybridization programme. The clustering pattern of strains did not follow the geographical distribution exactly.

Ravi *et al.* (2007) studied of coriander (*Coriandrum sativum* L.) seeds from eight regions of India, labelled as S1 to S8 were examined for their volatile constitutents by gas chromatography-mass spectroscopy (GC-MS). GC-olfactometry (GC-O) was carried out for major compounds and odour profiling was done by trained panelists. Essential oil content of coriander samples ranged from 0.18 to 0.39%. The GC-MS analysis revealed presence of 30 compounds in coriander oil and around 98% of the compounds were identified in all the samples. Linalool which has floral and pleasant odour notes was the major compound (56.71-75.14%) in the essential oil, but the variation in the linalool content did not significantly affect the pleasantness of samples as perceived by the panelists. Higher a-pinene content of S7 and S8 could be related to the higher turpentine note. Sweet and rose-like odour notes of S1 could be due to occurrence of higher levels of geranyl acetate and lemonol. The odour profiling depicted the overall odour perceived, while the GC-O represented the odour notes of specific volatile compounds of coriander. Principal component analysis showed that samples S7 and S8 loaded with a-pinene, myrcene and undecanal. The results of GCO, sensory and PCA indicated possible association of major compounds with the intensity of characteristic odour notes perceived by the trained panel. Electronic nose pattern matching further complimented sensory and GC-MS results by showing segregation of samples. The study provides description of a few aroma notes in the coriander essential oil and the possibility of discriminating the aroma by sensory and instrumental methods.

Beemnet *et al.*(2011) studied the genetic divergence among 49 Ethiopian coriander *(Coriandrum sativum L.)* accessions employing Mahalanobi's distance (D^2) analysis based on 15 characters. The accessions were grouped in to eight clusters. Cluster II and III were the largest each with 12 accessions, followed by clusters I and V each consisting of seven accessions. The highest inter-cluster distance (480.5) was observed between clusters I and VIII, followed by clusters V and VIII (462.2), and then clusters II and VIII (336.1). Hence, crossing between accessions included in these clusters may give high heterotic response, and thereby better sergeants. Maximum contribution toward total genetic divergence was possessed by 1000 seed weight (15.67%), followed by basal leaf number (13.48%), plant height (10.29%), seeds umbellet-1 (9.81%) and umbel number plant-1 (7.84%). Based on means of all characters, accessions in clusters III, VII and VIII could be regarded as useful sources of genes for yield and its components, and the accessions from these clusters, therefore, could be used in improvement programmes to develop desirable types in coriander.

Singh *et al*. (2005) evaluation of Seventy germplasm lines of coriander (*Coriandrum sativum* L.) of diverse eco-geographical origin were undertaken in present investigation to determine the genetic divergence following multivariate and canonical analysis for seed yield and its 9 component traits. The 70 genotypes were grouped into 9 clusters depending upon the genetic architecture of genotypes and characters uniformity and confirmed by canonical analysis. Seventy percent of total genotypes (49/70) were grouped in 4 clusters (V, VI, VIII and IX), while apparent diversity was noticed for 30 percent genotypes (21/70) that diverged into 5 clusters (I, II, III, IV, and VII). The maximum inter cluster distance was between I and IV (96.20) followed by III and IV (91.13) and I and VII (87.15). The cluster VI was very unique having genotypes of high mean values for most of the component traits. The cluster VII had highest seeds per umbels (35.3 ± 2.24), and leaves per plant (12.93 ± 0.55), earliest flowering (65.05 ± 1.30) and moderately high mean values for other characters.

Marangoni and Moura, 2011 The descriptive terminology and sensory prolife of four samples of Italian salami were determined using a methodology based on the Quantitative Descriptive Analysis (QDA). A sensory panel consensually defined sensory descriptors, their respective reference materials, and the descriptive evaluation ballot. Twelve individuals were selected as judges and properly trained. They used the following criteria: discriminating power, reproducibility, and individual consensus. Twelve descriptors were determined showing similarities and differences among the Italian salami samples. Each descriptor was evaluated using a 10 cm non-structured scale. The data were analyzed by ANOVA, Tukey test, and the Principal Component Analysis (PCA). The salami with coriander essential oil (T_3) had lower rancid taste and rancid odor, whereas the control (T_1) showed high values of these sensory attributes. Regarding brightness, T_4 showed the best result. For the other attributes, T_1, T_2, T_3, and T_4 were similar.

Materials and Methods

Chapter- 3 MATERIALS AND METHODS

The present investigation on the "evaluation of coriander (*corianderum sativum* L.) germplasm for growth and yield characters under *Tarai* conditions of Uttarakhand" was conducted at Vegetable Research Centre of the G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand during *Rabi* season of 2009-10 and 2010-11. Geographically Pantnagar is situated at 29.5° N latitude, 79.3° E longitude and at an altitude of 243.84 meters above the mean sea level in sub-mountainous region of Shivalik hills, known as *Tarai*. The climate of this place is humid and subtropical and frost can be expected from last week of December to end of the January. The details of materials used and methodology followed in the present investigation are mentioned as follows.

3.1 Experimental materials

The experimental materials for present investigation comprised of 90 germplasm accessions collected from different locations as mentioned in the table3.1 with three checks. The detailed information about genotypes and checks have been prescribed in Table 3.1.

Table 3.1: List of 90 germplasm accessions and 3 checks under study and their source.

S. No.	Genotype	Source of seed
1.	Pant Haritima*	G.B.P.U.A.&T., Pantnagar
2.	DH-5(Hisar Sonali)*	HAU, Hissar
3.	ACr-728*	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
4.	ACr-1	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
5.	ACr-4	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
6.	ACr-10	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
7.	ACr-11	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
8.	ACr-13	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
9.	ACr-18	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
10.	ACr-19	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
11.	ACr-20	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
12.	ACr-23	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
13.	ACr-24	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
14.	ACr-25	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
15.	MKSM-1052	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)

16.	MKSM-1055	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
17.	MKSM-1056	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
18.	MKSM-1059	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
19.	MKSM-1065	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
20.	MKSM-1069	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
21.	MKSM-1072	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
22.	MKSM-1079	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
23.	MKSM-1084	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
24.	MKSM-1088	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
25.	MKSM-1091	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
26.	MKSM-1101	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
27.	MKSM-1104	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
28.	MKSM-1110	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
29.	MKSM-1111	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
30.	MKSM-1117	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
31.	MKSM-1119	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
32.	MKSM-1122	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
33.	MKSM-1125	N.R.C.S.S.Tabiji,Ajmer (Rajasthan)
34.	SC-1	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
35.	SC-4	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
36.	SC-6	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
37.	SC-8	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
38.	SC-9	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
39.	SC-10	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
40.	SC-11	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
41.	SC-12	Dr.Y.S.P. U. of Horticulture &Forestry solan (H.P.)
42.	UD-325	SKN College of Agriculture, Jobner (Rajasthan)
43.	UD-326	SKN College of Agriculture Jobner (Rajasthan)
44.	UD-373	SKN College of Agriculture Jobner (Rajasthan)
45.	UD-374	SKN College of Agriculture Jobner (Rajasthan)
46.	UD-590	SKN College of Agriculture Jobner (Rajasthan)
47.	UD-594	SKN College of Agriculture Jobner (Rajasthan)
48.	UD-601	SKN College of Agriculture Jobner (Rajasthan)
49.	UD-603	SKN College of Agriculture Jobner (Rajasthan)
50.	UD-605	SKN College of Agriculture Jobner (Rajasthan)
51.	UD-607	SKN College of Agriculture Jobner (Rajasthan)
52.	UD-609	SKN College of Agriculture Jobner (Rajasthan)
53.	UD-610	SKN College of Agriculture Jobner (Rajasthan)
54.	UD-615	SKN College of Agriculture Jobner (Rajasthan)
55.	UD-618	SKN College of Agriculture Jobner (Rajasthan)
56.	UD-620	SKN College of Agriculture Jobner (Rajasthan)
57.	UD-622	SKN College of Agriculture Jobner (Rajasthan)
58.	UD-623	SKN College of Agriculture Jobner (Rajasthan)
59.	UD-634	SKN College of Agriculture Jobner (Rajasthan)
60.	UD-635	SKN College of Agriculture Jobner (Rajasthan)

61.	UD-643	SKN College of Agriculture Jobner (Rajasthan)
62.	UD-684	SKN College of Agriculture Jobner (Rajasthan)
63.	UD-689	SKN College of Agriculture Jobner (Rajasthan)
64.	UD-699	SKN College of Agriculture Jobner (Rajasthan)
65.	UD-704	SKN College of Agriculture Jobner (Rajasthan)
66.	UD-711	SKN College of Agriculture Jobner (Rajasthan)
67.	UD-715	SKN College of Agriculture Jobner (Rajasthan)
68.	UD-716	SKN College of Agriculture Jobner (Rajasthan)
69.	UD-717	SKN College of Agriculture Jobner (Rajasthan)
70.	UD-718	SKN College of Agriculture Jobner (Rajasthan)
71.	UD-719	SKN College of Agriculture Jobner (Rajasthan)
72.	UD-720	SKN College of Agriculture Jobner (Rajasthan)
73.	UD-721	SKN College of Agriculture Jobner (Rajasthan)
74.	UD-722	SKN College of Agriculture Jobner (Rajasthan)
75.	UD-725	SKN College of Agriculture Jobner (Rajasthan)
76.	UD-727	SKN College of Agriculture Jobner (Rajasthan)
77.	UD-728	SKN College of Agriculture Jobner (Rajasthan)
78.	UD-730	SKN College of Agriculture Jobner (Rajasthan)
79.	UD-742	SKN College of Agriculture Jobner (Rajasthan)
80.	UD-743	SKN College of Agriculture Jobner (Rajasthan)
81.	UD-744	SKN College of Agriculture Jobner (Rajasthan)
82.	UD-745	SKN College of Agriculture Jobner (Rajasthan)
83.	UD-746	SKN College of Agriculture Jobner (Rajasthan)
84.	UD-747	SKN College of Agriculture Jobner (Rajasthan)
85.	UD-748	SKN College of Agriculture Jobner (Rajasthan)
86.	UD-750	SKN College of Agriculture Jobner (Rajasthan)
87.	UD-752	SKN College of Agriculture Jobner (Rajasthan)
88.	UD-753	SKN College of Agriculture Jobner (Rajasthan)
89.	UD-768	SKN College of Agriculture Jobner (Rajasthan)
90.	UD-772	SKN College of Agriculture Jobner (Rajasthan)
91.	UD-787	SKN College of Agriculture Jobner (Rajasthan)
92.	UD-788	SKN College of Agriculture Jobner (Rajasthan)
93.	UD-789	SKN College of Agriculture Jobner (Rajasthan)

* Use as check

3.2 Experimental Methods

3.2.1 Experimental design and layout plan

The experiment was laid out in Augented Block Design and suggested by Federer and Raghavarao (1975). The details of experimental plan are given below:

Total number of genotypes : 90

Number of checks : 3

Spacing : 30 X 45 cm

Row length	:	3.0 m
Number of genotypes per block	:	15
Number of blocks	:	6
Plot size	:	1.5 m^2

3.2.2 Field operations

All the standard agronomical package and practices are applied to raise a healthy crop of coriander in the tarai region of Uttarakhand.

3.3 Observation Recorded

All the observations were recorded on randomly selected five individual plants basis and averaged seed yield was taken per plot basis. Five plants per plot were selected randomly and tagged each genotype to record various observations as per details given below:

3.3.1 Days to 50 per cent flowering

It was recorded from the days of sowing till the days in which 50 per cent of the plants in the plot show flowering

3.3.2 Plant height upto main umbel (cm)

The height of the five randomly selected individual plants from each plot was recorded from ground level to main umbel of the plant with the help of a meter scale and averaged.

3.3.3 Plant height including main umbel (cm)

The height of the five randomly selected individual plants from each plot was recorded from ground level to shoot apex of the plant with the help of a meter scale and averaged.

3.3.4 Number of primary branches per plant

At full growth stage of the plant the number primary of branches originating from the main stem of randomly selected five individual plants and averaged.

3.3.5 Number of secondary branches per plant

At full growth stage of the plant the number secondary of branches originating from the all primary branches were counted in five randomly tagged plants and averaged.

3.3.6 Number of umbels per plant

At full growth stage of plant the number of umbels originating from all the branches were counted in five randomly tagged plants and averaged.

3.3.7 Number of umbellates per umbel

At full growth stage of plant number of umbellate present in all umbels of a plant were counted in five tagged plants and averaged.

3.3.8 Number of fruits per umbel

At full growth stage of plant number of fruits in an umbel was counted in five randomly tagged plant and average was taken.

3.3.9 Number of fruits per umbellat

At full growth stage of plant number of fruits in a umbellate was counted in five randomly tagged plant and averaged.

3.3.10 Seed yield per plot (g)

Weight of all plant seed in a plot to obtain seed yield per plot (g) was recorded

3.3.11 Seed yield per plant (g)

The tagged plants were harvested and threshed separately and seeds collected from individual plant weighed separately and averaged to get seed yield per plant in (g).

3.3.12 1000-seed weight (g)

1000 seeds from each accession were counted and weight was taken in grams.

3.3.13 Seed yield (kg per hectare)

The seed yield per plot was converted in to seed yield kg per ha by multiplying conversion factor is 6666.66.

3.4 Statistical Analysis

3.4.1 Analysis of variance

The analysis of variance for augented design was done by using method given by **Federer (1956) and Federer and Raghavarao (1975)**. For this purpose two way table of checks was prepared as under**:**

Checks	**Blocks**				**Total**	**Mean**
	1	**2**	**3**	**j**		
Pant Haritima	$X_{1.1}$	$X_{1.2}$	$X_{1.3}$	$X_{1.j}$	C_1	X_1
Hisar anand	$X_{2.1}$	$X_{2.2}$	$X_{2.3}$	$X_{2.j}$	C_2	X_2
ACr-728	$X_{3.1}$	$X_{3.2}$	$X_{3.3}$	$X_{3.j}$	C_3	X_3
Total	B_1	B_2	B_3	B_j	G	M

Where,

X_{ij} = Yield of the i^{th} check in the j^{th} block

B_j = ΣX_{ij} = Sum of all the checks in the j^{th} block

C_i = ΣX_{ij} = Sum of the all yield of the i^{th} check

G = ΣB_j = ΣC_i = Grand total of all check yields

X_i = C_i/b = Mean yield of the i^{th} check

M = ΣX_i = G/b = Sum of the check means

b = Number of block

c = Number of checks

Then an adjustment factor r_j for block effect is computed as follows:

r_j = $(1/c)\ (B_j\text{-}M)$

Thereafter a table is adjusted and actual yields of all the new selections were prepared as follows:

Selection block	**Yield observed**	**Adjusted yield**
1	Y_{1j}	Y_1
2	Y_{2j}	Y_2
.	.	.
.	.	.
.	.	.
V	Y_{vj}	$\hat{Y}v$

Where,

Y_{ij} = Yield of the i^{th} new selection in the j^{th} block

$\hat{Y}v$ = Y_{ij}-r_j = Adjusted yield of the i^{th} new selection (adjusted for block effect).

To obtain estimate of experimental error for computing least significant differences (LSD) and comparing mean, the analysis of variance table of check varieties was prepared as follows:

Source of variance	Degree of freedom	Sum of square	Mean sum of square
Block	(b-1)	SSB	MSB
Check	(c-1)	SSC	MSC
Error	(b-1)(c-1)	SSE	MSE
Total	(bc-1)	SST	MST

Where,

SSB = $(1/c)\ \Sigma_j B_j^2 - G^2/bc$

SSC = $(1/b)\ \Sigma_j C_i^2 - G^2/bc$

SST = $\Sigma_i \Sigma_j X_{ij}^2 - G^2/bc$

SSE = SST – SSB – SSC

MSB = SSB/(b-1)

MSC = SSC/(c-1)

MSE = SSE/ (b-1)(c-1)

Variance for different pair wise comparison

Variance was calculated as given below:

I. Difference between the mean of two check varieties $S_C^2 = 2MSE/b$

II. Difference between adjusted yield of two new selection in the same blocks $S_B^2 = 2\ MSE$

III. Difference between adjusted yield of two new selections in adjusted blocks $S_V^2 = 2\ MSE/(c+1)/c$

IV. Difference between adjusted yield of a two new selection and a check mean $S_{VC}^2 = MSE(b+1)(c+1)/bc$

Least significant difference(LSD) value

LSD's was computed using the variance, given below, in the following way:

1. For two check means = $t\sqrt{2MSE/b}$
2. For the adjusted yield of two genotypes in the same block = $t\sqrt{2MSE}$
3. For adjusted yield of two genotypes in different blocks = $t\ \sqrt{2\ MSE\ (C+1)/C}$

4. For an adjusted yield of genotypes against check mean = t √ MSE (b+1) (c+1) (c+1)/bc

For all LSD's the t value is the value at 5% level on (b-1)(c-1) degree of freedom.

The analysis gave adjusted values for all characters in each genotype. Further classificatory analysis was done on these adjusted values of variables.

Estimation of variability:

Mean, range, per cent of variation for different characters were worked out for all new selections.

Mean

Mean of the individual genotype was calculated as arithmetic average of the values of each character:

$$X = \sum^{n} \frac{X_i}{n}$$

where,

X = mean

X_i = value of the character of the i^{th} plant

n = number of plants

Range

This denotes the largest and the smallest value of the character in the material under investigation.

3.4.2 Correlation coefficients

The estimation of correlation coefficient is based on the variance and covariance of x and y variables. Correlation is ranged between +1 to –1. The intensity of relationship is measured by correlation coefficients (r). The formula for estimation of correlation coefficients given by **Searle (1961):**

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

Where,

r_{xy} = Correlation coefficient between x and y

Cov. (xy) = Covariance between x and y

Var. (x) = Variance of x

Var. (y) = Variance of y

Variance and covariance were calculated by the following formula:

$$\text{Var.}(x) = \frac{1}{n}\left[\sum x^2 - \frac{\left(\sum x\right)^2}{n}\right]$$

$$\text{Var.}(y) = \frac{1}{n}\left[\sum y^2 - \frac{\left(\sum y\right)^2}{n}\right]$$

$$\text{Cov.}(xy) = \frac{1}{n}\left[\sum xy - \frac{\left(\sum x\right)\left(\sum y\right)}{n}\right]$$

To test the significance of correlation coefficient the calculated t-value is compared with tabulated t-value on n-2 degree of freedom **(Snedecor and Cochran, 1967):**

$$t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

Where,

r = correlation coefficient and

n = number of observations

3.4.3 Path coefficients analysis

The path coefficient analysis of component traits with tuber yield was done by following method of **Dewey and Lu (1959)**. The direct and indirect effects were calculated by solving the following set of simultaneous equations:

Py_1	+	Py_2r_{12}	+	Py_3r_{13}	+	…………..	+	Py_nr_{1n}	=	ry_1
Py_1r_{12}	+	Py_2	+	Py_3r_{23}	+	…………..	+	Py_nr_{2n}	=	ry_2
-		-		-		-		-		-
-		-		-		-		-		-
-		-		-		-		-		-
Py_1r_{1n}	+	Py_2r_{2n}	+	Py_3r_{3n}	+	…………..	+	Py_n	=	ry_n

Where $Py_1, Py_2, Py_3 \ldots\ldots, Py_n$ are the direct path effects of 1, 2, 3………….., n variables on dependent variable 'y' and $r_{12}, r_{13}, r_{19} \ldots\ldots, r\ (r - 1)_n$ are the genotypic coefficient of correlation between various independent variables $ry_1, ry_2 \ldots\ldots, ry_n$ are the genotypic correlation coefficients of independent variables with dependent variable 'y' $Py_1r_{12}, Py_3r_{23} \ldots\ldots, Py_nr_{2n}$ are the indirect effects.

The variation in the independent variable, which remained undetermined by including all variables, was assumed to be due to variable(s) not included in the present investigation. The degree of determination (P^2yx) of such variable(s) on dependent variable was calculated as follows:

$$P^2yx = 1- (P^2y_1 + 2Py_1r_{12} + 2Py_1\,Py_3r_{13} \ldots\ldots + P^2y_2 + 2Py_2\,Py_3r_{23} + P^2y_3 + 2\,Py_3\,Py_4r_{34} \ldots\ldots + P^2y_n) \text{ and}$$

Residual effect (R^2) = $\sqrt{P^2yx}$

3.4.4 Principal Component Analysis (PCA)

The mean scores on fifty genotypes were subjected to ordination procedure by principal analysis.

The concept of principal component which is a multivariate technique, was developed by **Hotelling (1933)** after its original concept given by **Pearson (1901)** and later on its application to plant science was reviewed by **Sokal and Sheath (1963), Blackkith and Regent (1971).**

For the principal component analysis each genotype was identified on the basis of correlation matrix as a single point in a standardized multidimensional space. The axes of this space were principal components obtained from the original data as orthogonal transformation of the original variety. In this way each principal component becomes a linear combination of the varietal scores corresponding to the original variables.

The Euclidean distance between any two points represents the degree of similarity or dissimilarly between the two varieties whose score on the principal axes determines their respective position in the hyperspace. The Euclidean distance is a Pythagorean distance extended to multiple axes and consists of difference in scores of any two varieties on each of the principal axes retained.

If two varieties are closely related genetically, they are expected to occupy the same region in the hyperspace. The distance between them being small, if they are more distantly related they are genetically diverse. For calculating Euclidean distances, the first few components in reduced dimension were used that accounted for sufficient variation.

The statistical procedure used for principal component analysis has been described as follows:

Principal component are no scale invariant and the results depends on the units of measurements. To avoid such drawback of principal components, raw data was standardized in the following way:

$$xij = \frac{\left(x_{ij} - X_j\right)}{\sqrt{\sum_i^n = \left(x_{ij} - X_j\right)^2}}$$

X_{ij} is the observation on i^{th} genotypes for character 'j'.

Taking unit scatter and mean as zero the correlation matrix. R = (r_{ij}) was computed. The next requirement was to see if variation can be accounted for these scores by a smaller subset of independent basic dimensions, i.e., principal components. The number of non-zero principal component is equal to the rank of the correlation matrix. However, our aim of solution was to explain most of the variation of these variables by principal components.

The first step in the procedure was to compute successive powers of the correlation matrix. Starting with R, the values of RR = R^2, $R^2R^2 = R^4$, $R^4R^4 = R^8$ and so on, were computed until the element of the vector a' R^i and a' R^{2i} become proportional to each other. The vector a' can be any arbitrary vector and when a' R^i is proportional to a' R^{2i} is proportional to the largest latent vector of eigen vector. For more rapid convergence, it was best to have the elements by a' proportional to the row total of the correlation matrix.

$$R = (r_{ij})$$

$$R^2 = (r_{ij})(r_{ij})$$

$$a' R^2 = (a')(R^2)$$

$$= (a_1, a_2, \ldots\ldots a_p)$$

Where,

p = number of elements in the vector = number of variables

Now this vector can be standardized by dividing each element by the largest elements of the vector, say, a_1:

$$= \frac{a_1,\ a_2, \text{-------------------}\ ap}{a_1,\ a_2,}$$

$$=[a_1s',\ a_2s'\text{--------------------}a_ps]$$

Where, subscript s in all the elements represents standardization. Next step was to compute $R^4 = R^2R^2$

$$a'R^4 = (a')\ (R^4)$$

$$= (b_l, b_2 \ldots\ldots\ldots b_p)$$

$$= \frac{b_1,\ b_2, \text{----------------}\ bp}{b_1,\ b_2, \qquad b_1}$$

Standardized vector:

$$b = [b_1s', b_2s' \ldots\ldots\ldots b_ps]$$

Where,

a and b = Vector of coefficient

Next step was to compare this vector with the previous one for their agreement with each other. If they agree with each other upto third decimal place, next order of power is not computed, otherwise, next and successive order of power is computed until two successive vectors showed close agreement with each other.

The last vector, which was in close agreement with previous one, was converted into a latent vector (eigon vector) by diving each element by square root of sum of squares of the p elements.

$$\sqrt{(d_{1s})^2 + +(d_{2s})^2 + \cdots\cdots\cdots\cdots\cdots\cdots (d_{ps})^2}$$

$$\sqrt{\sum_{i=1}^{p}[(d_{1s})^2]}$$

Where,

d = standardized value thus latent vector (eigon vector) will be

$$\frac{\text{dis}}{\sqrt{\sum_{i=1}^{p}[(d_{1s})^2]}} \quad \frac{\text{dis}}{\sqrt{\sum_{i=1}^{p}[(d_{1s})^2]}} \text{-------------} \frac{\text{dis}}{\sqrt{\sum_{i=1}^{p}[(d_{1s})^2]}}$$

= (t_{11}, t_{12}……… t_{p1}) with restriction of unit length that is t^{o}'

$$t''_{ij}\, t_{ij} = \Sigma\, t_{ij}^{2} = 1$$

$$t_{ij} = \sum_{j=i}^{p} \text{tij}^2 = 1$$

Since Rt = λt

Or

$$[r_{11}, r_{12} \text{-----------------} r_{1p}] \begin{bmatrix} t_{11} \\ t_{21} \\ - \\ - \\ t_{p1} \end{bmatrix} = [t_{11}]\lambda$$

$$\lambda = [r_{11}, r_{12} \text{-----------------} r_{1p}] \begin{bmatrix} t_{11} \\ t_{21} \\ - \\ - \\ t_{p1} \end{bmatrix} = [t_{11}]\lambda$$

Where,

t = eigen vector of latent vector

A = eigen value of eigen root or latent root

This λ holds equally for all rows of R and is the largest latent root (eigen root or eigen value) of matrix (R- λ I) = 0 where, I = identity matrix. So that, the associated latent vector become (t_{11}, t_{21}……….t_{p1}). This latent vector is also the heightening vector for the largest principal component and its associated λ is equal to the variance of the largest first principal component.

Next step is to derive a second principal component that is orthogonal to the first and the variance of which is maximized. The first step in doing this is to calculate a residual correlation matrix Ii which reflects what is left of the variance and covariance terms of the original correlation matrix after the influence of the first principal component is subtracted out. Thus,

RS = T-tt'

Where,

RS = Residual correlation matrix

R = Original correlation matrix

A = latent root (eigen root or eigen value) corresponding to the largest first principal component)

t = latent (eigen) vector and

t' = transpose of t

To obtained second and then successive principal component, the same procedure when was used for first principal correlation matrix. As successive principal component are closer and closer to a null matrix. Thus the principal component analysis can be summarized as follows:

Variables	t_l	t_2	Eigen vector	tp
X_1	t_{11}	12	-----	t_{1p}
X_2	21	t	-----	2p
-	t	t_{22}	-----	t
-			-----	
-				
X_p	t_{pl}	t_{p2}		t_{pp}
Total				

Eigen value $\hat{\lambda}_1$ $\hat{\lambda}_2$ ------ $\hat{\lambda}_{p1}$ = sum of $\hat{\lambda}_{1}$------ $\hat{\lambda}_2$ =G

Per cent of sum $\frac{100\,\hat{\lambda}_1}{G}$ $\frac{100\,\hat{\lambda}_2}{G}$ $- - - - - - - - -$ $\frac{100\,\hat{\lambda}_{p1}}{G}$

Cumulative Per cent $\frac{100\,\hat{\lambda}_1}{G}$ $\left[\frac{100\hat{\lambda}_1+\hat{\lambda}_2}{G}\right]$ $- - - - - -$ $\left[\frac{100\hat{\lambda}_1+\hat{\lambda}_2 --------\hat{\lambda}_p}{G}\right]$

Now principal component of R may be described as follows. Let be a new variable then j[th] principal component can be defined as:

$y_j = \quad t_j\,[x\text{-}x\,]$

$= \quad t_{1j}\,[x_{11}\text{-}x_1] + \quad t_{2j}\,[x_{12}\text{-}x_2] +$ --------------------------- $t_{pj}[x_{1p}\text{-}x_p]$

$= \quad t_{1j}\,[x_{21}\text{-}x_1] + \quad t_{2j}\,[x_{22}\text{-}x_2] +$ --------------------------- $t_{pj}[x_{2p}\text{-}x_p]$

$= \quad t_{1j}\,[x_{n1}\text{-}x_1] + \quad t_{2j}\,[x_{n2}\text{-}x_2] +$ ------------------------- $t_{pj}[x_{np}\text{-}x_p]$

Where,

n = number of objects

p = number of variables

y_j = j^{th} principal component of R

t_j = eigen vector value of the j^{th} principal component

[x-x] = matrix of centered or mean deviated scores

$$\sum_{j-1}^{p} x_j = \sum \frac{\overline{x_{ij}}}{n}$$

Since these are ‘p’ non-zero eigon values of r, their, still remains to choose the appropriate solution. The variance of ‘y’ may be made arbitrarily large by suitable choice of the element t, therefore, it is conventional to norm t to unit length t’t = 1.

Maximum t’Rt, subject to t’t-1

Joining the constraint to the objective function with a langrange multiplier μ and differentiating the solution, t must satisfy the following

δ

δ

or,

[R-μt] = 0

Where,

t = one of the eigon vector of R

μ= associated eigon value

As found above Rt = μt, multiplying *from* the left by 't' then

T’Rt = μt’t= μ = var (Y)

Since t’t = 1 therefore, the vector of coefficients for Y is the eigen vector of R corresponding to the largest eigen value and this eigen value is itself equal to the variance of Y. The linear composite Y is called the first principal component and the linear composite formed by using the eigen vector corresponding to the j^{th} largest eigen value is called the j^{th} principal component.

The first principal has the largest variance of any linear combination of the variables represented in the data matrix, the second principal component has the largest variance of any linear combination orthogonal to the first principal component, the third has the largest variance of any linear combination to the first two and so fourth.

In particular, if A (L) is an PxL matrix whose columns are L eigen vector values, the L x n matrix of principal component, scores is Y (L) = A(L)’ X.

Where,

P = row vector = number of variables

L = column vector = eigen vector of largest eigen values in reduced dimension

X = original matrix

These scores on principal components axis were used in Euclidean D^2 statistics for computation of genetic distance in the principal component space.

$$d_{ij}^{2} = \sum_{i=1}^{t}(x_{ij} - x_{jk})^{2}$$

The corresponding individual genetic distance between each variety becomes a basis for clustering of variety with relative similarity within a cluster or relative dissimilarly between clusters. The basic aim to be finding out numerical discontinuity in data set by means of appropriate clustering method the non hierarchical clustering approach was followed.

3.4.5 Non-hierarchical cluster analysis

Non-hierarchical Euclidean cluster analysis described by **Beale (1969)** and elaborated by **Spark (1973)** was used to study the genetic divergence among genotypes. The principal component scores obtained from original variables were utilized for this analysis. According to **Beale (1969)** initially each observation is located to the closest cluster centre. The means of the cluster are then calculated and are taken to the new cluster centres. At the same times, the sum of squared deviation of the observations from their respective cluster centre is computed. The observation are then checked in turn to see if a shift to a different cluster centre results in a decrease in the total sum of squares. This assumes that $d_j^2 < dK^2$, where, d_j is the distance from the centre of cluster i.e. however, a more effective criterion involves reassigning the observation if of cluster i, is less than that from centre of cluster k, even when the cluster centre are simultaneously reposition that is when:

$$\frac{n_i}{n_i + 1} d_i^{2} < \frac{n_i}{nk + 1} d_k^{2}$$

Where, ni is the number of observation in cluster ‘i’

In delimiting cluster usually average among a subset of 'm' point is considered, not the individual i_2m (m-l) deviances. If the i^{th} variable on the j^{th} member is X_{ij} average of the means deviance of set of 'm' is as follows:

$$= \frac{1}{m(m-1)} \sum_{i=1}^{D} \sum_{j=1}^{M} \sum_{k=1}^{M} \left(x_{ij} - x_{kj}\right)^2$$

$$= \frac{1}{m(m-1)} \sum \sum_{i=1}^{p} \sum_{k=1}^{M} \left[\left(x_{ij} - x_{lj}\right) - \left(x_{ik} - x_i\right)\right]$$

Where, x_i is the mean of x_i over m members.

$$= \frac{1}{m(m-1)} \left[\sum_j \sum_k \left(x_{ij} - x_l\right) + \sum_j \sum_k (x_{ik} - x_i)^2 - 2 \sum_j \sum_k \left(x_{ij} - x_l\right)(x_{ik} - x_i) \right]$$

The cross product term vanishes and other two are equal:

$$\text{average devian } = \frac{1}{m(m-1)} \sum_{i \neq 1}^{m} \sum_{j=1}^{p} \left[x_{kj} - x_i\right]^2$$

Thus,

Now, instead of calculating 1/m (m-1) deviance, ‘m’ deviance from the centre of gravity is calculated.

Thus assumption in this method are that the Euclidean distances ‘D’ separating ‘n’ point in a ‘p’ dimensional space are proportional to the dissimilarities between the objects, and secondary, that no object belongs simultaneously to two clusters.

Initially, a given number of vector D of cluster centre are located in the ‘p’ space. The position of three centres can be chosen arbitrary of randomly, however, a good choice of initial cluster centres reduces the amount of computation to a considerable extent. To start with ‘n’ cases are allocated to a predator-mixed maximum number of clusters (c. max) according to the procedure suggested by **Beale (1969).** The residual sum of sequences RSS (c) for the solution involving ‘c’ clusters is calculated.

Then the number of cluster ‘c’ is reduced by 1 (unless c = min) and this procedure is repeated till ‘c’ max. is reached i.e. further reduction is negligibly small. For each step RSS (c) is calculated when RSS (c) values for ‘c’ max.., c min are available, these are used in a sequential ration test of the null hypothesis that the solution for ‘c’ cluster provides no better fit than the solution for the C_2 with $C_l > C_2$. This F ratio is calculated as:

$$F = \frac{RSS\ (c1) - RRS\ (c1)}{RRS\ (c1)} / \frac{(n - c1c2)2/\ p - 1}{n - c1c2}$$

With p (c_1-c_2) and p (n-c_1) df. The null hypothesis is rejected if this F exceeds the Table value of F.

For calculating the number of clusters by 1 till c min is reduced, Beale has suggested certain procedure instead of using Belays procedure for merging two clusters. **Doshi *et al.* (1981)** have adopted a simple procedure. When a solution is found for ‘c’ clusters “c” of new cluster are calculated. From this set of new cluster centre vectors, last vector is dropped and (c-l) vector are used as initial vector of cluster centres for arriving at (c-l) cluster. For determining the appropriate number of cluster F -test gives rough guide is exploratory analysis.

The classificatory analysis gave clusters of genotypes where similar types occur in one cluster. The solution provides classified genotypes. The cluster mean were graphically depicted in the form of bar diagram.

Results & Discussion

CHAPTER 4 RESULTS AND DISCUSSION

The present investigation was conducted on ninety genotypes and three check varieties of coriander (*Coriandrum sativum* L.) to study the genetic variability for different growth and yield characters, association among them and direct and indirect effects of component traits on yield per plant. An attempt has also been made to categorize the genotypes on the basis of morphological features, to assess the genetic diversity using Principal Component Analysis (PCA) on the basis of non-hierarchical Euclidean cluster analysis. The salient findings of the investigation are being expressed under following sub-headings:

4.1 Analysis of variance

4.2 Estimation of variability

4.3 Character association

4.4 Path coefficient analysis

4.5 Principal component analysis

4.6 Non-hierarchical Euclidean cluster analysis

4.1 Analysis of variance

The analysis of variance was carried out for all the characters in augented block design and results are presented in Table 4.1 and 4.2 for the year 2009-10 and 2010-11, respectively. The differences among block were highly significant for number of fruits per umbel and significant difference was observed between check for plant height up to main umbels and number of umbel per plant in 2009-2010,in 2010-11 highly significant difference was observed between block number of umbellates per umbels in 2010-11and highly significant difference was observed between check for plant height up to main umbels, number of secondary branch per plant ,number of umbellates per umbels ,yield per plot (g),yield (kg per ha)and weight of 1000 seed (g) and significant difference was observed for plant height including main umbels and seed yield per plant (g).

These results were in agreement with **Sharma and Sharma (1989)**. They reported significant variability for plant height, branches per plant, days to flowering and maturity, umbels per plant and umbellets per plant, seed per umbellets, 1000 grain weight, straw and seed yield per plant**.** Similar result were reported by **Karla *et al.*(2003**) they found high variability were observed for all the characters and **Shridhar *et al*. (1990)** found genetic variability noted for number of leaves, secondary branches, fresh weight of plant, days to 50 per cent flowering, 1000-seed weight and seed yield per plant**.** The similar finding have also been reported by **Megeji and Karla (2002), karla *et al.* (2003), shah *et al.* (2003) and Rajput and Singh (2003)**

Germplasm is a vital source in generating new plant types having desirable traits that help in increasing crop production with quality and thus improve the level of human nutrition. In order to maintain, evaluate and utilize germplasm efficiently and effectively, it is important to investigate the extent of genetic diversity it contains **(Smith and Smith, 1989).** In any crop breeding programme germplasm evaluation play vital role for identification of superior genotypes for different qualitative and quantitative characters which may be further used to create variability by hybridization. The genotypes which are suitable at present may not be suited in future due to change in environment and susceptibility to biotic and abiotic stresses.

Yield is a complex polygenic character and is resultant of interactions of several genetic and environmental factors. According to **Grafius (1959)** and **Whitehouse *et al.* (1958)** there may not be genes for yield *per se* but for their components, the multiplicative interactions result in ultimate yield. It would be therefore desirable to have information on component characters and their relationship with yield and among the components.

The experimental material for present study comprised of 90 genotypes along with 3 checks viz., Pant Haritima , Hisar Aanand and ACr-728. These lines were evaluated in *Tarai* region of Uttarakhand during *Rabi* 2009-10 and 2010-11, at Vegetable Research Center, Pantnagar.

The genotypes were evaluated in Augented Block Design developed by **Federer (1956)**. Observations were recorded on 13 characters to study the morphological variation and nature and extent of genetic variability. The capacity of plants to produce economic yield is the function of various yield components and productivity, depends upon the interaction between potential of the plants and the environmental conditions prevailing during the plant growth, considering nutrition as a constant factor. This phenomenon has been also kept in mind while discussing the results. The findings of the present investigation are discussed here under with all possible explanations.

The results of table 4.1 and 4.2 for analysis of variance showed that genetic differences among block and check varieties were much considerable for different characters.

4.2 Estimation of variability

The general mean, range of variation and per cent range of variation for different characters are given in Table 4.3 for both the years, check means and least significant differences are presented in Table 4.4 and Table 4.5 for 2009-2010 and 2010-11, respectively, while numbers of superior lines for different characters with respect to best check are presented in Table 4.6 and Table 4.7 for 2009-2010 and 2010-11, respectively. The results obtained from various characters are given below.

4.2.1. Days to 50 per cent flowering

The range of days to 50 per cent flowering was found to vary from 70.89 to 130.89 days and 76.17 to 142.17 days and the mean value was calculated to be 88.67 and 92.07 days whereas, per cent ranges of variation vary from 100 to 139.1 and 100 to 186.65 for the year 2009-10 and 2010-11, respectively (Table 4.3,4.4 &4.5). Three genotypes namely UD-750, UD-752 and UD-787 in the year 2009-2010 were significantly superior to the best check Pant Haritima and four genotypes namely MKSM-1055, MKSM-1104, MKSM-1125 and UD-704 in the year 2010-11 were significantly superior to the best check Hisar Aanand for early flowering (Table 4.6 & 4.7).

4.2.2 Plant height up to main umbel

Plant height up to main umbel ranged from 67.82 cm to 143.22 cm and from 57.98 cm to 107.56 cm and the calculated means were 107.70 cm and 82.11 cm for 2009-10 and 2010-11, respectively. The per cent ranges of variation for the first and second year vary from 100 to 211.18 and from 100 to 185.51, respectively (Table 4.3, 4.4 & 4.5). In the first year twenty four genotypes namely MKSM-1104, MKSM-1117, SC-4, SC-9, SC-11, DU-325, UD-326, UD-373, UD-603, UD-622, UD-634, UD-635, UD-643, UD-684, UD-716, UD-721, UD-725, UD-730, UD-744, UD-747, UD-

772, UD- 788,UD-789 and SC-13 were significantly superior to the tallest check Pant Haritima and in second year no any genotype significant superior to the tallest check ACr-278 (Table 4.6 & 4.7).

4.2.3 Plant height including main umbels (cm)

Plant height including main umbel ranged from 79.52 cm to 158.88 cm and 64.82 cm to 136.25 cm and the calculated means were 113.88 cm and 103.56 cm for the year 2009-10 and 2010-11, respectively. The per cent ranges of variation for the first and second year vary from 100 to 199.8 and from 100 to 210.2, respectively (Table 4.3, 4.4 & 4.5). Seven namely SC-4, SC-9, UD-326, UD-711, UD-725, UD-772 and UD-788 and three genotypes namely UD-722,UD-721 and UD-789 were significantly superior to the best check Pant Haritima and ACr-728 in the year 2009-10 and 2010-11, respectively (Table 4.6 & 4.7).

4.2.4 Number of primary branches per plant

The range of variation for this character varied from 4.24 to 8.31 and 1.76 to 7.53 with mean values of 6.25 and 5.97 and per cent range of variation from 100 to 195.99 and 100 to 427.84 for the years 2009-10 and 2010-11, respectively (Table 4.2,4.4 & 4.5). No any genotype during 2009-10 and in year 2010-11 were significantly superiority over best check Hisar Aanand and Pant Haritima respectively (Table 4.6 & 4.7).

4.2.5 Number of secondary branches per plant

Number of secondary branches per plant ranged from 7.07 to 28.07 and 5.18 to 15.15 and the means are 14.83 and 9.45 for the 2009-10.

and 2010-11, respectively. The per cent ranges of variation for the first and for the second year vary from 100 to 397.03 and 100 to 292.47, respectively (Table 4.3,4.4 & 4.5). Only one genotype namely ACr-10 in first and two genotypes namely MKSM-1084 and ACr-4, in second year were significantly superior to the best check ACr-728 and Pant Haritima respectively (Table 4.6 & 4.7).

4.2.6 Number of umbels per plant

Number of umbels per plant was found to vary from 10.17 to 56.30 and 15.00 to 110.00 and the mean value was calculated to be 8.18 and 42.16 whereas, per cent range of variation varied from 100 to 553.59 and 100 to 515.4 in 2009-10 and 2010-11 respectively (Table 4.3, 4.4 & 4.5). No any genotypes in 2009-10 and in 2010-11 were significantly superior to the best check Pant Haritima in the both year (Table 4.6 & 4.7).

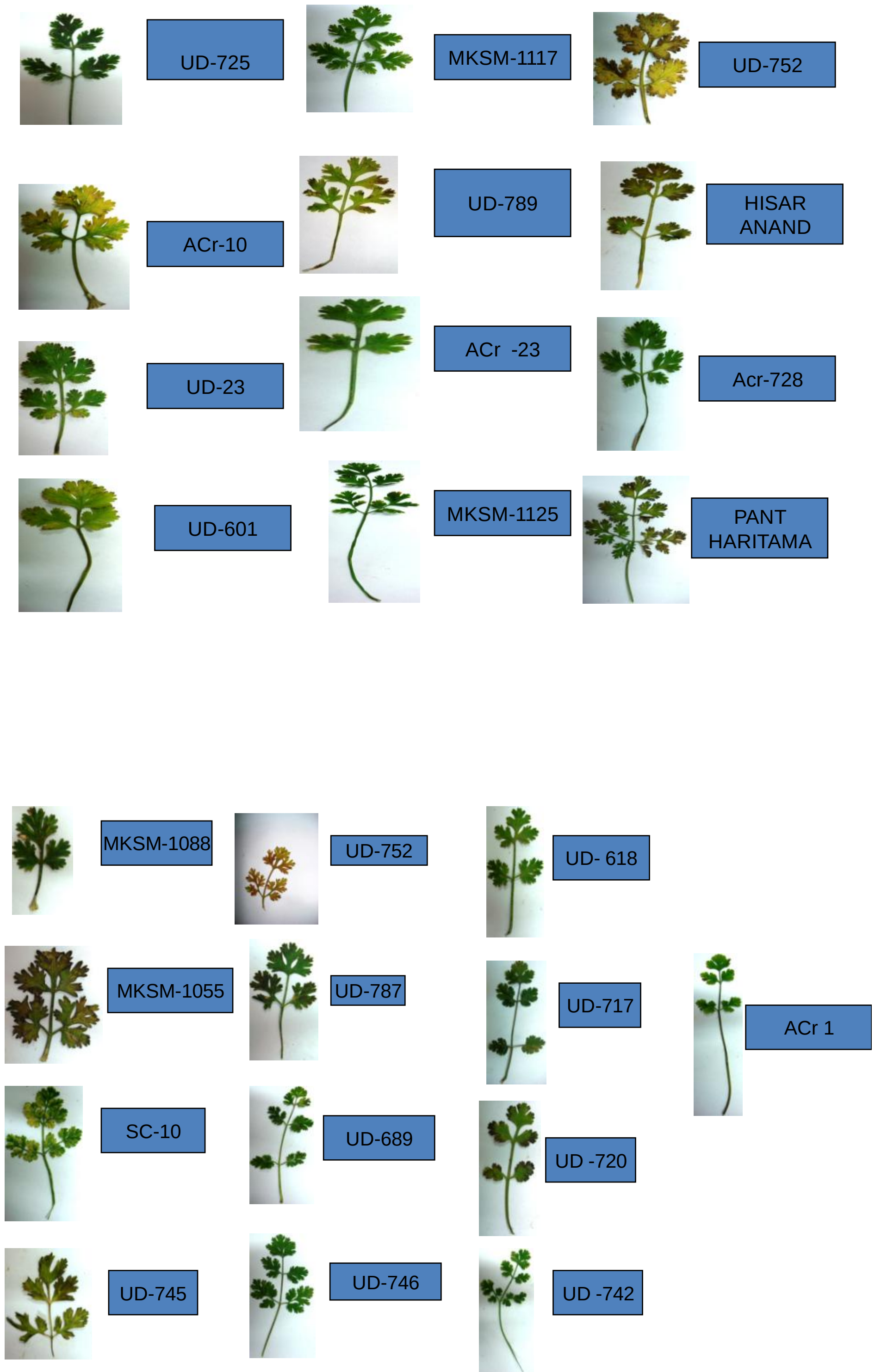

Plate 1: leaf variability in coriander germplasm

Table 4.1: Analysis of variance for different character in 2009-10.

S. No.	Character	Mean sum of squares		
		Block (5)	Check (2)	Error (10)
1.	Days to 50% flowering.	31.156	23.72	23.85
2.	Plant height upto main umbel (cm).	49.32	122.08*	18.36
3.	Plant height including main umbel (cm).	46.79	18.40	38.66
4.	Number of primary branches per plant.	1.18	1.90	1.76
5.	Number of secondary branches per plant.	46.49**	16.18	7.48
6.	Number of umbels per plant.	57.56	316.66*	81.93
7.	Number of umbellate per umbels.	0.31	0.38	0.29
8.	Number of fruits per umbels.	175.52*	25.65	48.13
9.	Number of fruits per umbellates.	11.73**	1.12	1.83
10.	Seed yield per plot (g).	2253.7	4471.16	3897.36
11.	Seed yield per plant (g).	0.0000059	0.000037	0.000032
12.	Seed yield (kg per ha)	743432.0	872729.5	501559.3
13.	Weight of 1000- seeds (g).	2.42	0.36	1.57

*** Significant at 5% level of probability**
**** Significant at 1% level of probability**
Degree of freedom are shown in parenthesis

Table 4.2: Analysis of variance for different character in 2010-11.

S. No.	Character	Mean sum of squares		
		Block (5)	Check (2)	Error (10)
1.	Days to 50% flowering	30.90	75.50	54.40
2.	Plant height upto main umbel (cm)	15.59	1104.31**	41.64
3.	Plant height including main umbel (cm)	149.97	264.78	75.15
4.	Number of primary branches per plant	0.760	3.17	4.00
5.	Number of secondary branches per plant	1.10	20.58**	0.84
6.	Number of umbels per plant	30.21	81.51	26.94
7.	Number of umbellate per umbels	0.97**	0.64**	0.09
8.	Number of fruits per umbels	9.17	112.07*	17.06
9.	Number of fruits per umbellates	0.68	0.97	0.68
10.	Seed yield per plot (g)	2341.38	26401.38**	1284.72
11.	Seed yield per plant (g)	0.000019	0.000077*	0.000011
12.	Seed yield (kg per ha)	86953.06	1364653.5**	78269.19
13.	Weight of 1000- seeds (g)	1.72	21.14**	0.71

*** Significant at 5% level of probability**
**** Significant at 1% level of probability**
Degree of freedom are shown in parenthesis

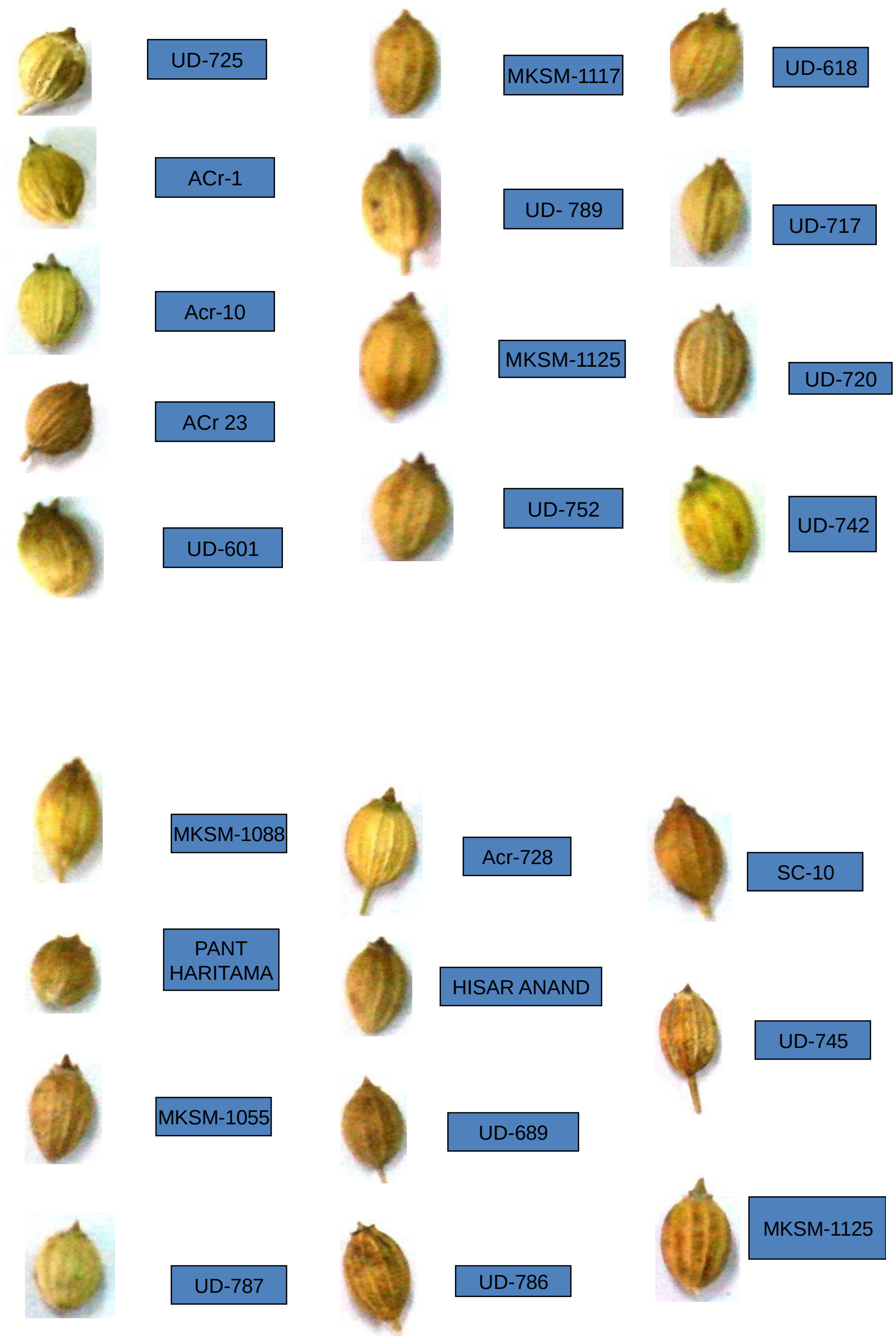

Plate 2: variability in coriander seeds

4.2.7 Number of umbellate per umbels

Number of umbellates per umbels was found to vary from 3.57 to 7.30 and 3.11 to 8.19 and the mean value was calculated to be 5.19 and 5.28 whereas, per cent range of variation was from 100 to 204.48 and 100 to 263.34 for 2009-10 and 2010-11, respectively (Table 4.3,4.4 & 4.5). In first year no any genotypes and in second year three genotypes MKSM-1088, UD-590 and UD-601 were significantly superior to the best check Pant Haritima (Table 4.6 & 4.7).

4.2.8 Number of fruits per umbel

Number of fruits per umbel was found to vary from 7.92 to 60.60 and 9.64 to 60.45 and the mean value were calculated to be 30.23 and 27.91 whereas per cent range of variation was from 100 to 765.15 and 100 to 627.07 for 2009-10 and 2010-11, respectively(Table 4.3,4.4 & 4.5). In first no any genotype were significantly superior to the best check while in the second year six genotypes namely ACr-23, MKSM-1088, MKSM-1091, MKSM-1117, MKSM-1125 and UD-590 were significantly superior to the best check ACr-728 for number of fruits per umbel (Table 4.6 & 4.7).

4.2.9 Number of fruits per umbellate

Number of fruits per umbellate was found to vary from 1.85 to 14.09 and 2.28 to 13.31 and the mean value was calculated to be 7.43 and 6.41 whereas per cent range of variation was from 100 to 761.62 and 100 to 583.77 for 2009-10 and 2010-11, respectively (Table 4.3,4.4 & 4.5). Two genotype namely MKSM-1059 and UD-725 in first year and eighteen genotypes namely ACr-10, ACr-23, ACr-1, ACr-18, MKSM-1125, MKSM-1056, MKSM-1059, MKSM-1079, MKSM-1088, MKSM-1091, MKSM-1104, MKSM-1117, SC-9, UD-590, UD-601, UD-610, UD-643 and UD-689 in second year were significantly superior to the best check Pant Haritima and ACr-728 respectively (Table 4.6 & 4.7).

4.2.10 Seed yield per plot (g)

The plat size of the experiment was 1.5 M^2; in the first yield per plot (g) ranged 8.5 g to 430.50 g while in second year it was 7.06 g to 716.39 g with means value was calculated to be 162.46 g and 167.82 g, respectively. The per cent range of variation varies from 100 to 506.47 in 2009-10 and from 100 to 10147.17 in 2010-11(Table 4.3,4.4 & 4.5).Three genotype namely UD-622, UD-743 and UD-789 in first year and fifteen genotypes namely ACr-10, ACr-19, ACr-23, SC-9, UD-601, UD-605, UD-623,

UD-634, UD-635, UD-643, UD-689, UD-711, UD-720, UD-750 and UD-787 in second year were significantly superior to the best check Pant Haritima and ACr-728 respectively for seed yield per plot (g) (Table 4.6 & 4.7).

4.2.11 Seed yield per plant (g)

In the first year, seed yield per plant ranged 0.004 g to 0.080 g while in second year it was 0.001 g to 0.162 g with means of 0.13 g and 0.143 g, respectively. The per cent range of variation varies from 100 to 8905.48 in 2009-10 and from 100 to 2200.16 in 2010-11 (Table 4.3, 4.4 & 4.5). Three genotype namely MKSM-1052, MKSM-1119 and UD-718 in first year and twenty one genotypes namely ACr-10, ACr-18, ACr-23, ACr-24, MKSM-1059, MKSM-1065, MKSM-1117, SC-11, SC-12, UD-325, UD-374, UD-720, UD-727, UD-730, UD-743, UD-745, UD-750, UD-772, SC-13, and UD-789 in second year were significantly superior to the best check ACr-728 and Pant Haritima respectively (Table 4.6 &4.7) .

4.2.12 Seed yield (kg per ha)

In the first year seed yield ranged from 36.50 kg per ha to 3250.50kg per ha while in second year it was 192.50 kg per ha to 4236.17 kg per ha with mean values of 1310.77 kg per ha and 1114.41 kg per ha respectively. The per cent range of variation varies from 100 to 8905.48 in 2009-10 and from 100 to 2200.16 in 2010-11 (Table 4.3,4.4 & 4.5). Three genotype namely UD-622, UD-743 and UD-789 in first year and fifteen genotypes namely ACr-10, ACr-19, ACr-23, SC-9, UD-601, UD-605, UD-623, UD-634, UD-635, UD-643, UD-689, UD-711, UD-720, UD-750 and UD-787 in second year were significantly superior to the best check Pant Haritima and ACr-728 respectively (Table 4.6 & 4.7).

4.2.13 1000 -seed weight

In the first year 1000-seed weight ranged from 3.03 g to 17.76 g while in second year it was 4.40 g to 14.46 g with means of 10.21 g and 9.37 g, respectively. The per cent range of variation varies from 100 to 586.14 in 2009-10 and from 100 to 335.45 2010-11(Table 4.3,4.4 & 4.5). Twelve genotypes namely ACr-23, ACr-25, SC-10, UD-325, UD-603, UD-615, UD-620, UD-634, UD-715, UD-722, UD-746 and UD-747 in first year and one genotypes namely UD-742 in second year were significantly superior to the best check Hisar Aanand for the both year (Table 4.6 & 4.7).

The similar finding have also reported by **Megeji and Karla (2002), Karla *et.al.* (2003), Rajput and Singh (2003), Shah *et.al.*(2003), Singh *et.al.*(2003), Singh**

***et.al.* (2003), Selvarajan *et. al. (*2008), Bhandari and Gupta (1991)** in coriander genotypes which exhibited genetic variation for plant height, primary and secondary branches, days to flowering and maturity, umbels and umbellates per plant, seed per umbellate, 1000 seed weight, straw yield and grain yield per plant and harvest index.

The similar results were reported by **Selvarajan *et al.* (2008)** They found that pooled analysis of the data indicated that CS 12 was the best with the highest yield of 579.3 kg per ha, followed by CS 102, recording yield of 561.0 kg per ha. The increase in yield for CS 12 was 10 per cent over the control cultivar CO3, which recorded yield of 529.6 kg per ha. **Bhagat *et al.* (2010)** found also the similar result with 13 genotype of coriander. They observed that maximum yield was recorded in COR-31 (950.35 kg per ha) followed by COR-28 (872.57 kg per ha) and COR-32 (865.63 kg per ha).

The efficiency of a breeding programme for the improvement of quantitative traits depends to a large extent on magnitude of variability

It is an established fact that greater variability would lead to better scope for selection. However, the phenotypic variability arises due to genotype and environmental influences. Thus high phenotypic variability does not guarantee for effective selection unless it is genetic in nature and especially additive genetic variability ensures high scope for efficient selection. Therefore an appropriate breeding strategy and information about the extent of variability is very essential.

4.3 Character association

Crop improvement programme largely depends on availability of sufficient variability and association among different characters which are the pre-requisite for executing an effective selection programme. Yield, being a complex quantitative trait, is dependent on a number of component characters. Therefore, knowledge of association of different components together with their relative contributions has immense value in selection. The estimation of correlation coefficients among different economic traits has been presented in Table 4.8.

The covariance indicates that how two related characters tend to vary together *i.e.,* they are correlated with each other. The intensity of this correlation between the cause and the effect can be measured by correlation coefficient, symbolized as '*r*'. Thus '*r*' is a conventional statistic to determine the degree to which the two related variants can carry together.

Table 4.3: The general mean, range of variation and per cent range of variation in coriander genotype in 2009-10 and 2010-11.

S. No.	Character	General mean		Range of variation		% Range of variation	
		2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
1.	Days to 50% flowering	88.67	92.07	78.89-130.89	76.17-142.17	100-165.91	100-186.65
2.	Plant height upto main umbel (cm)	107.70	82.11	67.82-143.22	57.98-107.56	100-211.18	100-185.51
3.	Plant height including main umbel (cm)	113.88	103.56	79.52-158.88	64.82-136.25	100-199.8	100-210.2
4.	Number of primary branches per plant	6.25	5.97	4.24-8.31	1.76-7.53	100-195.99	100-427.84
5.	Number of secondary branches per plant	14.83	9.45	7.07-28.07	5.18-15.15	100-397.03	100-292.47
6.	Number of umbels per plant	27.31	21.69	10.17-56.30	8.18-42.16	100-553.59	100-515.4
7.	Number of umbellate per umbel	5.19	5.28	3.57-7.30	3.11-8.19	100-204.48	100-263.34
8.	Number of fruits per umbel	30.23	27.91	7.92-60.60	9.64-60.45	100-765.15	100-627.07
9.	Number of fruits per umbellate	7.43	6.41	1.85-14.09	2.28-13.31	100-761.62	100-583.77
10.	Seed yield per plot (g)	162.46	167.82	8.5-430.50	7.06-716.39	100-506.47	100-10147.17
11.	Seed yield per plant (g).	0.13	0.143	0.004-0.080	0.001-0.162	100-2000.00	100-16200
12.	Seed Yield (kg/ha)	1310.77	1114.41	36.50-3250.50	192.50-4236.17	100-8905.48	100-2200.16
13.	Weight of 1000 seeds (g).	10.21	9.37	3.03-17.76	4.40-14.76	100-586.14	100-335.45

Plate 3a. Variability in coriander plant

Table 4.4: Mean, range and least significant differences in coriander genotypes in 2009 -10

S. No.	Character	Genotypes		Checks			CV%	CM	AVSB	AVDB	AVAC
		General mean	Range	Pant Haritima	Hisar Aanand	ACr-728					
1.	Days to 50% flowering	88.67	70.89-130.89	98.50	99.00	102.16	4.88	6.28	15.38	17.76	13.56
2.	Plant height upto main umbel (cm)	107.70	67.82-143.22	105.78	97.56	104.90	4.17	5.51	13.50	15.58	11.98
3.	Plant height including main umbel (cm)	113.88	79.52-158.88	120.63	118.00	117.31	5.24	7.99	19.58	22.61	17.27
4.	Number of primary branches per plant	6.25	4.24-8.31	6.75	6.96	5.90	20.31	1.70	4.18	4.83	3.69
5.	Number of secondary branches per plant	14.83	7.07-28.07	17.58	17.20	20.21	14.92	3.51	8.61	9.95	7.60
6.	Number of umbels per plant	27.31	10.17-56.30	50.83	39.16	37.50	21.29	11.64	28.51	32.92	25.14
7.	Number of umbellate per umbel	5.19	3.57-7.30	6.05	5.93	6.41	8.90	0.70	1.72	1.98	1.51
8.	Number of fruits per umbel	30.23	7.92-60.60	39.25	38.93	42.66	17.22	8.92	21.85	25.23	19.27
9.	Number of fruits per umbellate	7.43	1.85-14.09	7.15	6.45	6.35	20.35	1.74	4.26	4.92	3.76
10.	Seed yield per plot (g)	162.46	8.5-430.50	211.16	158.00	195.33	33.17	80.28	196.65	227.08	173.43
11.	Seed yield per plant (g).	0.13	0.004-0.080	0.0183	0.0191	0.0230	28.32	0.0032	0.0179	0.0207	0.0158
12.	Seed yield (kg per ha)	1310.77	36.50-3250.50	2110.16	1762.00	1348.33	40.69	910.78	2230.95	2576.08	1967.51
13.	Weight of 1000 -seeds (g).	10.21	3.03-17.76	9.58	10.05	9.95	12.73	1.61	3.95	4.56	3.48

CM =least significant difference between the means of two check varieties,
AVSB =least significant difference between adjusted values of two selections in the same block,
AVDB =least significant difference between adjusted value of two selection in different blocks,
AVAC = least significant difference between an adjusted selection value and a check mean.

Table 4.5: Mean, range and least significant differences in coriander genotypes 2010-11

S. No.	Character	Genotypes		Checks			CV%	CM	AVSB	AVDB	AVAC
		General mean	Range	Pant Haritima	Hisar Aanand	ACR-728					
1.	Days to 50% flowering	92.07	76.17-142.17	102.50	100.00	107.00	7.15	9.49	23.25	26.85	20.50
2.	Plant height upto main umbel (cm)	82.11	57.98-107.56	94.34	75.85	102.29	7.10	8.29	20.32	23.47	17.92
3.	Plant height including main umbel (cm)	103.56	64.82-136.25	110.17	107.00	119.60	7.71	11.14	27.30	31.53	24.08
4.	Number of primary branches per plant	5.97	1.76-7.53	6.10	4.73	5.85	35.97	2.57	6.30	7.27	5.55
5.	Number of secondary branches per plant	9.45	5.18-15.15	11.15	7.45	9.53	9.82	1.18	2.90	3.35	2.56
6.	Number of umbels per plant	21.69	8.18-42.16	31.03	23.90	25.83	19.27	6.67	16.35	18.88	14.42
7.	Number of umbellates per umbel	5.28	3.11-8.19	5.18	4.60	5.15	6.04	0.38	0.94	1.09	0.83
8.	Number of fruits per umbel	27.91	9.64-60.45	32.75	27.01	35.48	13.00	5.31	13.01	15.02	11.47
9.	Number of fruits per umbellate	6.41	2.28-13.31	5.84	5.78	6.51	13.71	1.06	2.61	3.01	2.30
10.	Seed yield per plot (g)	167.82	7.06-716.39	185.83	88.33	215.00	21.98	46.09	112.91	130.37	99.57
11.	Seed yield per plant (g).	0.143	0.001-0.162	0.0200	0.0183	0.0205	17.2083	0.0043	0.0106	0.0122	0.0093
12.	Seed yield (kg/ha)	1114.41	192.50-4236.17	1288.00	588.16	1499.33	24.86	359.78	881.30	1017.63	777.23
13.	Weight of 1000 seeds (g).	9.37	4.40-14.76	8.64	10.84	7.10	9.51	1.08	2.65	3.06	2.34

CM =least significant difference between the means of two check varieties,
AVSB =least significant difference between adjusted values of two selections in the same block,
AVDB =least significant difference between adjusted value of two selection in different blocks,
AVAC = least significant difference between an adjusted selection value and a check mean.

Table 4.6: Relative performance of coriander genotypes according to best check for different characters in 2009-10

S. No	Character	Number of Genotypes Significantly Superior	Number of Genotypes at Par	Number of Genotypes Significantly Inferior
1.	Days to 50% flowering	3	0	83
2.	Plant height upto main umbel (cm)	24	0	66
3.	Plant height including main umbel (cm)	7	0	83
4.	Number of primary branches per plant	0	0	90
5.	Number of secondary branches per plant	1	0	89
6.	Number of umbels per plant	0	0	90
7.	Number of umbellates per umbel	0	0	90
8.	Number of fruits per umbel	0	0	90
9.	Number of fruits per umbellate	2	1	87
10.	Seed yield per plot (g)	3	0	87
11.	Seed yield per plant (g).	4	1	86
12.	Seed yield (kg/ha)	3	0	87
13.	Weight of 1000 seeds (g).	11	9	70

Table 4.7: Relative performance of coriander genotypes according to best check for different characters in 2010-11

S. No	Character	Number of Genotypes Significantly Superior	Number of Genotypes at Par	Number of Genotypes Significantly Inferior
1.	Days to 50 % flowering	4	0	87
2.	Plant height upto main umbel (cm)	0	0	90
3.	Plant height including main umbel (cm)	3	0	87
4.	Number of primary branches per plant	0	0	90
5.	Number of secondary branches per plant	2	0	88
6.	Number of umbels per plant	0	0	90
7.	Number of umbellates per umbel	3	15	72
8.	Number of fruits per umbel	6	0	84
9.	Number of fruits per umbellate	18	11	61
10.	Seed yield per plot (g)	15	0	75
11.	Seed yield per plant (g).	21	0	2
12.	Seed yield (kg/ha)	15	0	75
13.	Weight of 1000- seeds (g).	1	3	86

Plate 3b. Variability in coriander plant

The correlation coefficient, *r* ranged from -1 to +1, *r* =-1 means there is 100 per cent correlation between x and y, but both vary in.

The simple phenotypic correlation coefficients among thirteen characters worked out on the pooled adjusted means of two years and estimates are presented in the Table 4.8.

In present investigation on seed yield showed highly significant and positive correlation with plant height upto main umbel (0.325), plant height including main umbel (0.331), number of fruits per umbel (0.290), seed yield per plot (0.743) and seed yield per plant (0.361). The similar result was reported by **Jain, *et al.* (2003), Beemnet *et al*. (2011), Singh, *et al.* (2008)**, **Dtta (2006), Bhandari and Gupta (1991).** They reported that yield per plant were highly significant and positive with number of grain per umbel, number of primary branches and plant height

The present study suggested that plant height upto main umbel; plant height including main umbel, number of fruits per umbel, seed yield per plot and seed yield per plant trait may be selected for seed yield improvement of the coriander.

1000- seed weight showed significant and positive correlation with number of secondary branches (0.490). Highly significant but negative correlation was seen with days to 50 per cent flowering (-0.333), and significant but negative correlation was seen number of fruits per umbellate (-0.243).The similar result reported by **Jain *et al*. (2005).**They reported that plant height was positively associated with 1000-seed weight.

Seed yield per plant showed highly significant and positive correlation with days to 50 per cent flowering (0.371) and significant but positive correlation was seen with yield per plot (0.241).These results were agreement with **Cosge *et al.*(2009) and Jain *et al*. (2003).** They found positive correlation single plant yield, seed yield was positively and significant correlated with all the trait.

Seed yield per plot (g) showed highly significant and positive correlation with plant height up to main umbel (0.370), plant height including main umbel (0.424) and number of secondary branches per plant (0.327).The similar result was reported. by **Suthanthirapandis *et al.(*1980), Roa *et al*. (1981), Tripathi *et al*. (2000) and Dutta (2006),** yield attributing character with respect to yield revealed that primary branch per plant ,secondary branch per plant umbellate per plant and seed per umbel were positively and significant correlated with yield**. Mehata *et al.* (1990),** reported that seed yield per plant was significantly and positively correlated with yield per plant.

Number of fruits per umbellate showed significant positive correlation with number of fruits per umbel (0.260). The similar result reported by **Shah *et al*. (2003)**, They found number of seeds per umbel and number of umbels per plant were significantly correlated with seed yield per plant under all the environments.

Number of fruits per umbel showed highly significant and positive correlation with number of umbellates per umbel (0.416) and significant but negatively correlation with number of secondary branches (-0.230). All the above finding can be conformed by **Bhandari and Gupta (1991),** They found phenotypic correlations of grain yield per plant were highly significant and positive with umbellates per plant, number of umbels per plant, number of effective branches, straw yield per plant, number of primary branches per plant , plant height, number of seed per umbellates and harvest index. Similar result reported by **Jain *et al.* (2003) and Singh *et al.* (2008)**. They reported that number of umbels per plant showed highly significant and positive correlation with number of primary branches (0.271), number of secondary branches (0.317).The above finding can also conformed with similar result obtained by **Arumugan and Muthurkrishnan (1979).** They found that number of umbellates per umbel were positively correlated with seed yield.

Number of secondary branches showsed significant and positive correlation with plant height including main umbel (0.213) and highly significant and negative correlation with days to 50 per cent flowering (-0.325). The above finding were conformed with similar result obtained by **Gurbuz (2001).** The highest correlation was found between branches number and seed yield.

Plant height including main umbel showsed highly significant and positive correlation with plant height up to main umbel (0.790). The result were in agreement with **Garg *et al*. (2003).** They found that plant height exhibited significant positive genotypic association with all the traits.

4.4 Path-coefficient studies

Path-coefficient analysis gives ideas about contribution of each independent character on dependent character *i.e.*, yield. Since the mutual relationship of component characters might vary both in magnitude and direction, with association of yield with other attributes, it is necessary to partition the genetic correlation into direct and indirect effects of each other. The results are presented in Table 4.9.

4.4.1 Direct effect

The path coefficient analysis based on pooled data of two years adjusted means revealed that the highest direct effect was shown by seed yield per plot (0.6975), towards seed yield (kg per ha), followed by number of fruits per umbel (0.2716), seed yield per plant (0.1143), weight of 1000-seed (0.0895), days to 50 per cent flowering (0.0281), number of primary branches (0.0734) and plant height up to man umbel (0.0703). These result were in agreement with **Jain *et al.* (2003)**. They found total plant height was positively associated with number of umbels per plant, height up to the base of the main umbel, number of branches per plant, number of umbelletes per umbel, number of seeds per umbel, and 1000-seed weight. The similar results reported by **Singh and Mittal (2003)**. They reported that seed yield per plant was positively and significantly associated with plant height, number of primary branches per plant, number of secondary branches per plant, number of umbels per plant, umbel diameter, 1000-seed weight and seeds per umbel. **Shah *et al.* (2003)** found that number of primary branches per plant and plant height was positively associated with seed yield,the number of primary branches and number of umbels per plant had a negative association with seed yield.

Similarly negative direct effect was recorded for number of umbellates per umbel (-0.1652), number of secondary branches (-0.0975), plant height including main umbel (-0.0361), number of fruits per umbellates (-0.0270) and number of umbel per plant (-0.0008).These result were in agreement with **Cosge *et al.* (2009)**. They found maximum negative and direct contribution to biological yield, the similar result reported by **Shah *et al*. (2003)**. They found 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.

Table: 4.8: Simple correlation coefficient between different characters of coriander.

S. No.	Characters	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Days to 50 % flowering	1.00	0.192	0.159	-0.119	-0.325**	-0.036	0.086	0.069	-0.176	-0.064	0.371**	-0.333**	0.090
2.	Plant height upto main umbel (cm)		1.00	0.790**	-0.125	0.170	0.057	0.157	0.169	-0.031	0.370**	0.048	0.100	0.325**
3.	Plant height including main umbel (cm)			1.00	-0.098	0.213*	0.002	0.125	0.114	-0.065	0.424**	0.033	0.169	0.331**
4.	Number of primary branches per plant				1.00	0.131	0.271**	0.082	0.119	0.022	0.104	0.085	-0.116	0.135
5.	Number of secondary branches per plant					1.00	0.317**	-0.198	-0.230*	0.066	0.327**	-0.152	0.490*	0.113
6.	Number of umbels per plant						1.00	-0.048	0.091	-0.127	0.167	0.060	0.010	0.150
7.	Number of umbellate per umbel							1.00	0.416**	0.100	0.014	-0.031	-0.129	-0.021
8.	Number of fruits per umbel								1.00	0.260*	0.084	0.110	-0.243*	0.290**
9.	Number of fruits per umbellate									1.00	0.023	0.043	-0.082	0.220
10.	Seed yield per plot (g)										1.00	0.241*	0.193	0.743**
11.	Seed yield per plant (g).											1.00	-0.104	0.361**
12.	Seed yield (kg/ha)												1.00	0.087
13.	Weight of 1000 seeds (g).													1.00

**** Significant at 1 % level of probability**
*** Significant at 5 % level of probability**

4.4.2 Indirect effect

Days to 50 per cent flowering made positive indirect contribution to yield *via* seed yield per plant (0.0423), number of secondary branches per plant (0.0316), number of fruits per umbellate (0.0186), plant height up to main umbel (0.0134), seed yield per plot (0.0047) and number of umbels per plant (0.00003). The results were agreement with **Shah *et al.* (2003).** They reported significant positive direct effect on seed yield exhibited by the number of primary branches per plant. The similar results were reported by **Jain *et al.* (2003)**. They found that number of days to 50 per plant flowering had a significant negative correlation with seed yield.

The results of present investigation suggest that selection for higher seed yield greater plant height, number of umbels per plant and 1000-seed weight shoud be selection parameters

Plant height up to main umbel made positive contribution to yield indirectly *via* seed yield per plot (0.2583), number of fruits per umbel (0.0460) and days to 50 per cent flowering (0.0157), weight of 1000-seed (0.0089), seed yield per plant (0.0054) and number of fruits per umbellate (0.0008). The similar result reported by **Jain *et al.* (2003).** They found that total plant height was positively associated with number of umbels per plant, height up to the base of the main umbel, number of branches per plant, number of umbellates per umbel, number of seeds per umbel, and 1000-seed weight.

Plant height including main umbel showed maximum positive indirect on yield effect *via* yield per plot (0.2959), plant height up to main umbel (0.0555), number of fruits per umbel (0.0460), weight of 1000- seed (0.0151), days to 50 per cent flowering (0.0130) and number of fruits per umbellate (0.0017). These results were in agreement with **Jain *et al.* (2003)**. They found path analysis revealed that total plant height had the greatest positive direct effect on seed yield, followed by number of umbels per plant and 1000-seed weight.

Number of primary branches per plant showed maximum positive indirect effect on yield *via* seed yield per plot (0.0722), number of fruit per umbel (0.0322), seed yield per plant (0.0097), and plant height including main umbel (0.0035) ,

Number of secondary branches per plant had maximum positive indirect effect on yield *via* seed yield per plot (0.2282), weight of 1000- seed (0.0438), number of umbellates per umbel (0.0327), plant height up to main umbel (0.0119), and number of primary branches per plant (0.0096).

Number of umbels per plant had maximum positive indirect effect on yield *via* seed yield per plot (0.1167), number of fruits per umbel (0.0247), number of primary branches per plant (0.0199), number of umbellates per umbel (0.0079), number of seeds per plant (0.0068), plant height up to main umbel (0.0045) and number of fruits per umbellate (0.0034).

Number of umbellates per umbel made positive indirect contribution to yield *via* number of fruits per umbel (0.1130) and number of secondary branches per plant (0.0193), plant height up to main umbel (0.0110), seed yield per plot (0.0098), days to 50 per cent flowering (0.0070), number of primary branches per plant (0.0060) and number of umbels per plant (0.0004).

Number of fruits per umbel had maximum positive indirect effect on yield *via* seed yield per plot (0.0583), number of secondary branches per plant (0.0223), seed yield per plant (0.0125), plant height up to main umbels (0.0119), number of primary branches per plant (0.0087) and days o 50 per cent flowering (0.0056).

Number of fruits per umbellate made positive indirect contribution to yield *via* number of fruits per umbel (0.0707), yield per plot (0.0161), seed yield per plant (0.0048), plant height including main umbel (0.0023), number of primary branches per plant (0.0016) and number of umbels per plant (0.0001).

Seed yield per plant made positive indirect contribution to seed yield *via* seed yield per plant (0.0275), plant height up to main umbel (0.0260), number of fruits per umbel (0.0227) weight of 1000 -seed (0.0172) and number of primary branches per plant (0.0076). The similar results were reported by **Singh *et al.* (2008).** They found seed yield per plant, test weight and umbels per plant, branches per plant, leaves per plant, umbels per plant and seeds per umbel exhibited positively significant genotypic correlation among themselves and all were positively and significantly associated with seed yield per plant. A positive significant correlation with seed yield per plant and its main components seeds per umbel and umbels per plant .

1000- seed weight made positive indirect contribution to yield *via* yield per plot (0.1346), number umbellates per umbels (0.0213), plant height up to main umbels (0.0070) and number of fruit per umbellates (0.0022). The similar result obtained by

Srivastava *et al.* (2000).They reported weight of 1000-seed had positive direct effect on seed yield. Days to flowering had highest direct effect on seed yield followed by days to maturity and number of umbels per plant. Plant height, number of primary branches and number of seeds per umbel had weak direct effect on seed yield.

Seed yield per plant made positive indirect contribution to yield *via* yield per plot (0.1680), days to 50 per cent flowering (0.0304), number of fruits per umbel (0.0298) and number of secondary branches per plant (0.0148), number of primary branches per plant (0.0062), number of umbellates per umbel (0.0051) and plant height up to main umbel (0.0033).

The similar finding have also reported by **Arumugam and Muthurkrishnan (1979)**, **Suthanthirapandian *et al.* (1980), Rao *et al.* (1981), Bhandari and Gupta (1991) , Srivastava *et al.* (2000), Tripathi *et al*. (2000), Gurbuz (2001)**, **Choudhary and Ramkrishna** (**2003), Davila *et al*. (2004), Singh *et al.* (2008)** , **Datta (2006)** , **Singh *et al*. (2006**) **and Singh *et al.* (2011**).

As regards the residual effect, it was seen that apart from the variables under study, there could be certain factors influencing the yield as evident from the estimates of residual factor +0.3340.

The correlation coefficient becomes more meaningful when genotypic correlations are partitioned into components of direct and indirect effects through path analysis because correlation coefficients indicate only the inter relationship of the characters irrespective of cause and effect **(Dewey and Lu, 1959)**. Therefore, partitioning of correlation coefficient into direct and indirect effects appears logical to operate effective selection programme. Path analysis differs from simple correlation in that it points out the cause and their relative importance. An in depth analysis of direct and the indirect effects of various characters on yield was carried out in present study to assess the relative importance of various yield components in coriander. For path analysis, yield was taken as dependent variables and all other 13 characters used for correlation studies, were considered as causal variables.

Table 4.9: Path coefficient analysis for different pairs of character in coriander.

Characters	Correlation with Yield	Direct Effect	Indirect Effect											
			Days to 50% flowering.	Plant height upto main umbel (cm).	Plant height including main umbel (cm).	Number . of primary branches per plant.	Number .of secondary branches per plant	Number of umbels per plant	Number of of umbellates per plant umbel.	Number of fruits per umbel.	Number of fruits umbellate	Seed yield per plot (g).	Seed yield per plant (g).	Weight of 1000 seeds (g).
Days to 50 % flowering	0.089	0.0821	--	0.0134	-0.0057	-0.0087	0.0316	0.00003	-0.0142	-0.0142	0.0186	0.0047	0.0423	-0.0298
Plant height upto main umbel (cm)	0.325**	0.0703	0.0157	--	-0.0285	-0.0092	-0.0166	-0.00004	-0.0259	0.0460	0.0008	0.2583	0.0054	0.0089
Plant height including main umbel (cm)	0.331**	-0.0361	0.0130	0.0555	--	-0.0071	-0.0208	-0.000001	-0.0205	0.0308	0.0017	0.2959	0.0037	0.0151
Number of primary branches per plant	0.135	0.0734	-0.0098	-0.0088	0.0035	--	-0.0127	-0.0002	-0.0135	0.0322	-0.0006	0.0722	0.0097	-0.0103
Number of secondary branches per plant	0.112	-0.0975	-0.0266	0.0119	-0.0077	0.0096	--	-0.0002	0.0327	-0.0623	-0.0017	0.2282	-0.0174	0.0438
Number of umbels per plant	0.149	-0.0008	-0.0029	0.0040	-0.00006	0.0199	-0.0309	--	0.0079	0.0247	0.0034	0.1167	0.0068	0.0008
Number of umbellate per umbel	-0.021	-0.1652	0.0070	0.0110	-0.0045	0.0060	0.0193	0.00004	--	0.1130	-0.0026	0.0098	-0.0035	-0.0115
Number of fruits per umbel	0.289**	0.2716	0.0056	0.0119	-0.0041	0.0087	0.0223	-0.00007	-0.0687	--	-0.0070	0.0583	0.0125	-0.0217
Number of fruits per umbellate	0.022	-0.0270	-0.0144	-0.0021	0.0023	0.0016	-0.0064	0.0001	-0.0164	0.0707	--	0.0161	0.0048	-0.0073
Seed yield per plot (g)	0.743**	0.6975	-0.0052	0.0260	-0.0153	0.0076	-0.0319	-0.0001	-0.0023	0.0227	-0.0006	--	0.0275	0.0172
Seed yield per plant (g).	0.360**	0.1143	0.0304	0.0033	-0.0011	0.0062	0.0148	-0.00005	0.0051	0.0298	-0.0011	0.1680	--	-0.0093
Seed yield (kg/ha)	0.087	0.0895	-0.0273	0.0070	-0.0060	-0.0085	-0.0477	-0.000008	0.0213	-0.0660	0.0022	0.1346	-0.0119	--

Residual factor: 0.3340

4.5 Principal component analysis

The pooled analysis for principal component analysis (PCA) of 90 coriander genotypes is based on correlation matrix of growth and yield traits. The analysis has yield 13 eigen roots (eigen values) and eigen vectors. These values and associated per cent of variation explained by eigen root have been presented in (Table 4.10)

The principal component analysis was based on 13 morphological traits. First 10 principal components explain 94.72 per cent of total variation. Separate per cent of variation attributable to the 13 components by decreasing order were 21.67, 16.79, 12.31, 11.08, 8.78, 6.19, 5.43, 5.37, 3.90, 3.20, 2.38, 1.60, and 1.30, respectively from first to thirteenth principal component.

The first principal component had the largest eigen root 2.817, followed by 2.183, 1.600, 1.440, 1.142, 0.805, 0.706, 0.698, 0.507, 0.416, 0.309, 0.208 and 0.169, from second to thirteen principal components, respectively.

The eigen vector of 13 principal components had been scored in such a way that the largest element in each vector is unity. These were interpreted as relative weight of the variables in each component. The important variables are those which have high positive and negative relative weights values.

The first principal component (PC1) had high positive weight for all the character that is seed yield per plot (0.4844), seed yield kg per ha (0.4578), plant height including main umbel (0.4470), plant height up to main umbel (0.4368), number of secondary branches per plant (0.2295), \number of umbels per plant (0.1559), number of fruits per umbel (0.1542), weight of 1000- seed (0.1517).

The second principal component (PC 2) had high positive weight for days to 50 per cent flowering (0.4175), number of fruits per umbel (0.3883), number of umbellates per umbel (0.3145) and seed yield per plant (0.2756).

The third principal component (PC3) had high positive weight for number of primary branches per plant (0.5561), number of umbels per plant (0.3748), number of fruits per umbel (0.2695), number of fruits per umbellate (0.2510).

The fourth principal component (PC 4) had high positive weight for number of umbellates per umbel (0.4626), number of fruits per umbel (0.4204), and plant height including main umbel (0.1529).

The fifth principal component (PC5) had high positive weight for number of umbels per plant (0.5173), number of primary branches per plant (0.2939), number of umbellates per umbel (0.2559), plant height up to main umbel (0.1685), and plant height including main umbel (0.1546).

The sixth principal component (PC 6) had high positive weight for number of fruit per umbellate (0.5742), number of umbels per plant (0.3341), number of secondary branches per plant (0.2867), days to 50 per cent flowering (0.2331), plant height up to main umbel (0.2289) and plant height including main umbel (0.1322).

The seventh principal component (PC7) had high positive weight for number of umbels per plant (0.4473), weight of 1000- seed (0.4175), number of fruits per umbel (0.2797), seed yield per plant (0.2553) and number of umbellates per umbel (0.2472).

The eighth principal component (PC8) had high positive weight for seed yield per plant (0.4483), number of umbellates per umbel (0.4125), number of primary branches per plant (0.3925), days to 50 per cent flowering (0.2319) and number of secondary branches per plant (0.2172).

The ninth principal component (PC9) had high positive weight for number of fruits per umbel (0.4931), weight of 1000- seed (0.3696), number of primary branches per plant (0.2591), seed yield per plant (0.1669) and plant height including main umbel (0.1540).

The tenth principal component (PC10) had high positive weight for days to 50 per cent flowering (0.6528), number of secondary branch per plant (0.3044), number of fruits per umbel (0.2359) and 1000-seed weight (0.1999).

The eleventh principal component (PC11) had high positive weight for weight of 1000-seed (0.3799), number of fruits per umbel (0.3350), number of umbels per plant (0.3186) and seed yield kg per ha (0.1631).

The twelfth principal component (PC 12) had high positive weight for plant height including main umbel (0.6190), seed yield per plot (0.2700), number of fruits per umbel (0.1248) and number of umbels per plant (0.0875).

The thirteenth principal component (PC13) had high positive weight for seed yield per plot (0.5820), plant height up to main umbel (0.2863), number of fruits per umbel (0.2054) and days to 50 per cent flowering (0.1261).

Principal component analysis suggested by **Hotelling (1933)** after its original concept given by **Pearson (1901)** and non-hierarchical Euclidean cluster analysis described by **Beale (1969)** was used for grouping all genotypes into clusters.

The principal component analysis was done on correlation matrix of important economic traits. The Eigen roots and Eigen vectors of correlation matrix have been given in table 4.11.

Patel *et al*. (2000) suggested that the D^2 values between pairs of genotypes ranged from 2.50 to 96.96. By using D^2 analysis the genotypes were grouped into nine clusters. The clustering was at random and without any relationship between genetic diversity and geographic diversity. Seed yield per plant had highest contribution towards genetic divergence followed by secondary branches and umbellets per plant.

The multivariate and cluster analysis is generally done to demonstrate the variability present in the germplasm ,data of various crops have been exposé for PCA however, very few studies one available in coriander crops.

The descriptive terminology and sensory prolife of four samples of Italian salami were determined by **Marangoni and Moura (2011)** using a methodology based on the Quantitative Descriptive Analysis (QDA). A sensory panel consensually defined sensory descriptors, their respective reference materials, and the descriptive evaluation ballot. Twelve individuals were selected as judges and properly trained. They used the following criteria: discriminating power, reproducibility, and individual consensus. Twelve descriptors were determined showing similarities and differences among the Italian salami samples. Each descriptor was evaluated using a 10 cm non-structured scale. The data were analyzed by ANOVA, Tukey test, and the Principal Component Analysis (PCA). The salami with coriander essential oil (T3) had lower rancid taste and rancid odor, whereas the control (T1) showed high values of these sensory attributes. Regarding brightness, T4 showed the best result. For the other attributes, T1, T2, T3, and T4 were similar

The assessed the structure and genetic variability in rapeseed cultivars analyzed by a principal component analysis from the allele frequency correlation matrix. The scales per corresponding Eigen vector for principal component taking the largest element in each vector as unity has been presented in Table 4.10. These elements may be interpreted as the relative weight given to the variables in each component and important variables are those which possess high positive and high negative weight **Jeffers, (1967)**.

The first principal component (PC1) contributed to 21.67 per cent of variation and has seed yield per plot, seed yield kg per ha, plant height including main umbel, plant height upto main umbel, number of secondary branches per plant, number of umbel per plant, number of fruits per umbel and weight of 1000- seed.

The second principal component (PC2) contributed to 16.79 per cent of variation and had high positive weight for days to 50 per cent flowering, number of fruits per umbel, number of umbellates per umbel and seed yield per plant.

The third principal component (PC3) contributed to 12.31 per cent of total variation and had high positive weight for number of primary branches per plant, number of umbels per plant, number of fruits per umbel, number of fruits per umbellate.

The fourth principal component (PC4) contributed to 11.08 per cent of total variation had high, number of umbellates per umbel, number of fruits per umbel, and plant height including main umbel.

The fifth principal component (PC5) contributed to 8.78 per cent of total variation and had high positive weight for number of umbels per plant, number of primary branches per plant, number of umbellates per umbel, plant height upto main umbel, and plant height including main umbels.

The sixth principal component (PC6) contributed to 6.19 per cent of total variation and had high positive weight for for number of fruits per umbellate, number of umbels per plant, number of secondary branches per plant, days to 50 per cent flowering, plant height upto main umbel and plant height including main umbels.

The seventh principal component (PC7) contributed to 5.43 per cent of total variation and had high positive weight for number of umbels per plant, weight of 1000-seed, number of fruits per umbel, seed yield per plant and number of umbellates per umbel.

The eighth principal component (PC8) contributed to 5.37 per cent of total variation and had high positive weight seed yield per plant, number of umbellates per umbel, number of primary branches per plant, days to 50 per cent flowering and number of secondary branches per plant .

The ninth principal component (PC9) contributed to 3.90 per cent of total variation and had high positive weight number of fruits per umbel, weight of 1000-seed, number of primary branches per plant, seed yield per plant and plant height including main umbel.

The tenth principal component (PC10) contributed to 3.20 per cent of total variation and had high positive weight for days to 50 per cent flowering, number of secondary branches per plant, number of fruits per umbel, and 1000-seed weight.

The eleventh principal component (PC11) contributed to 2.38 per cent of total variation and had high positive weight for weight of 1000-seed, number of fruit per umbel, number of umbel per plant and seed yield kg per ha.

The twelfth principal component (PC12) contributed to 1.60 per cent of total variation and had high positive weight for plant height including main umbel, seed yield per plot, number of fruits per umbel and number of umbels per plant.

The thirteenth principal component (PC13) contributed to 1.30 per cent of total variation and had high positive weight for seed yield per plot, plant height upto main umbel, number of fruits per umbel and days to 50 per cent flowering.

Broschat (1979) considered PCA as powerful technique for data reduction which removes interrelationships among components. Results reported by various researchers showed multivariate analysis as a valid system to deal with germplasm collection.

4.6 Non-hierarchical Euclidean cluster analysis

Non-hierarchical Euclidean cluster analysis was done to study divergence on 90 genotypes and three checks of coriander in respect of various morphological economic traits. The genotypes were grouped into 6 non over-lapping clusters.

Appropriate cluster arrangement was determined by using ‘F’ test. It was determined that cluster combination with 5 and 6 were most appropriate for the material, because the “F” value was significant at 5 per cent level of significance than the expected “F” values. The averages inter and intra cluster distances have been presented in table 4.12.

Table 4.11: Sequential F-ratio tests for comparison of cluster solutions

Cluster number	Degree of freedom (df^1)	Degree of freedom (df^2)	'F' value
5 and 6	11	957	3.78*

*** Significance at 5 per cent level of probability**

The Inter and Intra cluster distances were presented in Table 4.13. The intra cluster distance was ranged from 0.000 to 2.997. The maximum intra cluster distance was found in cluster III (2.997) and minimum in cluster V and VI (0.000). The clustering pattern does not correspond to their pedigree in general. The maximum inter cluster distance 10.294 was found in between clusters IV and VI, followed by 10.279 between clusters I and VI and 10.047 between cluster II and VI. Whereas, inter cluster distance 10.022 between cluster III and VI and 9.288 between cluster II and V. The cluster I had maximum number 25 genotypes namely ACr-4, ACr-20, ACr-25, MKSM-1084, UD-594 ,UD-607, UD-609, UD610, UD-615, UD-618, UD-620, UD-684, UD-699, UD-704, UD-715, UD-716, UD-717, UD-719, UD-742, UD-746, UD-748, UD-752, UD-753 and UD-784

followed by cluster number clusters II which had 23 genotypes namely ACr-10, ACr-18, ACr-19, ACr-23, ACr-24,SC-13, UD-601, UD-610, UD-622, UD-623, UD-634, UD-635, UD-643, UD-689, UD-720, UD-722, UD-730, UD-743, UD-744, UD-745, UD-747, UD-750, UD-787, UD-789, and cluster III contains 23 genotypes namely ACr-13, MKSM-1052, MKSM-1055, MKSM-1056, MKSM-1059, MKSM-1065, MKSM-1059, MKSM-1072, MKSM- 1079, MKSM-1101, MKSM-1104, MKSM-1111, MKSM-1119, MKSM-1122, MKSM-1125, SC-1, SC-6 , SC-8 , SC-10, SC-11, SC-12, UD-718, genotype in each cluster and cluster IV had 20 genotype namely ACr-1, MKSM-1088, MKSM-1091, MKSM-1117, SC-4, SC-9, UD-325, UD-326, UD-373, UD-590, UD-603, UD-605, UD-711, UD-721, UD-725, UD-728, UD-772, UD-788, Pant Haritima and ACr-728 and cluster V and VI had one genotype in each cluster namely UD-727 and MKSM-1110 respectively.

The cluster mean and standard deviation have been presented in Table 4.13.

Table 4.10: Eigen vectors, Eigen roots values and variation for principal components in 90 germplasm lines and 3 checks of coriander.

S. No.	TRAITS	EIGEN VECTORS												
		PC1	**PC 2**	**PC 3**	**PC 4**	**PC 5**	**PC 6**	**PC 7**	**PC 8**	**PC 9**	**PC 10**	**PC 11**	**PC 12**	**PC 13**
1.	Days to 50% flowering	0.0593	0.417580	-.257897	-.371410	0.139239	0.233174	0.083466	0.231952	-.134282	0.652817	0.136652	0.065787	0.126179
2.	Plant height upto main umbel (cm)	0.4368	0.076479	-.338696	0.168558	0.189204	0.228986	-.133063	0.011286	0.154045	-.214548	0.088503	-.628160	0.286322
3.	Plant height including main umbel (cm)	0.4470	0.024496	-.353058	0.152951	0.154612	0.132249	-.222175	0.070217	0.158337	-.149747	0.013115	0.619036	-.353504
4.	Number of primary branches per plant	0.0549	-.003963	0.556103	-.054830	0.293922	-.100327	-.573369	0.392545	0.259129	0.100990	0.146182	-.009677	0.081223
5.	Number of secondary branches per plant	0.2295	-.495303	0.113298	0.063159	0.076991	0.286795	0.066612	0.217282	-.173923	0.304446	-.625205	-.121115	-.129718
6.	Number of umbels per plant	0.1559	-.122575	0.374825	-.185618	0.517357	0.334192	0.447364	-.219549	-.103184	-.191355	0.318648	0.087594	-.039334
7.	Number of umbellate per umbel	0.0648	0.314511	0.054513	0.462695	0.255979	-.364229	0.247293	0.412509	-.459765	-.080939	0.002883	-.080557	-.160893
8.	Number of fruits per umbel	0.1542	0.388340	0.269532	0.360136	0.029815	-.035547	0.279239	-.274375	0.493160	0.235959	-.333135	0.124827	0.205458
9.	Number of fruits per umbellate	0.0034	0.074430	0.251008	0.420402	-.518167	0.574207	-.031485	0.146356	-.131509	0.050563	0.335006	0.039954	-.020169
10.	Seed yield per plot (g)	0.4844	-.074371	0.136013	-.090457	-.208049	-.231002	-.109341	-.154119	-.433976	-.025600	-.009304	0.270016	0.582068
11.	Seed yield per plant (g).	0.1747	0.275622	0.140842	-.452085	-.311197	0.078272	0.255303	0.448334	0.166917	-.454296	-.255457	-.004434	-.024443
12.	Seed Yield (kg/ha)	0.4578	0.090489	0.194748	-.171726	-.255700	-.253460	-.032884	-.281129	-.020025	0.232538	0.163171	-.311256	-.571921
13.	Weight of 1000 seeds (g).	0.1517	-.462451	-.129063	0.078890	-.143218	-.290403	0.417500	0.347824	0.369651	0.199935	0.379933	0.044391	0.131002
Eigen Roots		**2.817**	**2.183**	**1.600**	**1.440**	**1.142**	**0.805**	**0.706**	**0.698**	**0.507**	**0.416**	**0.309**	**0.208**	**0.169**
Variation (%)		**21.67**	**16.79**	**12.31**	**11.08**	**8.78**	**6.19**	**5.43**	**5.37**	**3.90**	**3.20**	**2.38**	**1.60**	**1.30**
Variation Cumulative			**38.46**	**50.77**	**61.85**	**70.63**	**76.82**	**82.25**	**87.62**	**91.52**	**94.72**	**97.1**	**98.7**	**100**

Cluster means indicate significant variation as it is indicated from Table 4.13. The days to 50 per cent flowering has the maximum value (97.36 days) in cluster VI fallowed by cluster III (94.36 days) and minimum value has in cluster V (80.36 days) (Fig 5.5.1). Plant height upto main umbel had maximum value in cluster IV (108.44 cm) fallowed by cluster II (99.22 cm) and minimum value in cluster VI (79.85 cm) (Fig 5.5.2). Plant height including main umbel had maximum value in cluster IV (124.15 cm) followed by cluster II (114.4 cm) and minimum value have cluster VI (96.08 cm) (Fig 5.5.3). Number of primary branch per plant had maximum value in cluster II (5.91) followed by cluster I (5.90) and minimum value in cluster VI (3.0090) (Fig 5.5.4). Number of secondary branches per plant had maximum value in cluster I (14.08) than cluster V (12.97) and minimum value had in cluster 0. (9.67) (Fig 5.5.5).

Number of umbels per plant had maximum value in cluster VI (37.44) than cluster I (25.59) and minimum value had in cluster V (14.19) (Fig 5.5.6). Number of umbellates per umbel had maximum in cluster V (5.94) than cluster VI (5.89) and minimum value had in cluster I (4.89) (Fig 5.5.7). Number of fruits per umbel had maximum value in cluster I (37.05) than cluster IV (35.20) and minimum value had in cluster I (24.17) (Fig 5.5.8). Number of fruits per umbellate had maximum value in cluster IV (7.05) than cluster III (6.92) and minimum value had in cluster (3.574) (Fig 5.5.9). Seed yield per plot had maximum value in cluster II (271.10 g) than cluster VI (241.44 g) and minimum value in cluster. (106.28 g) (Fig 5.5.10).

Seed yield per plant had maximum value in three clusters V, VI and II (0.03 g) and minimum value had in cluster. I (0.01 g) (Fig 5.5.11). Seed yield kg per ha maximum value in cluster II (1869.46 kg/ha) than in cluster VI (1828.17 kg/ha) and minimum value had in cluster I (250.83 kg/ha) (Fig 5.5.12). 1000 -seed weight had maximum value in cluster II (11.4 g) than cluster I (11.34 g) and minimum value in cluster VI (16.83 g) (Fig 5.5.13).

Cluster. I had maximum of genotypes 25. It had maximum value of number of secondary branches per plant (14.08). Similarly, i.e. cluster II had maximum value for number of primary branches per plant (5.91), seed yield per plot (271.10 g), seed yield per ha (1869 kg\ ha) and weight of 1000 seed (11.45 g). Cluster III had the maximum value for days to 50 flowering (94.36 days). Cluster IV had the maximum value for the plant height up to main umbel (108.44 cm), plant height including main umbel (124.15 cm) and number of fruits per umbellate. Cluster V had maximum value for number of umbellates per umbel (5.94) and seed yield per plant (0.03 g). Cluster. IV had maximum value for number of umbels per plant (37.44) and number of fruits per umbel (37.05).

Similarly minimum value for number of umbellates per umbel (4.89), number of fruits per umbel (24.17), seed yield per plant (0.01 g) and seed yield (750.83 kg/ha) in cluster I. Cluster III had minimum value for number of secondary branches per plant (9.67). Cluster V had minimum value for days to 50 per cent flowering (80.36 days), number of umbel per plant (14.19), number of fruits per umbellate (3.574) and yield per plot (106.26). Cluster VI had minimum value for plant height up to main umbel (79.85), plant height including main umbel (79.85 cm) and number of primary branches per plant (3.090) and weight of 1000- seed (6.83 g).

. The similar approach earmarking distant genotypes have been emphasized by several workers in clustering for coriander germplasm **Ali *et al*. (2000); Srivastava *et al*. (2000); Ravi *et al*. (2007); Beemnet *et al*. (2011) and Singh *et al.* (2005).**

Table 4.12: Average intra and inter cluster distances between six clusters coriander germplasm.

Cluster.	**I.**	**II.**	**III.**	**IV.**	**V.**	**VI.**
I.	**2.431**					
II.	3.085	**2.643**				
III.	2.890	3.720	**2.997**			
IV.	3.516	2.694	3.261	**2.430**		
V.	9.138	9.288	8.833	9.161	**0.000**	
VI.	10.279	10.047	10.022	10.294	13.414	**0.000**

. The intra cluster distances are shown in bold

Ninety genotypes and three checks were distributed among different clusters. The pattern of distribution, number and per cent of genotypes in different cluster is shown in Table 4.14.

On the basis of present study, outstanding genotypes in respect to various desirable characters are presented in Table 4.15 and 4.16. Table 4.17 shows some of most outstanding genotypes in respect to different traits. These genotypes may effectively used as donor for various characters in yield improvement programme.

Table 4.13: Mean and standard deviation of 13 growth and yield characters of coriander in six clusters.

Cluster No.	Days to 50 per cent flowering.	Plant height upto main umbel (cm).	Plant height including main umbel (cm).	Number of primary branches per plant	Number of secondary branches per plant	Number of umbels per plant	Number of umbellates 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/ha)	Weight of 1000 seeds (g).
I	85.76±7.64	91.65±9.31	158.2±7.69	5.90±0.83	14.08±1.90	25.59±8.20	4.89±0.55	24.17±7.18	6.32±1.26	113.71±40.53	0.01±0.00	750.83±376.53	11.34±1.87
II	89.63±6.36	99.22±8.22	114.04±7.45	5.91±0.66	13.21±2.67	25.34±5.97	5.01±0.66	27.32±8.95	6.84±1.63	271.10±66.47	0.03±0.01	1869.46±512.63	11.45±1.46
III	94.36±18.05	87.25±7.05	98.73±9.14	5.80±0.81	9.67±1.48	23.00±3.65	5.29±0.52	31.16±8.38	6.92±2.02	109.02±49.36	0.02±0.02	976.59±382.90	7.19±2.13
IV	97.75±6.37	108.44±8.76	124.15±8.47	5.82±0.74	11.61±2.32	24.72±6.03	5.73±0.65	35.20±7.69	7.05±1.67	179.00±59.01	0.02±0.01	1348.46±280.80	8.95±1.98
V	80.36±0.00	90.76±0.00	98.57±0.00	6.25±0.00	12.97±0.00	14.19±0.00	5.94±0.00	34.19±0.00	3.574±0.00	106.28±0.00	0.03±0.00	944.00±0.00	9.75±0.00
VI	82.86±0.00	79.85±0.0	96.08±0.00	3.090±0.00	12.92±0.00	37.44±0.00	5.89±0.00	37.05±0.00	5.77±0.00	241.44±0.00	0.03±0.00	1828.17±0.00	6.83±0.00

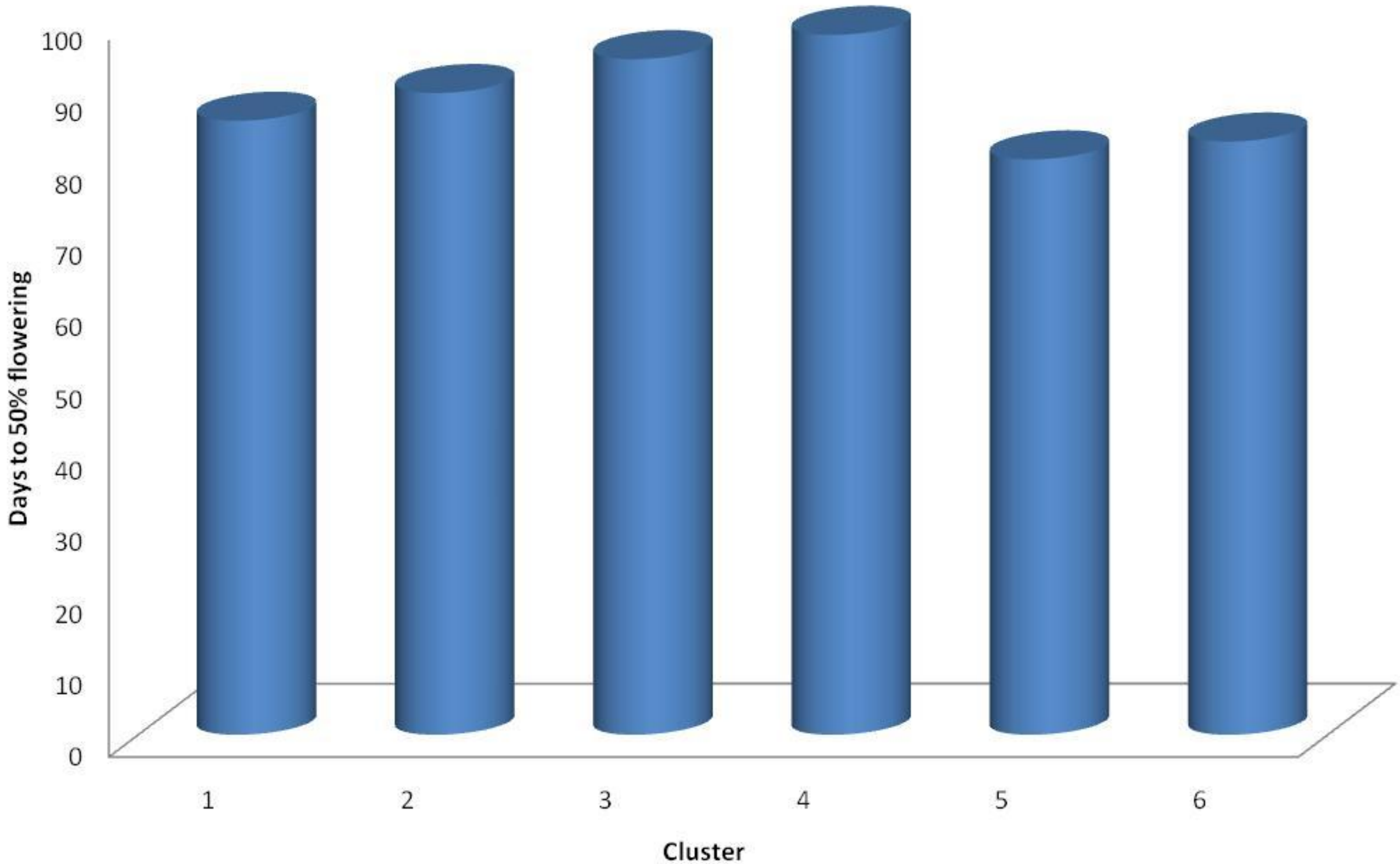

Fig. 5.5.1. Cluster wise mean for Days to 50 per cent flowering

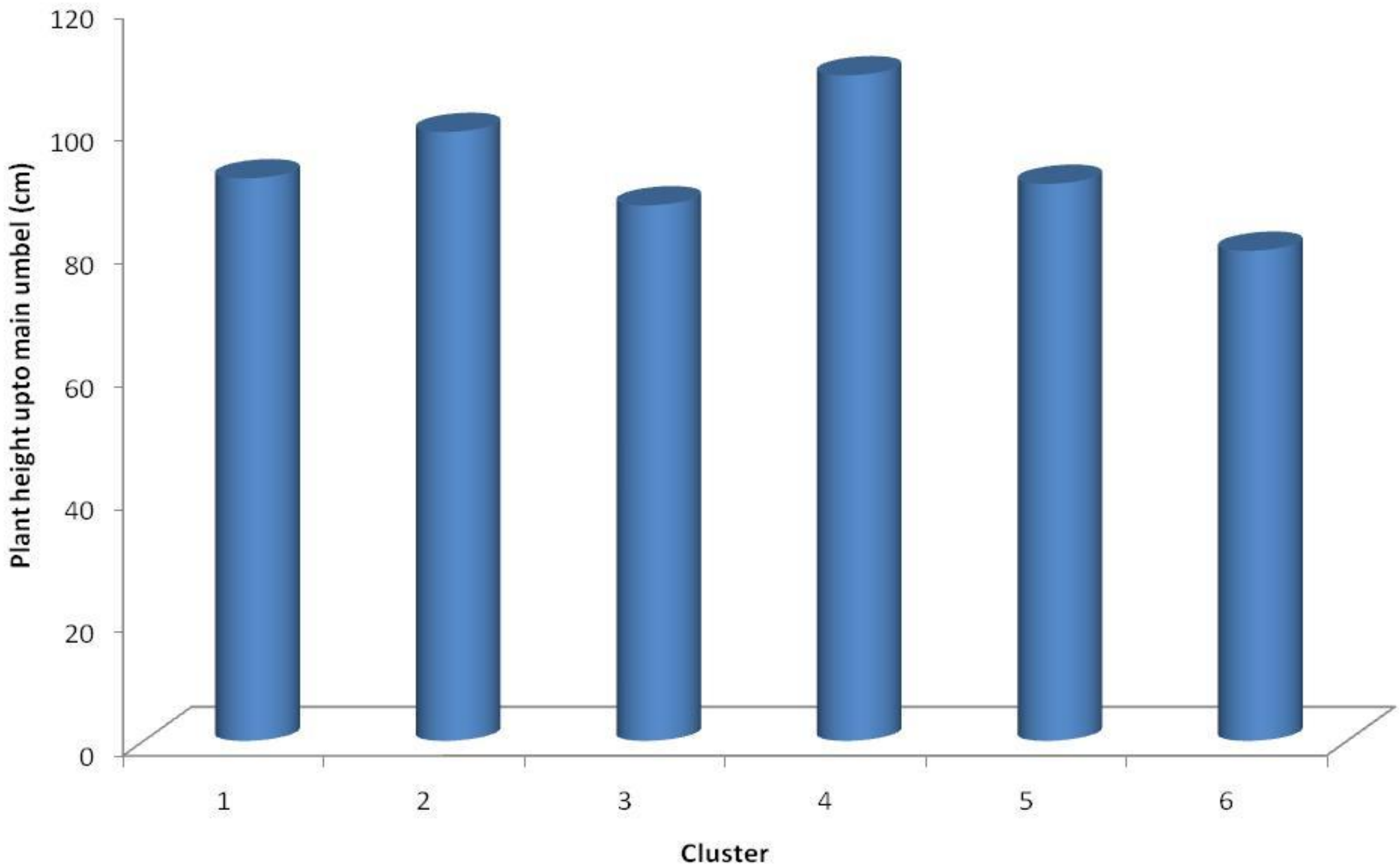

Fig. 5.5.2. Cluster wise means for plant height upto main umbel (cm)

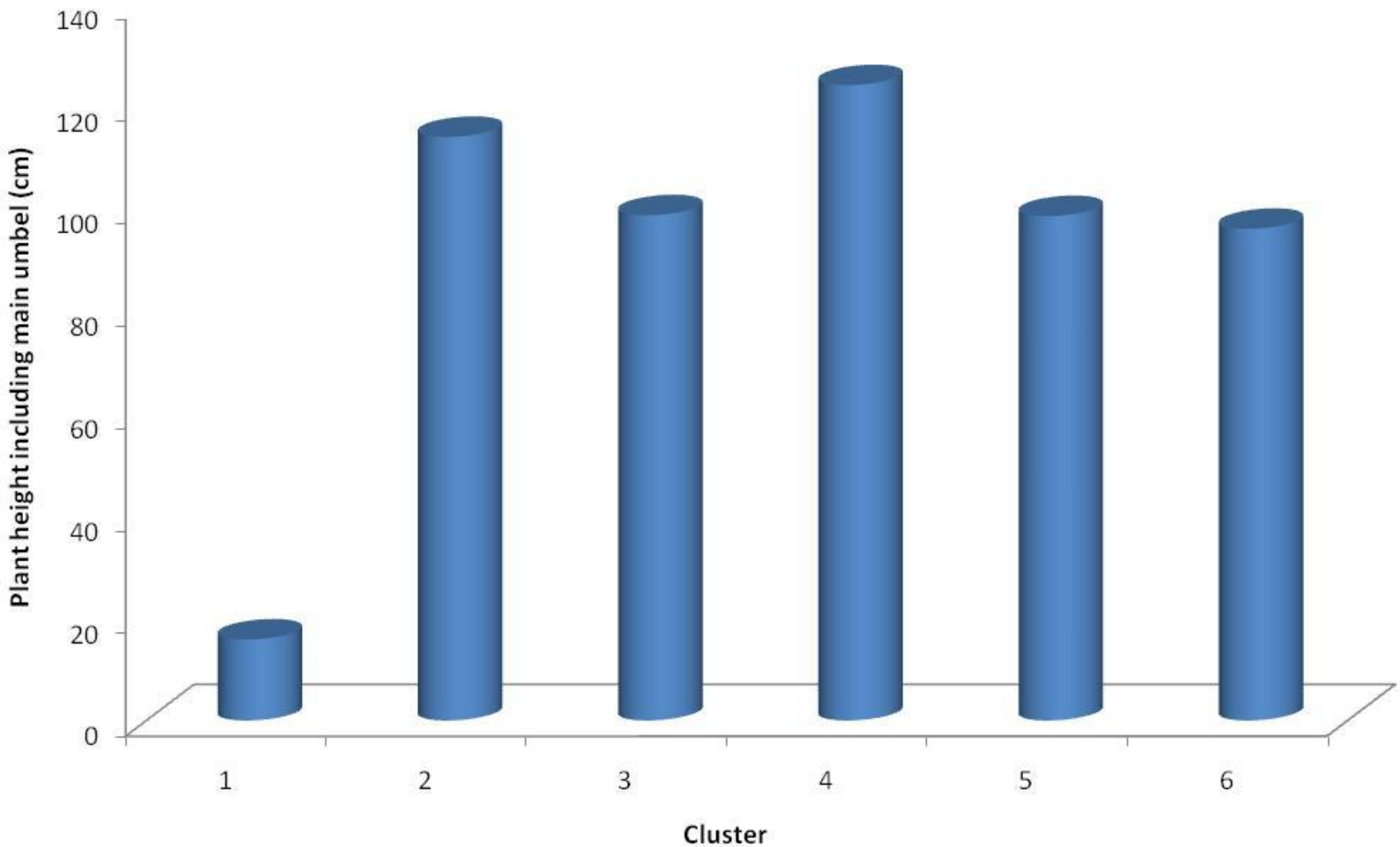

Fig. 5.5.3. Cluster wise means for plant height including of main umbel (cm)

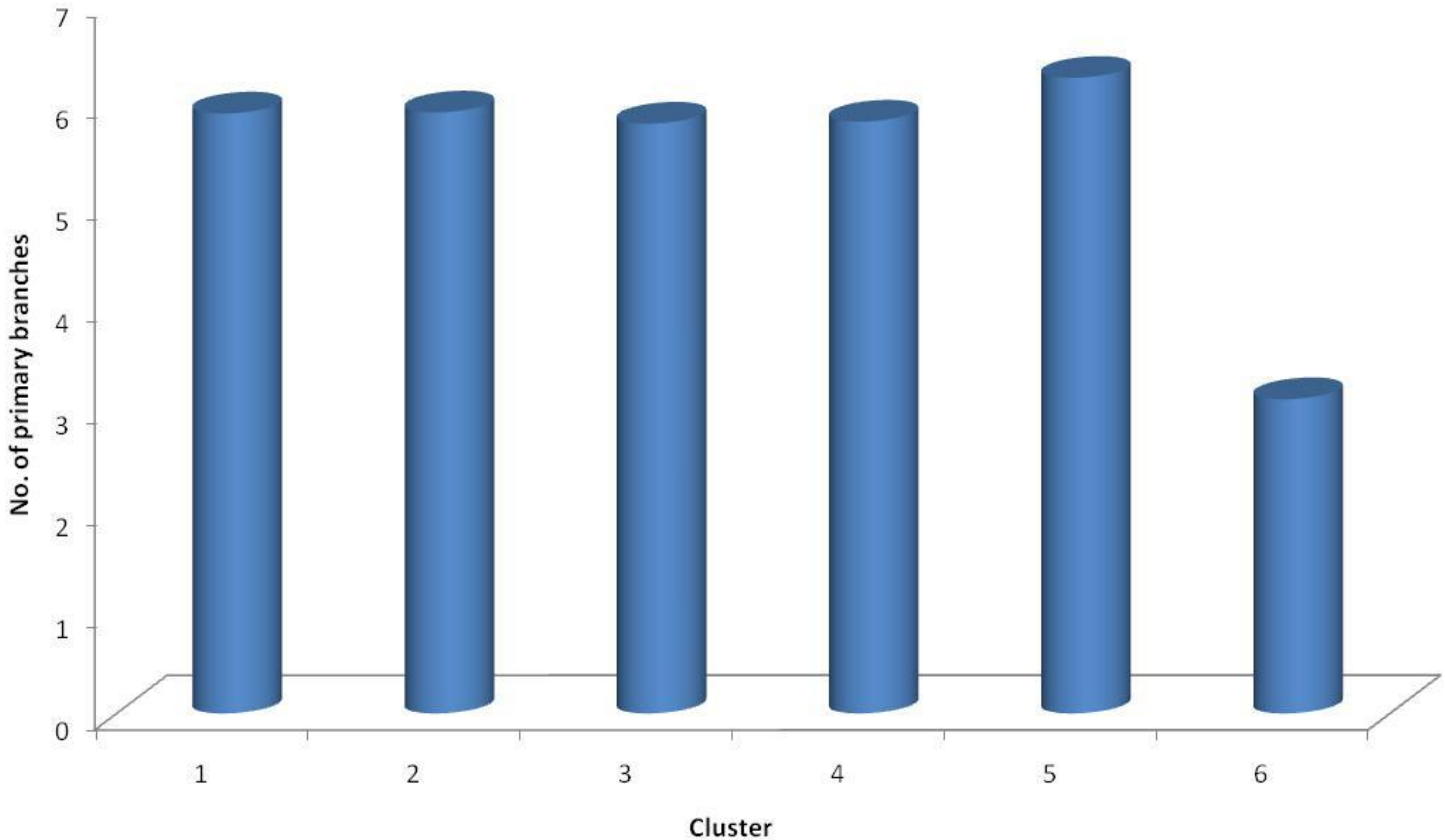

Fig. 5.5.4. Cluster wise means for number of primary branches

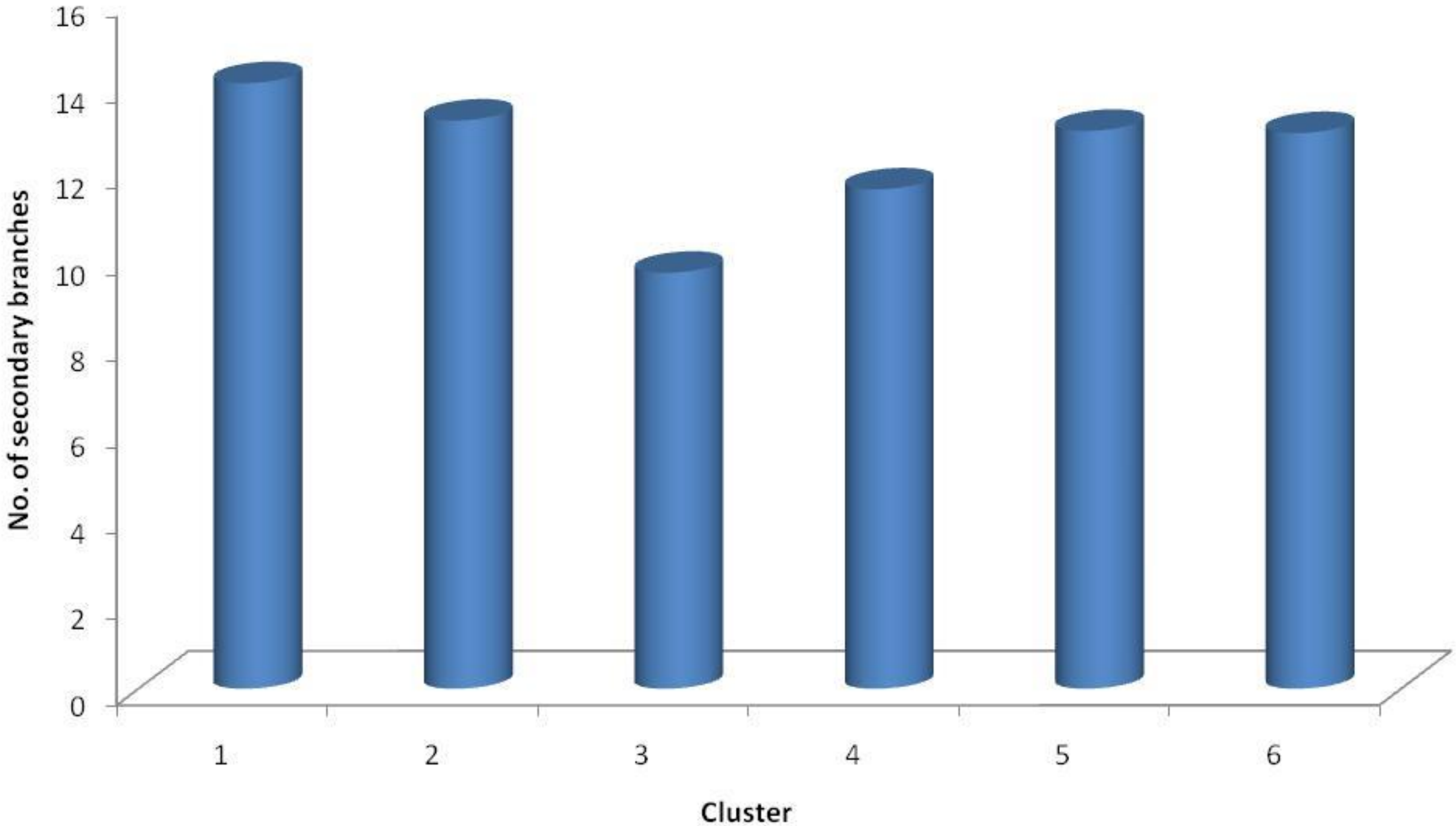

Fig. 5.5.5. Cluster wise means for number of secondary branches

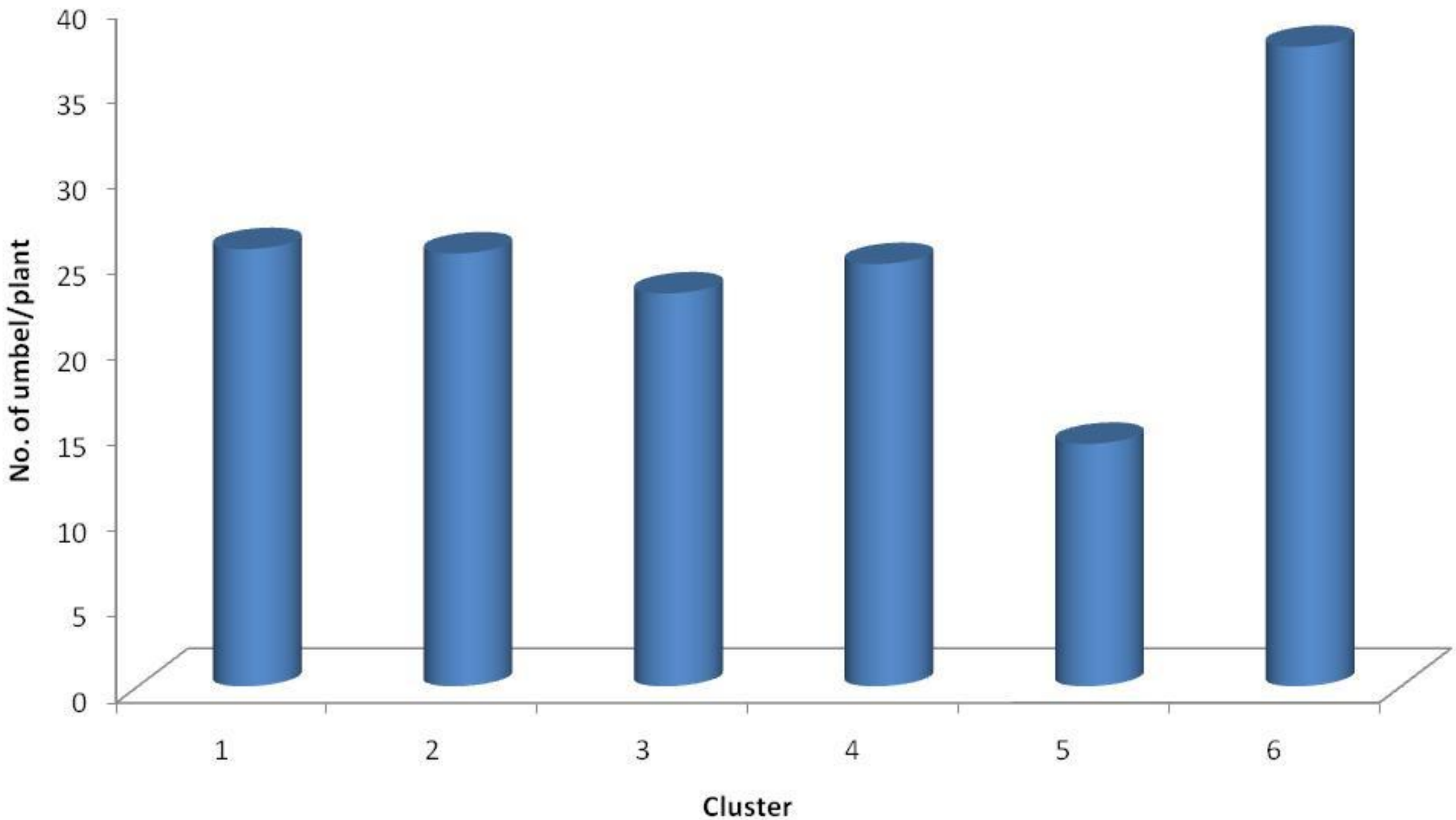

Fig. 5.5.6. Cluster wise means for number of umbel per plant

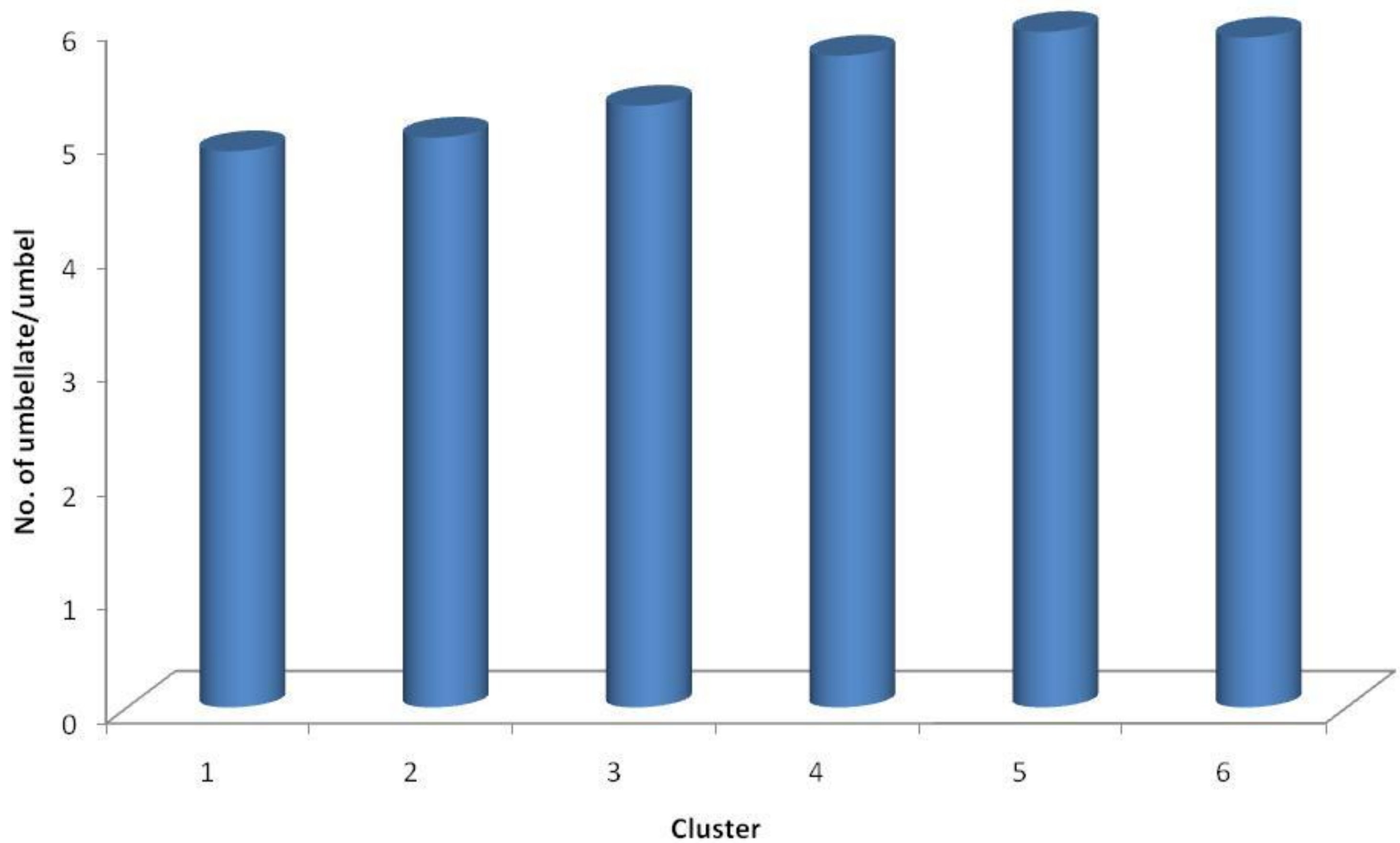

Fig. 5.5.7. Cluster wise means for number of umbellate per umbel

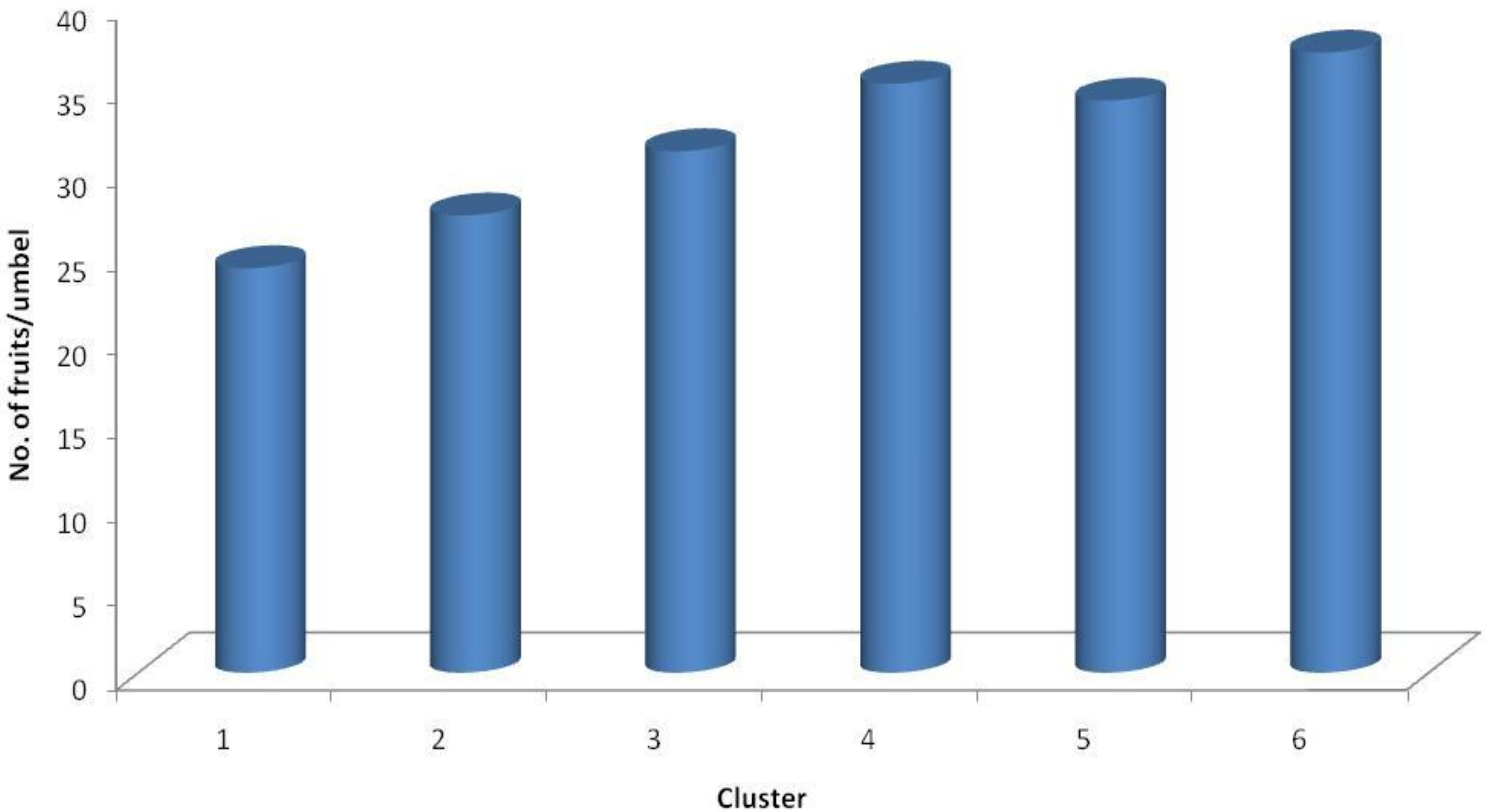

Fig. 5.5.8. Cluster wise means for number of fruit per umbel

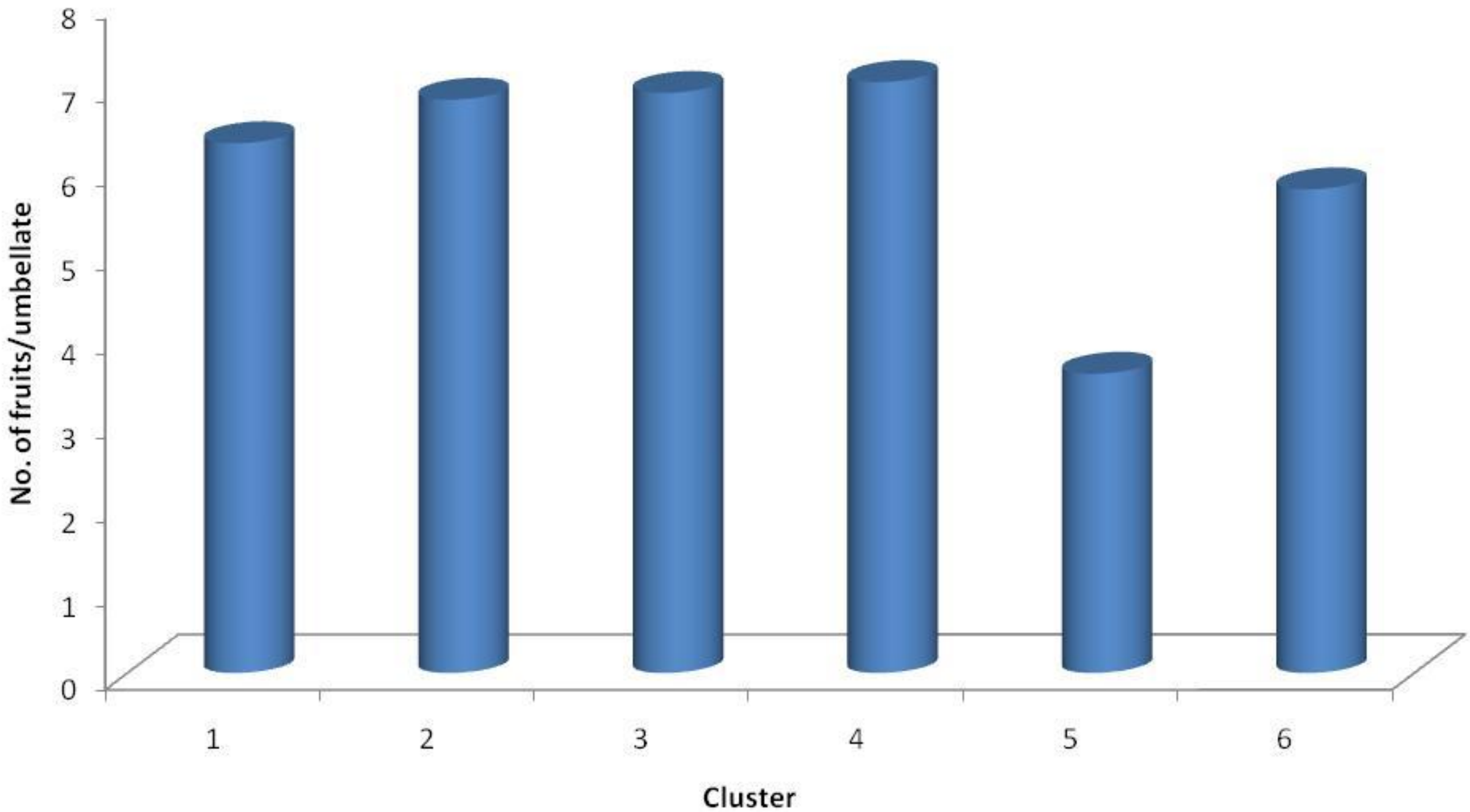

Fig. 5.5.9. Cluster wise means for number of fruit per umbellate

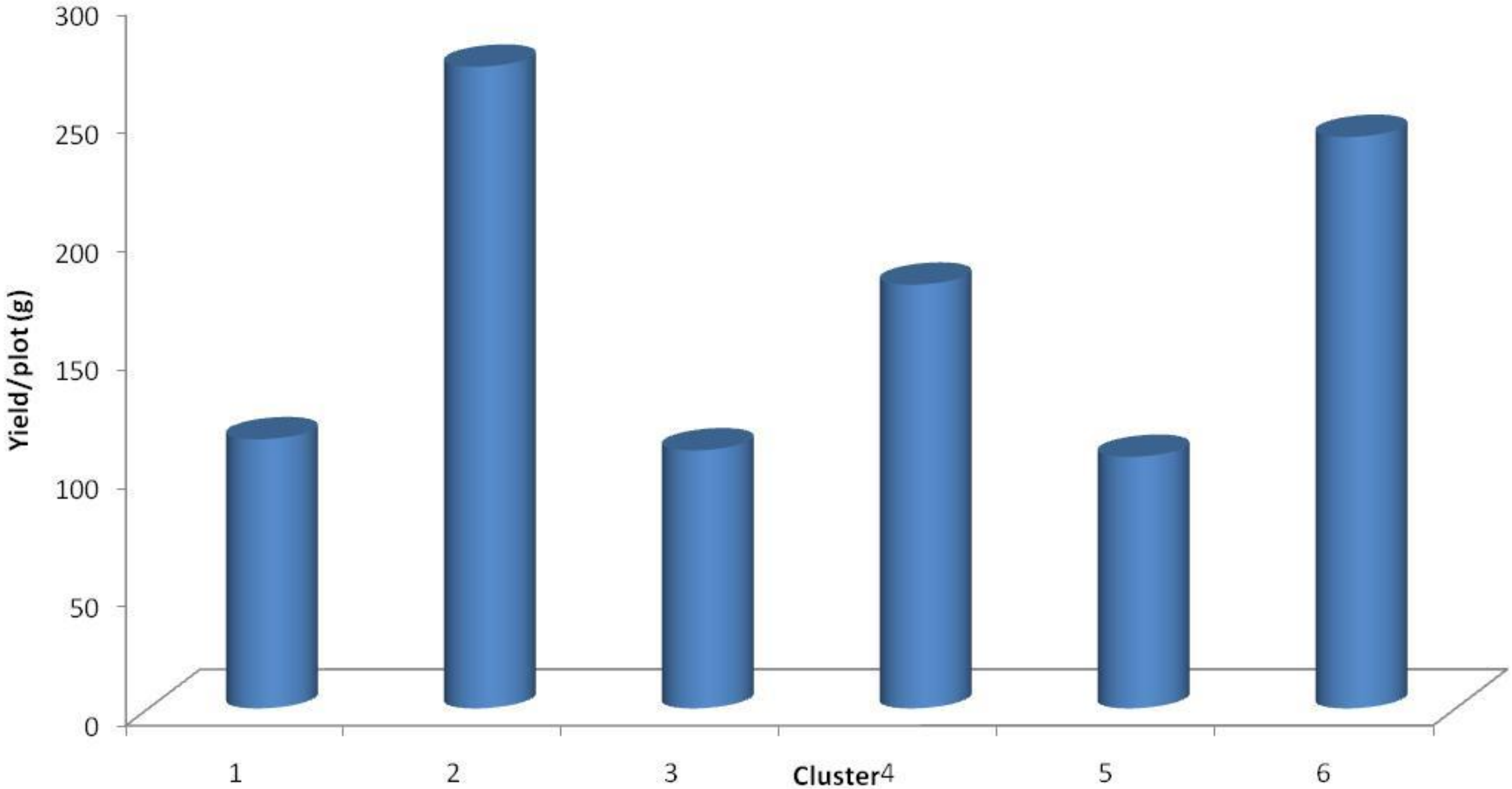

Fig. 5.5.10. Cluster wise means for seed yield per plot(g)

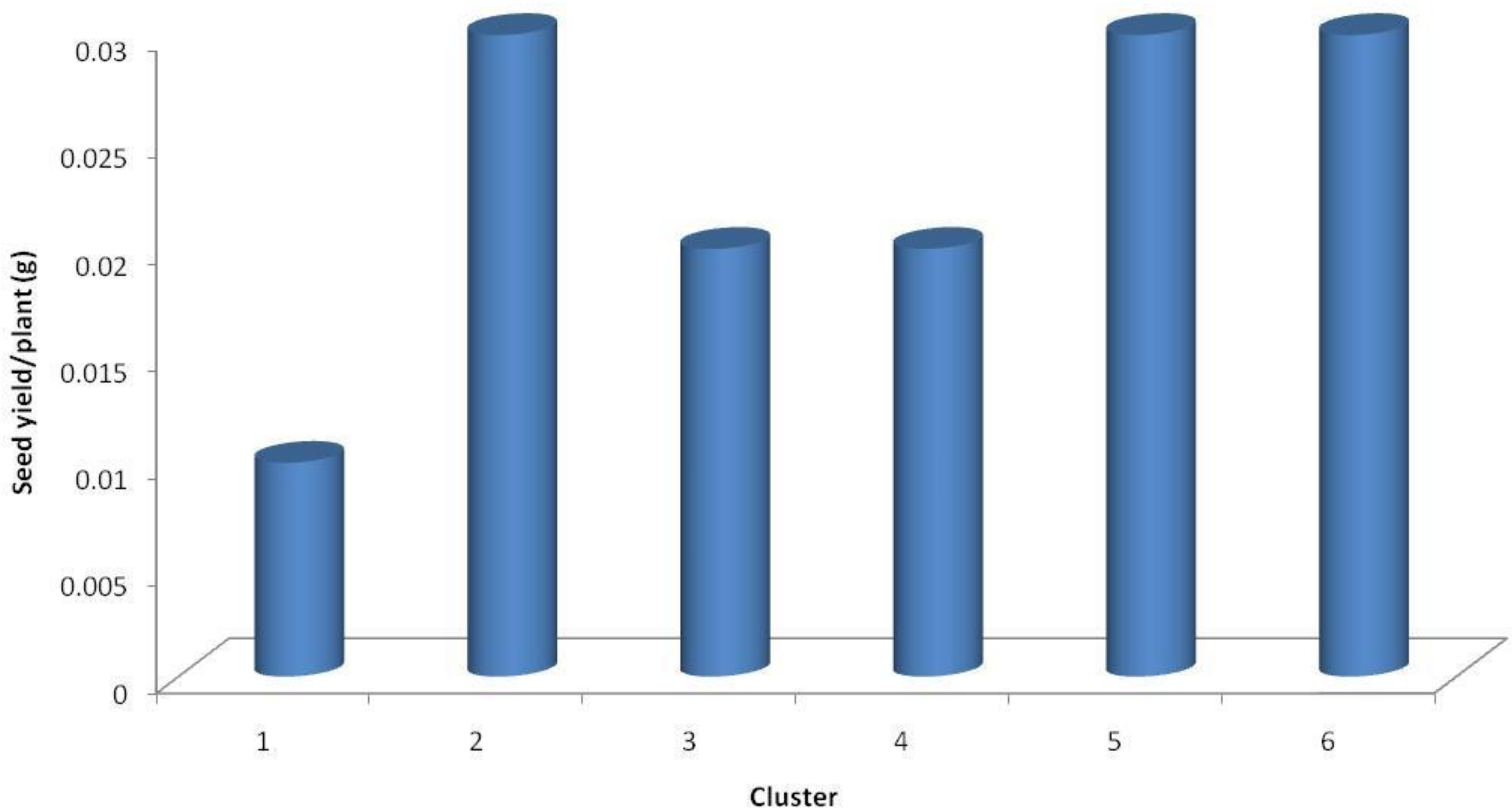

Fig. 5.5.11. Cluster wise means for seed yield per plant (g)

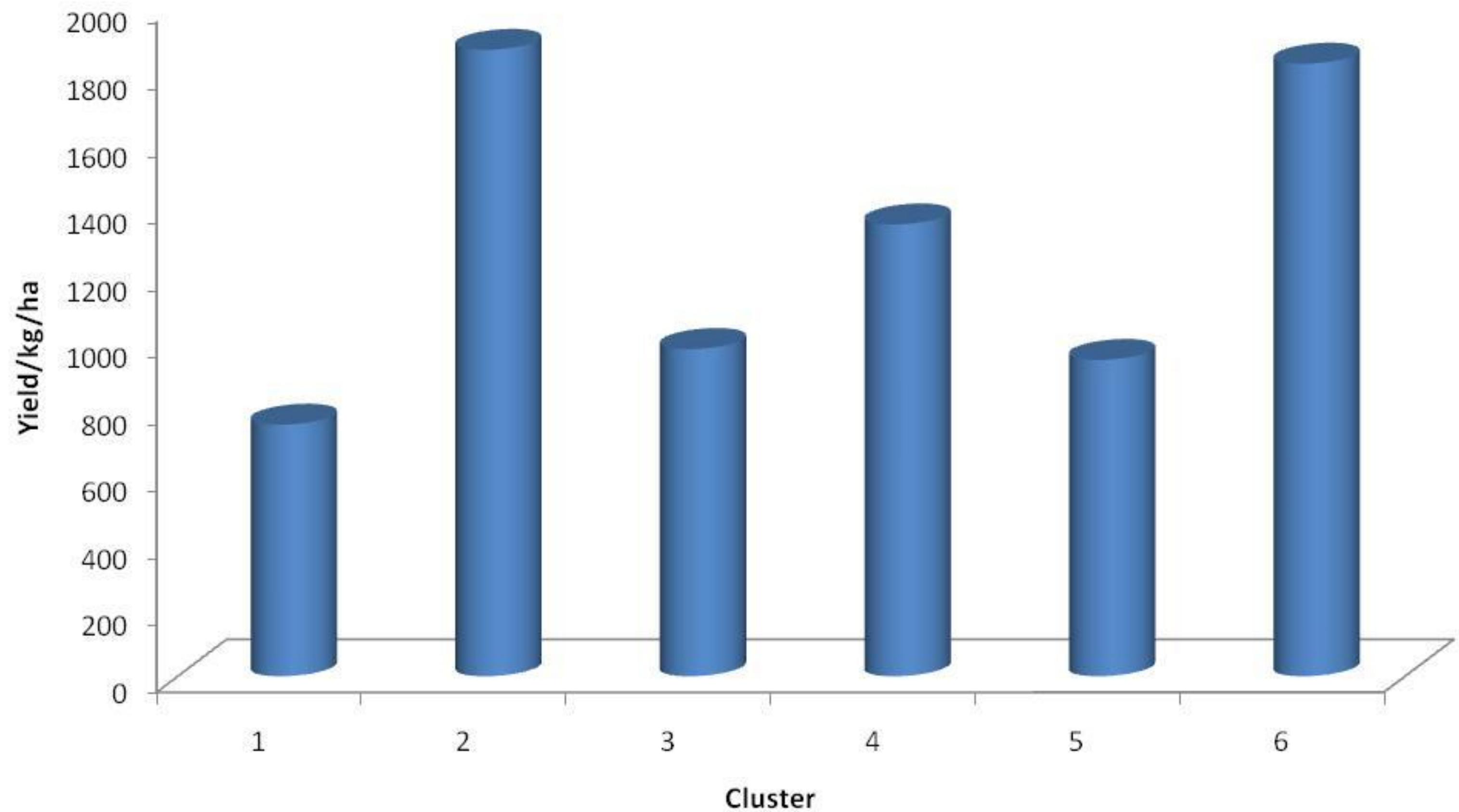

Fig. 5.5.12. Cluster wise means for seed yield kg per ha

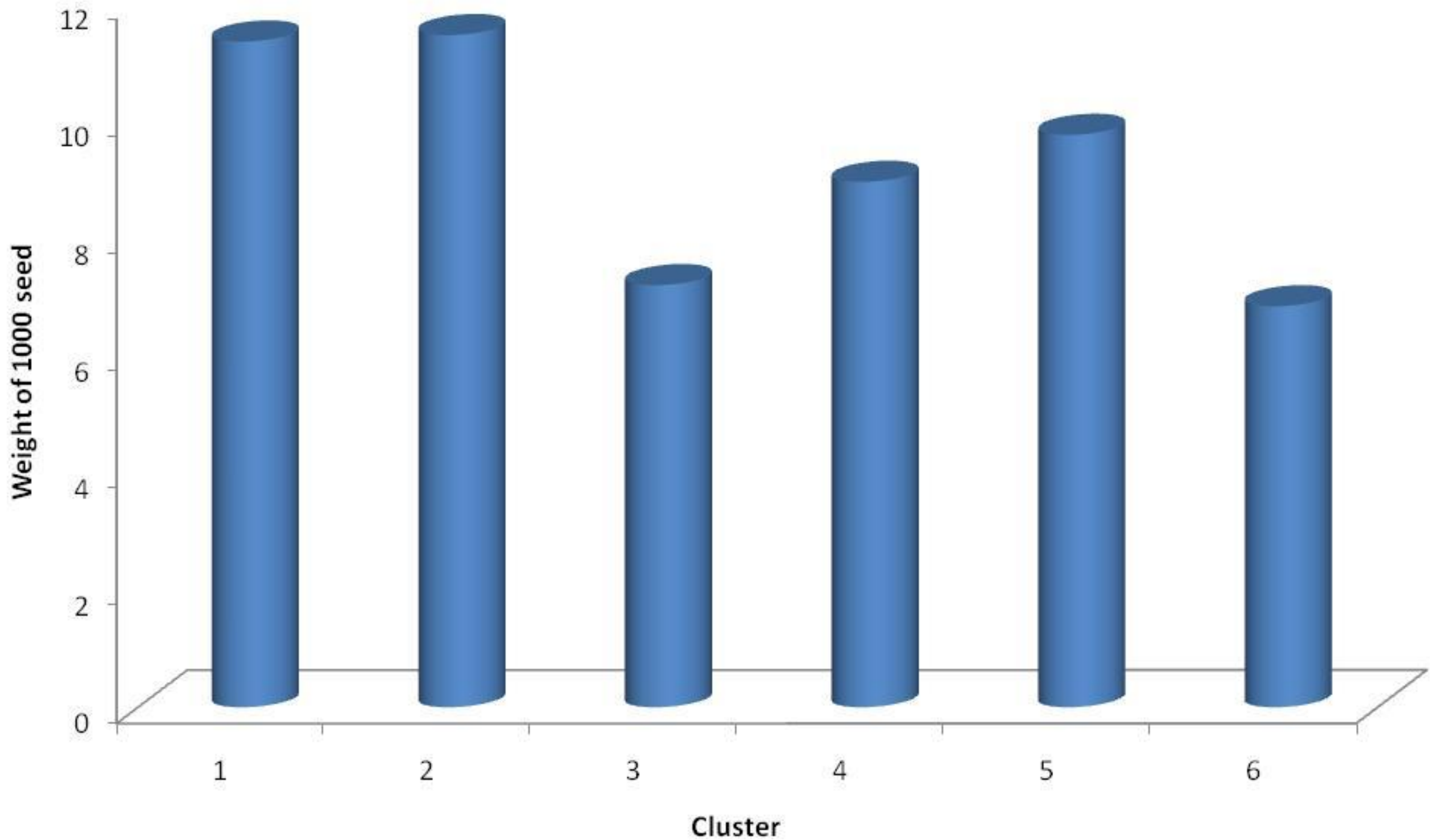

Fig. 5.5.13. Cluster wise means for1000 Seed weight (gm)

Table 4.14: Clustering of genotypes based on growth and yield characters of coriander.

Cluster No.	No. of Genotypes	Per centage of Total Collection (%)	Ajmer	Solan	Jobner	Checks
I.	25	27.78	ACr-4, ACr-20, ACr-25, MKSM-1084,		UD-594, UD-607, UD-609, UD610, UD-615, UD-618, UD-620, UD-684, UD-699, UD-704, UD-715, UD-716, UD-717, UD-719, UD-742, UD-746, UD-748, UD-752, UD-753, UD-784	Hisar Aanand
II.	23	25.56	ACr-10, ACr-18, ACr -19, ACr-23, ACr-24	SC-13	UD-601, UD-610, UD-622, UD-623, UD-634, UD-635, UD-643, UD-689, UD-720, UD-722, UD-730, UD-743, UD-744, UD-745, UD-747, UD-750, UD-787, UD-789.	
III.	23	25.56	ACr-13, MKSM-1052, MKSM-1055, MKSM-1056, MKSM- 1059, MKSM- 1065, MKSM-1059, MKSM-1072, MKSM- 1079, MKSM-1101, MKSM-1104, MKSM- 1111, MKSM-1119, MKSM-1122, MKSM-1125,	SC-1, SC-6 , SC-8 , SC-10, SC-11, SC-12,	UD-718,	
IV.	20	22.22	ACr-1, MKSM-1088, MKSM-1091, MKSM-1117,	SC-4, SC-9	UD-325, UD-326, UD-373, UD-590, UD-603, UD-605, UD-711, UD-721, UD-725, UD-728, UD-772, UD-788	Pant Haritiama, ACr-728
V.	1	1.11	UD-727			
VI.	1	1.11	MKSM-1110			

Table 4.15: List of outstanding genotypes of coriander in respect to various characters in 2009-10.

S. No.	Characters	Superior Check	Genotypes
1.	Days to 50% flowering	Pant Haritma	UD-750, UD-752, UD-787
2.	Plant height upto main umbel (cm)	Pant Haritma	MKSM-1104, MKSM-1117, SC-4, SC-9, SC-11, DU-325, UD-326, UD-373, UD-603, UD-622, UD-634, UD-635, UD-643, UD-684, UD-716, UD-721, UD-725, UD-730, UD-744, UD-747, UD-772, UD- 788, UD-789 and SC-13
3.	Plant height including main umbel (cm)	Pant Haritima	SC-4, SC-9, UD-326, UD-711, UD-725, UD-772 and UD-788
4.	Number of primary branches per plant	Hisar Aanand	No genotype superior to best check
5.	Number of secondary branches per plant	ACr-728	ACr-10
6.	Number of umbels per plant	Pant Haritima	No genotype superior to best check
7.	Number of umbellates per umbel	ACr-728	No genotype superior to best check
8.	Number of fruits per umbel	ACr-728	No genotype superior to best check
9.	Number of fruits per umbellates	Pant Haritima	MKSM-1059, and UD-725
10.	Seed yield per plot (g)	Pant Haritima	UD-622, UD-743, and UD-789
11.	Seed yield per plant (g).	ACr-728	MKSM-1052, MKSM-1119, and UD-718
12.	Seed Yield (kg/ha)	Pant Haritima	UD-622, UD-743, and UD-789
13.	Weight of 1000- seeds (g).	Hisar Aanand	ACr-23, ACr-25, SC-10, UD-325, UD-603, UD-615, UD-620, UD-634, UD-715, UD-722, UD-746 and UD-747

Table 4.16: List of outstanding genotypes of coriander in respect to various characters in 2010-11.

S. No.	Characters	Superior check	Genotypes
1.	Days to 50% flowering	Hisar Aanand	MKSM-1055, MKSM-1104, MKSM-1125 and UD-704
2.	Plant height upto main umbel (cm)	ACr-728	No genotype superior to best check
3.	Plant height including main umbel (cm)	ACr-728	UD-722, UD-721 and UD-789
4.	Number of primary branches per plant	Pant Haritima	No genotype superior to best check
5.	Number of secondary branches per plant	Pant Haritima	MKSM-1084 and ACr-4
6.	Number of umbels per plant	Pant Haritima	No genotype superior to best check
7.	Number of umbellates per umbel	Pant Haritima	MKSM-1088, UD-590 and UD-601
8.	Number of fruits per umbel	ACr-728	ACr-23, MKSM-1088, MKSM-1091, MKSM-1117, MKSM-1125 and UD-590
9.	Number of fruits per umbellate	ACr-728	ACr-10, ACr-23, ACr-1, ACr-18, MKSM-1125, MKSM-1056, MKSM-1059, MKSM-1079, MKSM-1088, MKSM-1091, MKSM-1104, MKSM-1117, SC-9, UD-590, UD-601, UD-610, UD-643 and UD-689
10.	Seed yield per plot (g)	ACr-728	ACr-10, ACr-19, ACr-23, SC-9, UD-601, UD-605, UD-623, UD-634, UD-635, UD-643, UD-689, UD-711, UD-720, UD-750 and UD-787
11.	Seed yield per plant (g).	Pant Haritima	ACr-10, ACr-18, ACr-23, ACr-24, MKSM-1059, MKSM-1065, MKSM-1117, SC-11, SC-12, UD-325, UD-374, UD-720, UD-727, UD-730, UD-743, UD-745, UD-750, UD-772, SC-13 and UD-789
12.	Seed yield (kg/ha)	ACr-728	ACr-10, ACr-19, ACr-23, SC-9, UD-601, UD-605, UD-623, UD-634, UD-635, UD-643, UD-689, UD-711, UD-720, UD-750 and UD-787
13.	Weight of 1000 -seeds (g).	Hisar Aanand	UD-742

Table 4.17: Selected genotypes of coriander outstanding for different characters

S. No.	Genotypes	Character
2009-10		
1.	UD-789	Plant height upto main umbels (cm), Seed yield per plot (g)
2.	UD-725	Plant height upto main umbes (cm), Plant height including main umbel (cm), Number of fruits per umbellate
3.	UD-603,UD-325	Plant height upto main umbels (cm), 1000 -seed weight.(g)
4.	UD-326,SC-4,SC-9	Plant height upto main umbels (cm), Plant height including main umbels (cm)
5.	ACr-10	Number of secondary branches per plant
6	UD-752	Days to 50 per cent flowering
2010-11		
1.	ACr-23	Number of fruits per umbel, Number of fruits per umbellate. Seed yield per plot (g), Seed yield per plant (g) and Seed yield (kg per ha)
2.	UD-601	Number of umbellate per umbel, Number of fruits per umbellate, seed yield per plot and Seed yield (kg per ha)
3.	MKSM-1117	Number of fruit per umbel, Number of umbels per plant and Seed yield (kg per ha)
4.	UD-590	Number of umbrellastes per umble , Number of fruits per umbel and Number of umbels per plant
5.	UD-789	Plant height including main umbels (cm) and Seed yield per plot (g),
6	UD-689	Number of fruits per umbellates. Seed yield per plot (g), and Seed yield (kg per ha)
7	MKSM-1125	Days to 50 per cent flowering, Number of fruits per umbellates

Summary & Conclusion

Chapter- 5 SUMMARY AND CONCLUSION

The present investigation "Evaluation of coriander (*Coriandrum sativum* L.) germplasm for growth and yield characters under *Tarai* conditions of Uttarakhand" was undertaken with the objectives to estimate extent of genetic variability, character association among agronomic characters, path coefficient analysis, principal component analysis and non-hierarchical Euclidean cluster analysis.

The experiment was conducted during *Rabi* season of 2009-10 and 2010-11 with 90 genotypes in Augmented Block Design including three checks (Pant Haritima, Hisar Anand and ACr-728) at Vegetable Research Center, G.B.Pant University of Agriculture and Technology.Pantnagar,Uttarakhand,

Observations were recorded on thirteen growth and yield characters namely days to 50 per cent flowering, plant height up to main umbel, plant height including main umbel, number of primary branches per plant, number of secondary branches per plant , umbels per plant, umbellates 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),

The pooled data were subjected to statistically analysis the results obtained and summarized as follows:

1.Analysis of variance revealed highly significant differences for number of fruits per umbel and significant differences were observed between check for plant height upto main umbel and number of umbels per plant in 2009-10, in 2010-11 Highly significant difference was observed between block for number of umbellates per umbel and highly significant difference was absorbed between check for plant height upto main umbel, number of secondary branches per plant, number of umbellates per umbel, seed yield per plot (g), seed yield kg per ha and weight of 1000- seed and significant diffeferance for plant height including main umbels,

The analysis of variance for few traits showed highly significant differences among genotypes indicating sufficient amount of variation for those characters.

1. The performance of genotypes were evaluated on the basis there performance with respect to best check for that character. Three genotypes viz. UD-725, ACr-10 and UD-752, showed best performance in 2009-10 and in 2010-11. Genotypes ACr-23, UD-601, MKSM-1117 and UD-789 showed best performance with reference to seed yield Based on the average performance of two years UD-787 was best genotype.

2. The range of variation was maximum for number of primary branches per plant, number of umbels per plant, number of fruits per umbellate, seed yield per plot (g), seed yield kg per ha and 1000-seed weight.

3. Character association analysis indicate that seed yield (kg per ha) exhibited significant and positive correlation with plant height upto main umbel, plant height including main umbels, number of fruits per umbel, seed yield per plot and seed yield per plant.

4. The path coefficient analysis revealed that the highest direct effect was shown by seed yield per plot (g), toward on seed yield (kg per ha) followed by number of fruits per umbel, seed yield per plant, 1000-seed weight , days to 50 per cent flowering, number of primary branches per plant and plant height upto main umbels.

5. The principal component analysis was done on correlation matrix of important economic traits of coriander. First 10 principal components explain 94.72 per cent of total variation. The maximum variation of 21.67 per cent was explained by first latent vector followed by second vector (16.79 per cent) and third vector (12.31 per cent). It is evident from the above trend that traits such as, seed yield per plot (g), seed yield kg per ha, plant height including main umbel, plant height upto main umbel. number of secondary branches per plant, number of umbels per plant, number of fruits per umbel, weight of 1000-seed weight, days to 50 per cent flowering, number of umbellates per umbel, seed yield per plant, number of primary branches per plant and number of fruits per umbellate.

6. Ninety genotypes and three checks were classified into six non-over lapping clusters on the basis of non-hierarchical Euclidean cluster analysis for yield and growth traits. The maximum (2.997) intra cluster distance was seen in cluster III and minimum (0.000) was observed in VI and V. The maximum inter cluster distance 13.414 was found in between clusters VI and V, followed by 10.279 between clusters I and VI than 10.047 between clusters II and VI. Whereas, minimum inter cluster distance 2.694 was observed between clusters IV and II, followed by 2.890 between clusters III and I and 3.085 between clusters II and I. Cluster I have the maximum number of genotypes (25) followed by cluster II and III have 23 genotypes in each cluster. The minimum numbers of genotypes have cluster V and VI only one genotypes in each cluster. The grouping of genotypes in clusters reflects the relative divergence of clusters and allows a convenient selection group of genotypes with their overall phenotypic similarity for hybridization programme facilitating better exploitation of germplasm. Thus it may be suggested that crosses between accessions of clusters VI & V, I & VI and II & VI may result in substantial segregates and further selection for overall improvement of species may be possible.

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Appendices

Appendix-I

Layout of Experiment (2009-10)

MAIN CHANNEL

MKSM-1125		UD-750	**DH-5**		**Acr-728**	UD-742		UD-730
ACr-23		UD-715	MKSM-1069		UD-745	UD-325		**PH**
MKSM-1055		UD-373	Acr-10		UD-326	UD-643		UD-787
MKSM-1104		UD-768	Acr-18		UD-603	**Acr-728**		UD-753
P.H		UD-721	Acr-24		UD-744	UD-607		UD-727
ACr-1		**Acr-728**	MKSM-1072		**DH-5**	UD-711		UD-**725**
MKSM-1087		UD-722	MKSM-1039		UD-717	UD-699		UD-720
Acr-20		UD-609	Acr-25		UD-743	UD-622		UD-**623**
DH-5	**SUB CHANNEL**	MKSM-1088	**P.H**	**SUB CHANNEL**	UD-728	UD-748	**SUB CHANNEL**	**DH -5**
SC-8		MKSM-1122	MKSM-1119		UD-722	UD-704		UD-788
SC-10		**DH-5**	MKSM-1101		UD-716	**PH**		UD-615
SC-4		MKSM-1052	MKSM-1056		UD-718	UD-590		UD-**719**
SC-9		MKSM-1117	Acr-4		UD-635	UD-746		UD-601
SC-1		MKSM-1059	Acr-13		**P.H**	UD-618		UD-**314**
SC-11		MKSM-1065	MKSM-1091		UD-594	UD-689		UD-620
SC-12		Acr-11	**Acr-728**		UD-605	UD-684		UD-634
SC-6		MKSM-1110	Acr-19		UD-610	UD-789		Acr-728
ACr-728		**PH**	MKSM-1111		UD-752	**DH-5**		UD-747

3.0m **0.5m**

19.5m

Layout of Experiment (2010-11)

MAIN CHANNEL

UD-730		**Acr-728**	UD-742		UD-750	**DH-5**		MKSM-1125
UD-787		UD-745	UD-325		UD-715	MKSM-1069		**P.H**
UD-753		UD-326	UD-643		UD-373	Acr-10		Acr-23
UD-727		UD-603	**Acr-728**		UD-768	Acr-18		MKSM-1055
P.H		UD-744	UD-607		UD-721	Acr-24		MKSM-1104
UD-725		**DH-5**	UD-711		**Acr-728**	MKSM-1072		Acr-1
UD-720		UD-717	UD-699		UD-722	MKSM-1039		MKSM-1087
UD-623		UD-743	UD-622		UD-609	Acr-25		Acr-20
DH-5	**SUB CHANNEL**	UD-728	UD-748	**SUB CHANNEL**	MKSM-1088	**P.H**	**SUB CHANNEL**	SC-8
UD-788		UD-722	UD-704		MKSM-1122	MKSM-1119		SC-10
UD-615		UD-716	**PH**		**DH-5**	MKSM-1101		SC-4
UD-719		UD-718	UD-590		MKSM-1052	MKSM-1056		**Acr-728**
Acr-728		UD-635	UD-746		MKSM-1117	Acr-4		SC-9
UD-601		**P.H**	UD-618		MKSM-1059	Acr-13		SC-1
UD-314		UD-594	UD-689		MKSM-1065	MKSM-1091		SC-11
UD-620		UD-605	UD-684		Acr-11	**Acr-728**		**DH-5**
UD-634		UD-610	UD-789		MKSM-1110	Acr-19		SC-12
UD-747		UD-752	**DH-5**		**PH**	MKSM-1111		SC-6

3.0m **0.5m**

19.5m

Appendix-II

Monthly weather data of Pantnagar during crop period (Nov 2009 to May 2010)

Period	Meteorological Data				
	Mean temperature		Relative Humidity %		Total Rainfall (mm)
	Max.	Min.	Morning	Evening	
Nov	25.9	11.3	89	44	20.6
Dec	22.8	6.8	92	48	0.0
Jan	16.5	6.9	94	72	2.6
Feb	23.5	8.9	89	52	62.2
Mar	31.5	14.0	86	37	0.2
Apr	37.4	18.0	67	21	26.4
May	37.1	23.0	67	36	18.8

Monthly weather data of Pantnagar during crop period (Nov 2010 to May 2011)

Period	Meteorological Data				
	Mean temperature		Relative Humidity %		Total Rainfall (mm)
	Max.	Min.	Morning	Evening	
Nov	28.9	10.6	90	33	3.2
Dec	23.5	6.8	94	48	0.8
Jan	20.1	5.8	97	53	10.3
Feb	24.0	7.4	93	45	6.1
Mar	29.3	11.7	89	40	4.1
Apr	35.4	17.1	63	26	13.9
May	38.0	22.7	60	32	52.7

Source: Meteorological Observatory, G.B.P.U. & T., Pantnagar

Appendix-III

Table 4.18: Adjusted means of 90 genotypes and 3 checks of coriander in 2009-10

Sl. No.	Accession Number	Days to 50% flowering	Plant height (Up to main umbel) (cm)	Plant height (including main umbel)	No. of primary branches per plant	No. of secondary bran./plant	Umbels/ plant	Umbelletes/ umbel	Fruits/ umbel	Fruit/ umbellete	Yield/ plot (g)	Yield/plant (kg)	Yield (kg/ha)	1000 seed weight (g)
1	Pant Haritima	98.5	105.78	120.63	6.75	17.58	50.83	6.05	39.25	7.15	211.16	0.018	2110.16	9.58
2	Hisar Sonali	99	97.56	118	6.96	17.2	39.16	5.93	38.93	6.45	158	0.019	1762	10.05
3	ARc-728	102.16	104.9	117.31	5.9	20.21	37.5	6.41	42.66	6.35	195.88	0.023	1348.33	9.95
4	ARc -1	94.22	92.82	130.12	5.81	9.67	29.50	5.97	37.65	10.44	68.17	0.023	1346.83	10.99
5	ARc -4	91.22	94.02	113.32	6.01	17.87	73.90	3.57	27.00	4.44	58.17	0.008	1266.83	12.89
6	ARc -10	99.22	91.02	100.72	7.41	28.07	53.50	4.57	60.60	10.24	268.17	0.030	2946.83	11.89
7	ARc -13	85.22	87.82	100.52	5.81	11.67	29.50	4.37	57.65	10.34	98.17	0.033	1586.83	13.49
8	ARc -18	93.22	87.82	91.52	5.81	9.67	56.30	4.57	34.90	7.24	208.17	0.006	2466.83	11.79
9	ARc -19	93.22	96.22	116.92	5.61	9.67	31.90	5.47	22.20	5.24	68.17	0.012	1346.83	11.59
10	ARc -20	95.22	96.22	120.12	6.61	14.67	21.50	4.77	33.60	7.04	38.17	0.008	1106.83	13.89
11	ARc -23	96.22	114.62	124.32	4.81	9.47	17.70	6.17	31.60	5.04	138.17	0.021	1906.83	14.49
12	ARc -24	90.22	100.42	125.32	5.01	7.27	21.10	3.57	26.40	5.34	158.17	0.010	2066.83	10.49
13	ARc -25	92.22	108.82	129.52	6.61	12.27	24.30	4.97	44.80	6.64	48.17	0.010	1186.83	14.09
14	MKSM1052	82.22	84.82	101.12	6.61	13.67	22.50	5.37	32.20	5.34	58.17	0.004	1266.83	5.29
15	MKSM1055	83.22	69.82	99.72	6.81	15.67	26.30	4.77	39.60	7.64	198.17	0.007	2386.83	11.19
16	MKSM1056	82.22	102.82	106.92	6.21	10.07	23.70	4.17	43.60	10.04	98.17	0.013	1586.83	5.19
17	MKSM1059	78.22	100.02	118.72	5.61	8.07	20.70	5.37	45.20	11.64	48.17	0.016	586.83	7.89
18	MKSM1065	91.22	91.82	109.92	5.61	10.47	18.50	5.17	41.00	9.64	98.17	0.009	1586.83	4.79
19	MKSM1059	102.56	108.92	111.55	5.91	9.50	21.43	4.83	26.19	7.49	63.17	0.027	486.50	6.03
20	MKSM1072	93.56	100.92	112.55	7.11	9.30	16.23	5.43	39.19	6.49	103.17	0.013	806.50	8.33
21	MKSM1079	90.56	101.52	109.35	7.11	9.30	19.83	5.63	26.59	7.29	153.17	0.023	1206.50	5.81
22	MKSM1084	97.56	109.72	120.35	8.31	13.30	51.23	3.98	20.99	5.89	153.17	0.030	1206.50	4.53
23	MKSM1088	83.56	111.12	114.95	7.11	11.50	22.03	5.43	33.19	7.49	163.17	0.012	1286.50	5.91
24	MKSM1091	81.56	100.32	123.95	6.71	9.30	28.43	5.23	50.59	4.49	253.17	0.023	2006.50	8.23
25	MKSM1101	92.56	100.12	117.75	7.71	9.70	22.03	4.63	23.59	7.09	203.17	0.010	1606.50	0.43
26	MKSM1104	80.56	122.72	124.95	4.91	11.30	25.83	5.23	23.39	7.69	273.17	0.008	2166.50	4.53
27	MKSM1110	83.56	90.92	93.75	6.91	16.70	34.23	5.83	42.99	2.89	313.17	0.030	2486.50	7.33
28	MKSM1111	91.56	100.12	112.35	7.31	9.70	26.83	5.03	20.19	6.09	63.17	0.017	726.50	11.63
29	MKSM1117	92.56	126.52	133.15	6.71	9.90	19.63	5.23	40.59	7.49	253.17	0.015	2006.50	12.43
30	MKSM1119	81.56	95.92	107.15	9.11	11.50	18.03	4.83	42.94	3.49	163.17	0.067	1286.50	6.63
31	MKSM1122	79.56	105.32	107.35	5.91	12.30	34.63	5.63	22.69	2.09	63.17	0.008	486.50	10.53
32	MKSM1125	78.56	84.52	93.95	7.11	11.90	14.23	5.63	30.19	7.09	53.17	0.011	406.50	8.43
33	SC-1	99.56	115.72	124.35	6.71	12.50	21.63	5.63	42.59	5.29	263.17	0.027	2086.50	4.53
34	SC-4	100.89	133.02	138.92	5.44	11.27	17.63	3.90	37.39	3.65	73.50	0.022	800.50	6.53
35	SC-6	97.89	96.92	42.92	5.34	9.27	20.83	6.50	31.09	4.15	8.50	0.004	280.50	8.25
36	SC-8	94.89	99.22	108.72	6.84	14.27	26.43	5.70	34.79	7.25	93.50	0.022	960.50	11.33
37	SC-9	102.89	143.82	148.72	4.24	7.07	22.23	5.70	34.99	6.53	253.50	0.020	2240.50	3.53
38	SC-10	130.89	83.82	104.72	5.64	8.27	20.03	5.10	22.84	3.45	93.50	0.014	1740.50	3.03
39	SC-11	129.89	67.82	79.52	4.84	6.87	26.23	4.70	12.99	1.85	128.50	0.012	1361.50	5.03
40	SC-12	130.89	85.82	99.92	5.04	7.67	24.83	4.75	18.34	2.65	123.50	0.012	1661.50	3.43
41	UD325	78.89	132.62	136.32	5.64	14.87	27.63	7.30	34.39	2.45	153.50	0.009	1440.50	14.03
42	UD-326	89.89	132.42	139.32	4.64	10.07	31.63	5.50	34.59	5.05	143.50	0.020	1360.50	7.73
43	UD-373	92.89	119.62	130.52	6.04	13.47	30.43	6.30	38.59	5.25	163.50	0.033	1520.50	11.93
44	UD-374	94.89	115.62	117.52	6.64	12.67	27.83	5.90	27.39	4.25	73.50	0.008	800.50	5.33
45	UD-590	94.89	111.62	118.52	4.64	9.47	24.43	6.10	32.39	4.25	143.50	0.012	1360.50	9.63

46	UD594	89.89	130.02	121.72	5.84	15.87	41.23	4.90	30.19	3.05	133.50	0.016	1280.50	11.43
47	UD601	91.89	110.82	112.92	7.04	18.47	39.43	6.90	41.39	4.45	373.50	0.022	3200.50	13.83
48	UD603	92.89	139.02	117.52	7.24	15.07	29.43	6.70	38.79	5.65	303.50	0.017	2640.50	14.33
49	UD605	96.89	115.42	123.82	5.47	13.67	35.50	4.43	10.52	7.02	95.17	0.013	-116.50	11.29
50	UD607	96.89	115.02	107.22	5.87	20.87	29.70	5.43	22.32	5.42	295.17	0.012	1483.50	12.89
51	UD609	76.89	104.42	111.42	6.87	17.07	40.70	5.23	17.72	5.82	135.17	0.018	203.50	11.49
52	UD610	81.89	109.02	117.82	5.87	20.07	32.50	5.23	13.72	6.42	115.17	0.019	43.50	13.69
53	UD615	77.89	100.82	105.42	6.87	22.62	27.50	5.43	21.92	6.42	255.17	0.015	1163.50	16.49
54	UD618	76.89	104.02	95.82	7.27	20.27	27.30	4.03	7.92	6.02	225.17	0.010	923.50	8.79
55	UD620	76.89	95.22	102.42	6.47	18.87	26.30	4.23	12.92	6.02	105.17	0.009	36.50	17.29
56	UD622	91.89	120.82	124.82	6.07	20.37	22.70	5.23	30.92	10.22	405.17	0.011	2363.50	11.79
57	UD623	89.89	110.22	125.42	6.47	21.07	41.50	3.63	13.12	5.57	125.17	0.016	123.50	10.79
58	UD634	94.89	127.82	133.02	6.27	14.87	23.50	4.03	24.12	8.02	205.17	0.017	763.50	16.09
59	UD635	89.89	123.82	133.22	6.67	17.87	33.50	4.43	13.12	8.22	255.17	0.018	1163.50	13.29
60	UD643	89.89	122.02	128.42	6.67	19.27	35.50	5.23	21.12	7.82	125.17	0.018	123.50	11.79
61	UD684	91.89	132.22	123.22	5.67	17.27	20.90	4.63	15.12	6.82	45.17	0.009	516.50	12.19
62	UD689	76.89	116.42	116.62	6.47	17.07	27.30	5.03	12.32	6.42	135.17	0.021	203.50	11.99
63	UD699	78.89	104.82	105.22	5.47	18.07	20.90	4.43	7.92	5.82	55.17	0.013	-436.50	13.59
64	UD704	78.56	109.02	102.48	5.94	20.70	15.97	4.17	20.49	7.49	109.50	0.007	1295.83	8.66
65	UD711	83.56	91.02	158.88	6.74	20.70	12.37	6.57	24.29	8.69	29.50	0.008	655.83	9.16
66	UD715	79.56	97.62	111.48	7.74	21.30	21.57	5.37	25.29	8.09	59.50	0.025	895.83	16.76
67	UD716	79.56	131.42	104.28	7.54	25.30	30.37	4.97	22.69	8.89	139.50	0.006	1535.83	9.06
68	UD717	83.56	84.02	92.28	6.54	18.70	17.57	5.17	17.09	8.49	39.50	0.007	735.83	9.96
69	UD718	83.56	113.42	98.28	7.54	16.70	22.57	5.17	17.69	8.09	169.50	0.080	1775.83	6.56
70	UD719	78.56	107.02	88.28	7.34	16.10	13.97	4.77	22.69	9.29	49.50	0.017	815.83	6.96
71	UD720	79.56	105.42	112.48	6.54	15.70	10.17	4.77	27.79	10.89	108.50	0.013	1287.83	9.96
72	UD721	97.56	119.02	109.08	6.34	17.30	30.97	4.57	28.49	10.29	159.50	0.014	1695.83	7.16
73	UD722	97.56	103.82	112.28	7.94	17.10	23.97	4.97	17.29	7.69	209.50	0.014	2095.83	17.76
74	UD725	99.56	139.22	145.28	7.34	17.90	21.57	4.77	37.09	14.09	209.50	0.033	2095.83	5.46
75	UD727	80.56	96.42	98.68	6.34	16.30	11.57	5.17	26.69	6.43	109.50	0.014	1295.83	9.36
76	UD728	95.56	113.02	118.28	6.34	15.10	14.77	5.37	25.49	10.29	199.50	0.038	2015.83	7.36
77	UD730	78.56	127.82	120.68	7.34	15.50	23.97	5.77	18.09	7.29	159.50	0.009	1695.83	13.56
78	UD742	94.56	100.42	111.88	7.34	16.70	17.37	5.77	18.09	7.89	49.50	0.011	815.83	11.36
79	UD743	88.89	108.62	126.52	5.64	17.80	30.17	4.90	36.42	7.72	420.50	0.023	2826.83	13.59
80	UD744	84.89	126.62	129.92	6.04	15.60	20.77	4.90	38.82	6.52	310.50	0.020	1946.83	9.09
81	UD745	84.89	120.02	123.52	5.44	14.00	28.97	5.50	41.02	8.12	220.50	0.012	1226.83	13.49
82	UD746	84.89	103.42	111.72	6.44	24.40	38.77	6.50	52.42	7.92	77.50	0.017	82.83	14.49
83	UD747	88.89	137.42	109.52	6.24	19.00	27.97	3.90	45.22	9.92	350.50	0.056	2266.83	14.49
84	UD748	90.89	106.62	112.32	5.04	17.75	27.57	4.90	38.62	5.72	130.50	0.017	506.83	12.49
85	UD750	70.89	104.62	110.72	4.84	15.20	17.77	5.70	37.62	7.32	150.50	0.011	666.83	9.59
86	UD752	70.89	109.82	114.92	6.24	15.20	27.57	4.90	33.62	6.32	170.50	0.014	826.83	10.69
87	UD753	85.89	109.82	100.52	5.04	12.60	22.37	4.70	35.82	5.12	330.50	0.017	2106.83	10.19
88	UD768	88.89	109.82	116.92	5.84	17.60	43.97	5.90	39.22	10.92	180.50	0.011	906.83	13.79
89	UD772	90.89	143.22	145.32	5.44	14.40	33.17	5.70	41.02	8.32	200.50	0.020	1066.83	9.99
90	UD787	70.89	112.82	116.72	5.64	15.60	37.97	5.30	36.22	6.12	290.50	0.058	1786.83	11.19
91	UD788	83.89	134.42	142.12	5.04	13.40	18.57	4.70	37.42	6.92	220.50	0.031	1226.83	13.19
92	UD789	84.89	125.62	117.12	5.64	20.00	34.77	4.70	37.22	4.92	430.50	0.017	2906.83	12.29
93	sc-13	93.89	124.42	115.12	5.84	21.00	32.17	5.70	33.92	5.52	380.50	0.022	1916.83	11.19

Table 4.19: Adjusted means of 90 genotypes and 3 checks of coriander in 2010-11

Sl. No.	Accession Number	Days to 50% flowering	Plant height (Up to main umbel) (cm)	Plant height (including main umbel)	No. of primary branches / plant	No. of secondary bran./plant	Umbels/ plant	Umbelletes/ umbel	Fruits/ umbel	Fruit/ umbellete	Yield/ plot (g)	Yield/plant (kg)	Yield (kg/ha)	1000 seed weight (g)
1	Pant Haritima	102.5	94.34	110.17	6.1	11.15	31.03	5.18	32.75	5.84	185.83	0.02	1288	8.64
2	Hisar Sonali	100	75.85	107	4.73	7.45	23.9	4.6	27.01	5.78	88.33	0.018	588.16	10.84
3	ARc-728	107	102.29	119.76	5.85	9.53	25.83	5.15	35.48	6.51	215	0.02	1499.33	7.1
4	ARc -1	101.17	99.71	110.97	4.89	7.54	18.51	5.29	32.22	10.31	203.06	0.020	1291.83	7.07
5	ARc -4	95.17	98.96	102.52	6.89	14.44	28.06	4.84	23.42	6.41	173.06	0.030	1191.83	9.39
6	ARc -10	92.17	97.46	111.47	7.09	13.30	25.86	3.64	42.02	13.31	463.06	0.050	3124.83	8.86
7	ARc -13	95.17	101.16	100.12	4.89	7.54	18.66	5.44	41.22	8.44	123.06	0.030	858.83	10.74
8	ARc -18	95.17	102.46	109.32	6.09	9.34	20.86	5.04	41.62	9.11	243.06	0.050	1658.83	9.18
9	ARc -19	95.17	107.56	108.97	6.25	10.34	20.66	5.04	20.22	4.31	323.06	0.050	2191.83	10.25
10	ARc -20	95.17	102.76	104.72	5.29	9.34	15.26	5.24	42.82	8.31	163.06	0.020	1124.83	11.51
11	ARc -23	95.17	78.36	91.52	5.09	9.47	23.26	5.14	51.22	11.11	333.06	0.050	2258.83	8.84
12	ARc -24	95.17	78.56	100.92	6.29	11.14	27.86	3.84	31.82	7.44	203.06	0.040	1391.83	9.97
13	ARc -25	92.17	79.16	92.12	5.29	10.54	16.46	4.20	25.22	5.11	153.06	0.010	1058.83	9.39
14	MKSM1052	77.17	89.16	107.22	4.89	8.04	22.01	5.04	20.02	6.11	103.06	0.020	724.83	7.57
15	MKSM1055	76.17	79.96	88.32	5.09	6.74	14.06	4.37	24.42	6.31	113.06	0.010	791.83	6.44
16	MKSM1056	77.17	70.71	90.72	5.09	8.29	21.06	4.24	31.02	10.91	93.06	0.020	724.83	5.57
17	MKSM1059	104.17	74.21	102.47	7.49	12.74	28.66	4.84	40.02	10.11	213.06	0.050	1458.83	6.81
18	MKSM1065	94.17	94.96	103.97	6.69	12.74	28.26	4.44	26.02	4.91	223.06	0.040	1524.83	10.88
19	MKSM1059	96.17	60.78	73.07	6.29	7.55	28.84	5.84	42.42	6.25	49.72	0.016	369.83	6.93
20	MKSM1072	94.17	67.38	82.02	5.89	7.55	29.44	5.84	26.87	6.45	129.72	0.006	902.83	7.87
21	MKSM1079	94.17	76.98	82.82	6.89	11.15	29.84	5.44	32.62	9.65	101.72	0.016	536.83	7.32
22	MKSM1084	87.17	96.98	87.82	6.89	15.15	40.84	4.44	22.62	8.65	94.72	0.016	576.83	6.32
23	MKSM1088	97.17	85.73	111.07	6.49	6.35	24.04	8.19	60.42	10.65	109.72	0.016	769.83	5.71
24	MKSM1091	82.17	95.98	108.32	4.89	7.15	25.84	6.64	48.12	10.15	89.72	0.016	635.83	6.37
25	MKSM1101	79.17	69.98	97.82	6.09	12.95	34.04	6.04	33.82	8.25	49.72	0.026	369.83	6.59
26	MKSM1104	76.17	77.23	74.22	4.09	8.35	29.04	4.94	34.42	10.81	69.72	0.016	502.83	5.94
27	MKSM1110	82.17	68.78	98.42	54.89	9.15	40.64	5.94	31.12	8.65	169.72	0.036	1169.83	6.32
28	MKSM1111	82.17	82.98	95.62	4.29	7.95	24.24	6.94	25.42	6.25	59.72	0.016	435.83	8.73
29	MKSM1117	97.17	99.58	114.32	7.29	12.55	33.64	6.24	51.78	10.05	139.72	0.046	969.83	8.57
30	MKSM1119	79.17	79.73	93.32	4.09	5.75	24.84	5.84	37.42	8.90	179.72	0.006	1235.83	6.46
31	MKSM1122	79.17	71.73	82.07	4.39	6.15	29.24	5.44	35.42	8.05	79.72	0.006	569.83	6.29
32	MKSM1125	76.17	57.98	64.82	5.49	9.55	36.04	6.84	49.32	11.45	99.72	0.006	702.83	6.61
33	SC-1	103.17	69.18	93.42	4.89	7.35	15.24	4.64	27.42	6.05	219.72	0.001	1502.83	4.40
34	SC-4	113.17	104.79	114.97	4.96	6.18	15.14	6.38	28.15	6.18	7.06	0.012	2125.50	7.07
35	SC-6	89.17	91.59	119.17	4.86	8.78	15.94	5.58	19.75	4.38	23.06	0.012	192.50	13.04
36	SC-8	110.17	80.59	88.17	5.16	7.98	10.14	6.78	38.95	8.18	103.06	0.012	725.50	5.59
37	SC-9	113.17	100.99	121.17	4.56	8.78	15.14	5.78	42.95	10.18	413.06	0.012	825.50	7.52
38	SC-10	142.17	82.64	88.02	1.76	5.18	10.94	5.18	28.15	4.38	33.06	0.008	258.50	6.12
39	SC-11	138.17	79.39	85.77	3.76	7.38	19.14	4.58	1.95	5.18	53.06	0.092	225.50	6.22
40	SC-12	142.17	80.39	89.52	6.96	6.58	20.74	5.18	32.20	8.18	27.06	0.162	218.50	6.82
41	UD325	109.17	68.21	108.77	5.56	11.58	29.94	5.98	26.55	5.98	193.06	0.052	1325.50	11.52
42	UD-326	113.17	89.79	117.97	6.56	13.38	27.74	5.88	34.55	7.18	63.06	0.022	134.51	5.75
43	UD-373	110.17	87.79	109.02	4.36	8.38	17.14	6.18	32.35	5.38	83.06	0.022	592.50	9.35
44	UD-374	96.17	77.39	100.77	5.76	10.38	20.14	4.98	31.05	6.18	84.06	0.072	717.50	8.32
45	UD-590	89.17	91.59	112.97	4.36	9.78	20.14	7.98	60.45	10.34	173.06	0.012	858.50	8.72
46	UD594	86.17	73.39	107.52	5.56	9.38	22.74	6.33	24.95	6.18	43.06	0.032	325.50	9.92
47	UD601	82.17	93.59	118.77	5.16	10.58	19.94	7.18	37.35	9.58	413.06	0.032	2792.50	8.55

48	UD603	89.17	93.79	112.77	4.36	8.78	18.94	5.58	19.75	4.18	23.06	0.012	192.50	8.75
49	UD605	104.17	96.48	127.75	6.56	9.38	25.18	6.31	26.49	6.18	316.39	0.018	2147.50	10.09
50	UD607	77.17	74.68	92.93	3.56	8.58	18.98	4.31	12.59	4.38	76.39	0.008	547.50	10.91
51	UD609	77.17	67.88	101.73	4.36	9.78	14.18	4.51	11.29	8.18	46.39	0.008	347.50	9.80
52	UD610	77.17	85.68	113.93	4.22	10.78	17.18	6.11	22.09	10.18	66.39	0.008	480.50	10.56
53	UD615	77.17	71.28	94.73	5.96	7.78	23.78	5.31	22.09	4.38	76.39	0.028	547.50	9.45
54	UD618	77.17	86.68	121.43	4.36	10.18	22.43	4.91	21.84	5.18	126.39	0.038	880.50	11.05
55	UD620	77.17	65.28	77.23	5.16	9.38	17.38	4.31	28.69	8.18	136.39	0.008	947.50	8.88
56	UD622	77.17	65.33	97.33	3.96	10.38	24.43	4.31	16.29	5.98	116.39	0.013	814.50	11.08
57	UD623	77.17	66.28	98.98	5.76	10.58	16.78	6.31	20.69	7.18	446.39	0.008	3014.50	8.74
58	UD634	77.17	74.48	106.73	5.16	7.98	17.38	5.11	17.29	5.38	356.39	0.028	2414.50	13.26
59	UD635	104.17	104.28	127.73	6.96	9.38	25.18	3.91	16.69	6.18	346.39	0.028	2347.50	9.83
60	UD643	73.17	76.68	105.53	4.99	11.58	19.78	5.31	21.92	10.34	716.39	0.028	1214.50	8.77
61	UD684	104.17	92.28	125.33	4.96	12.58	21.18	6.51	31.34	6.18	96.39	0.018	680.50	8.20
62	UD689	100.17	77.70	109.73	4.56	9.78	15.78	5.51	19.89	9.58	516.39	0.018	3480.50	9.59
63	UD699	77.17	43.08	101.53	4.36	7.18	15.98	3.51	12.89	4.18	46.39	0.003	347.50	8.80
64	UD704	76.17	91.79	99.65	5.56	11.45	27.41	5.11	17.84	3.00	173.06	0.021	1058.17	13.42
65	UD711	107.17	109.49	129.05	6.36	9.45	18.81	5.51	31.89	5.80	443.06	0.031	2858.17	8.67
66	UD715	83.17	77.79	102.90	6.36	10.85	42.16	4.41	21.59	6.00	153.06	0.021	925.17	13.12
67	UD716	83.17	79.29	98.90	6.96	11.65	20.01	5.51	31.69	7.40	103.06	0.021	592.17	10.95
68	UD717	80.17	64.29	98.25	5.76	7.65	21.81	3.11	15.49	5.00	53.06	0.011	258.17	11.97
69	UD718	83.17	62.04	128.65	4.36	6.25	16.61	5.11	31.69	6.60	93.06	0.011	525.17	11.66
70	UD719	80.17	75.49	98.25	6.46	8.85	16.41	4.11	27.49	8.80	73.06	0.021	392.17	10.14
71	UD720	107.17	91.69	112.85	6.56	12.05	28.81	4.11	19.09	4.20	333.06	0.041	2125.17	8.66
72	UD721	107.17	105.69	132.15	6.16	11.05	18.81	5.31	26.49	5.23	213.06	0.016	1325.17	10.18
73	UD722	107.17	108.49	136.25	5.46	7.85	16.61	5.41	24.49	4.40	213.06	0.011	1325.17	10.07
74	UD725	104.17	90.49	110.65	6.56	10.25	24.81	4.91	33.69	4.60	193.06	0.031	1192.17	10.23
75	UD727	80.17	85.09	98.45	6.16	9.65	16.81	6.71	41.69	7.20	103.06	0.041	592.17	10.15
76	UD728	107.17	103.49	123.05	6.46	10.51	16.41	5.51	30.49	7.20	233.06	0.021	1458.17	7.84
77	UD730	80.17	48.49	86.45	5.79	9.25	20.81	4.51	18.29	5.60	293.06	0.051	1858.17	13.02
78	UD742	103.17	70.69	89.45	6.12	12.45	23.61	5.11	23.09	3.60	133.06	0.021	792.17	14.96
79	UD743	98.17	78.29	103.32	5.89	10.91	13.18	4.87	21.24	4.28	174.72	0.053	1103.17	11.42
80	UD744	76.17	86.49	115.32	7.53	9.71	8.18	5.51	23.24	5.08	184.72	0.023	1170.17	11.18
81	UD745	80.17	72.29	107.72	4.73	6.11	13.18	3.71	9.64	2.28	104.72	0.053	4236.17	12.70
82	UD746	104.17	81.29	115.92	6.93	10.71	16.98	4.37	21.34	6.28	84.72	0.013	503.17	12.72
83	UD747	80.17	82.49	118.72	5.89	8.71	14.18	5.91	17.44	4.28	194.72	0.023	1236.17	13.61
84	UD748	80.17	63.89	101.92	4.33	9.51	12.18	3.51	12.64	3.28	94.72	0.008	570.17	12.51
85	UD750	104.17	66.04	97.52	4.53	10.26	30.33	5.91	26.84	6.48	344.72	0.043	2236.17	11.72
86	UD752	95.17	62.29	103.12	4.73	7.71	17.18	6.11	26.84	5.08	84.72	0.013	503.17	10.98
87	UD753	80.17	70.49	100.07	4.33	10.91	18.38	4.91	20.44	4.28	84.72	0.033	503.17	11.70
88	UD768	83.17	60.29	93.32	4.33	7.31	10.78	5.11	20.24	3.88	104.72	0.013	636.17	11.76
89	UD772	98.17	104.09	128.92	5.33	10.31	19.18	4.87	25.04	3.48	254.72	0.043	1636.17	10.88
90	UD787	101.17	87.09	95.72	4.93	8.71	20.58	5.11	20.84	4.48	424.72	0.033	2770.17	10.42
91	UD788	104.17	104.29	129.32	5.73	10.71	24.18	4.31	29.04	4.88	114.72	0.033	703.17	9.45
92	UD789	100.17	102.29	132.72	5.93	10.51	24.98	4.91	17.84	3.68	94.72	0.043	570.17	9.85
93	sc-13	103.17	98.29	124.32	5.63	10.31	24.38	5.11	19.14	4.48	134.72	0.043	1360.17	10.95

Table 4.20: Two year pooled data of 90 genotypes and 3 checks of coriander

Sl. No.	Accession Number	Days to 50% flowering	Plant height (Up to main umbel) (cm)	Plant height (including main umbel)	No. of primary branches/plant	No. of secondary bran./plant	Umbels/ plant	Umbelletes/ umbel	Fruits/ umbel	Fruit/ umbellete	Yield/ plot (g)	Yield/plant (kg)	Yield (kg/ha)	1000 seed weight (g)
1	Pant Haritima	100.5	100.06	115.4	6.425	14.365	40.93	5.615	36	6.495	198.495	0.019	1699.08	9.11
2	Hisar Sonali	99.5	86.705	112.5	5.845	12.325	31.53	5.265	32.97	6.115	123.165	0.0185	1175.08	10.445
3	ARc-728	104.58	103.595	118.535	5.875	14.87	31.665	5.78	39.07	6.43	205.44	0.0215	1423.83	8.525
4	ARc -1	97.69	96.26	120.54	5.35	8.60	24.00	5.63	34.94	10.37	135.61	0.02	1319.33	9.03
5	ARc -4	93.19	96.49	107.92	6.45	16.15	50.98	4.21	25.21	5.42	115.61	0.02	1229.33	11.14
6	ARc -10	95.69	94.24	106.09	7.25	20.68	39.68	4.11	51.31	11.77	365.61	0.04	3035.83	10.38
7	ARc -13	90.19	94.49	100.32	5.35	9.60	24.08	4.91	49.44	9.39	110.61	0.03	1222.83	12.12
8	ARc -18	94.19	95.14	100.42	5.95	9.50	38.58	4.81	38.26	8.17	225.61	0.03	2062.83	10.49
9	ARc -19	94.19	101.89	112.94	5.93	10.00	26.28	5.26	21.21	4.77	195.61	0.03	1769.33	10.92
10	ARc -20	95.19	99.49	112.42	5.95	12.00	18.38	5.01	38.21	7.67	100.61	0.01	1115.83	12.70
11	ARc -23	95.69	96.49	107.92	4.95	9.47	20.48	5.66	41.41	8.07	235.61	0.04	2082.83	11.67
12	ARc -24	92.69	89.49	113.12	5.65	9.20	24.48	3.71	29.11	6.39	180.61	0.02	1729.33	10.23
13	ARc -25	92.19	93.99	110.82	5.95	11.40	20.38	4.59	35.01	5.87	100.61	0.01	1122.83	11.74
14	MKSM1052	79.69	86.99	104.17	5.75	10.85	22.25	5.21	26.11	5.72	80.61	0.01	995.83	6.43
15	MKSM1055	79.69	74.89	94.02	5.95	11.20	20.18	4.57	32.01	6.97	155.61	0.01	1589.33	8.82
16	MKSM1056	79.69	86.76	98.82	5.65	9.18	22.38	4.21	37.31	10.47	95.61	0.02	1155.83	5.38
17	MKSM1059	91.19	87.11	110.59	6.55	10.40	24.68	5.11	42.61	10.87	130.61	0.03	1022.83	7.35
18	MKSM1065	92.69	93.39	106.94	6.15	11.60	23.38	4.81	33.51	7.27	160.61	0.02	1555.83	7.84
19	MKSM1059	99.36	84.85	92.31	6.10	8.52	25.14	5.34	34.30	6.87	56.44	0.02	428.17	6.48
20	MKSM1072	93.86	84.15	97.28	6.50	8.42	22.84	5.64	33.03	6.47	116.44	0.01	854.67	8.10
21	MKSM1079	92.36	89.25	96.08	7.00	10.22	24.84	5.54	29.60	8.47	127.44	0.02	871.67	6.57
22	MKSM1084	92.36	103.35	104.08	7.60	14.22	46.04	4.21	21.80	7.27	123.94	0.02	891.67	5.43
23	MKSM1088	90.36	98.42	113.01	6.80	8.92	23.04	6.81	46.80	9.07	136.44	0.01	1028.17	5.81
24	MKSM1091	81.86	98.15	116.13	5.80	8.22	27.14	5.94	49.35	7.32	171.44	0.02	1321.17	7.30
25	MKSM1101	85.86	85.05	107.78	6.90	11.32	28.04	5.34	28.70	7.67	126.44	0.02	988.17	3.51
26	MKSM1104	78.36	99.97	99.58	4.50	9.82	27.44	5.09	28.90	9.25	171.44	0.01	1334.67	5.24
27	MKSM1110	82.86	79.85	96.08	30.90	12.92	37.44	5.89	37.05	5.77	241.44	0.03	1828.17	6.83
28	MKSM1111	86.86	91.55	103.98	5.80	8.82	25.54	5.99	22.80	6.17	61.44	0.02	581.17	10.18
29	MKSM1117	94.86	113.05	123.73	7.00	11.22	26.64	5.74	46.18	8.77	196.44	0.03	1488.17	10.50
30	MKSM1119	80.36	87.82	100.23	6.60	8.62	21.44	5.34	40.18	6.19	171.44	0.04	1261.17	6.55
31	MKSM1122	79.36	88.52	94.71	5.15	9.22	31.94	5.54	29.05	5.07	71.44	0.01	528.17	8.41
32	MKSM1125	77.36	71.25	79.38	6.30	10.72	25.14	6.24	39.75	9.27	76.44	0.01	554.67	7.52
33	SC-1	101.36	92.45	108.88	5.80	9.92	18.44	5.14	35.00	5.67	241.44	0.01	1794.67	4.47
34	SC-4	107.03	118.91	126.94	5.20	8.72	16.39	5.14	32.77	4.92	40.28	0.02	1463.00	6.80
35	SC-6	93.53	94.26	81.04	5.10	9.02	18.39	6.04	25.42	4.27	15.78	0.01	236.50	10.64
36	SC-8	102.53	89.91	98.44	6.00	11.12	18.29	6.24	36.87	7.72	98.28	0.02	843.00	8.46
37	SC-9	108.03	122.41	134.94	4.40	7.92	18.69	5.74	38.97	8.36	333.28	0.02	1533.00	5.52
38	SC-10	136.53	83.23	96.37	3.70	6.72	15.49	5.14	25.49	3.92	63.28	0.01	999.50	4.57
39	SC-11	134.03	73.61	82.64	4.30	7.12	22.69	4.64	7.47	3.52	90.78	0.05	793.50	5.62
40	SC-12	136.53	83.11	94.72	6.00	7.12	22.79	4.96	25.27	5.42	75.28	0.09	940.00	5.12
41	UD325	94.03	100.42	122.54	5.60	13.22	28.79	6.64	30.47	4.22	173.28	0.03	1383.00	12.77
42	UD-326	101.53	111.11	128.64	5.60	11.72	29.69	5.69	34.57	6.12	103.28	0.02	747.51	6.74
43	UD-373	101.53	103.71	119.77	5.20	10.92	23.79	6.24	35.47	5.32	123.28	0.03	1056.50	10.64
44	UD-374	95.53	96.51	109.14	6.20	11.52	23.99	5.44	29.22	5.22	78.78	0.04	759.00	6.82
45	UD-590	92.03	101.61	115.74	4.50	9.62	22.29	7.04	46.42	7.30	158.28	0.01	1109.50	9.17
46	UD594	88.03	101.71	114.62	5.70	12.62	31.99	5.61	27.57	4.62	88.28	0.02	803.00	10.67
47	UD601	87.03	102.21	115.84	6.10	14.52	29.69	7.04	39.37	7.02	393.28	0.03	2996.50	11.19
48	UD603	91.03	116.41	115.14	5.80	11.92	24.19	6.14	29.27	4.92	163.28	0.01	1416.50	11.54
49	UD605	100.53	105.95	125.79	6.02	11.52	30.34	5.37	18.50	6.60	205.78	0.02	1015.50	10.69
50	UD607	87.03	94.85	100.08	4.72	14.72	24.34	4.87	17.45	4.90	185.78	0.01	1015.50	11.90
51	UD609	77.03	86.15	106.58	5.62	13.42	27.44	4.87	14.50	7.00	90.78	0.01	275.50	10.65
52	UD610	79.53	97.35	115.88	5.05	15.42	24.84	5.67	17.90	8.30	90.78	0.01	262.00	12.13
53	UD615	77.53	86.05	100.08	6.42	15.20	25.64	5.37	22.00	5.40	165.78	0.02	855.50	12.97

54	UD618	77.03	95.35	108.62	5.82	15.22	24.86	4.47	14.88	5.60	175.78	0.02	902.00	9.92
55	UD620	77.03	80.25	89.83	5.82	14.12	21.84	4.27	20.80	7.10	120.78	0.01	455.50	13.09
56	UD622	84.53	93.07	111.08	5.02	15.37	23.56	4.77	23.60	8.10	260.78	0.01	1589.00	11.44
57	UD623	83.53	88.25	112.20	6.12	15.82	29.14	4.97	16.90	6.38	285.78	0.01	1569.00	9.77
58	UD634	86.03	101.15	119.88	5.72	11.42	20.44	4.57	20.70	6.70	280.78	0.02	1589.00	14.68
59	UD635	97.03	114.05	130.48	6.82	13.62	29.34	4.17	14.90	7.20	300.78	0.02	1755.50	11.56
60	UD643	81.53	99.35	116.98	5.83	15.42	27.64	5.27	21.52	9.08	420.78	0.02	669.00	10.28
61	UD684	98.03	112.25	124.28	5.32	14.92	21.04	5.57	23.23	6.50	70.78	0.01	82.00	10.20
62	UD689	88.53	97.06	113.18	5.52	13.42	21.54	5.27	16.10	8.00	325.78	0.02	1842.00	10.79
63	UD699	78.03	73.95	103.38	4.92	12.62	18.44	3.97	10.40	5.00	50.78	0.01	-44.50	11.20
64	UD704	77.36	100.41	101.07	5.75	16.07	21.69	4.64	19.16	5.24	141.28	0.01	1177.00	11.04
65	UD711	95.36	100.26	143.97	6.55	15.07	15.59	6.04	28.09	7.24	236.28	0.02	1757.00	8.91
66	UD715	81.36	87.71	107.19	7.05	16.07	31.86	4.89	23.44	7.04	106.28	0.02	910.50	14.94
67	UD716	81.36	105.36	101.59	7.25	18.47	25.19	5.24	27.19	8.14	121.28	0.01	1064.00	10.00
68	UD717	81.86	74.16	95.27	6.15	13.17	19.69	4.14	16.29	6.74	46.28	0.01	497.00	10.96
69	UD718	83.36	87.73	113.47	5.95	11.47	19.59	5.14	24.69	7.34	131.28	0.05	1150.50	9.11
70	UD719	79.36	91.26	93.27	6.90	12.47	15.19	4.44	25.09	9.04	61.28	0.02	604.00	8.55
71	UD720	93.36	98.56	112.67	6.55	13.87	19.49	4.44	23.44	7.54	220.78	0.03	1706.50	9.31
72	UD721	102.36	112.36	120.62	6.25	14.17	24.89	4.94	27.49	7.76	186.28	0.01	1510.50	8.67
73	UD722	102.36	106.16	124.27	6.70	12.47	20.29	5.19	20.89	6.04	211.28	0.01	1710.50	13.91
74	UD725	101.86	114.86	127.97	6.95	14.07	23.19	4.84	35.39	9.34	201.28	0.03	1644.00	7.84
75	UD727	80.36	90.76	98.57	6.25	12.97	14.19	5.94	34.19	35.74	106.28	0.03	944.00	9.75
76	UD728	101.36	108.26	120.67	6.40	12.80	15.59	5.44	27.99	8.74	216.28	0.03	1737.00	7.60
77	UD730	79.36	88.16	103.57	6.57	12.37	22.39	5.14	18.19	6.44	226.28	0.03	1777.00	13.29
78	UD742	98.86	85.56	100.67	6.73	14.57	20.49	5.44	20.59	5.74	91.28	0.02	804.00	13.16
79	UD743	93.53	93.46	114.92	5.76	14.36	21.67	4.89	28.83	6.00	297.61	0.04	1965.00	12.51
80	UD744	80.53	106.56	122.62	6.78	12.66	14.47	5.21	31.03	5.80	247.61	0.02	1558.50	10.14
81	UD745	82.53	96.16	115.62	5.08	10.06	21.07	4.61	25.33	5.20	162.61	0.03	2731.50	13.10
82	UD746	94.53	92.36	113.82	6.68	17.56	27.87	5.44	36.88	7.10	81.11	0.01	293.00	13.61
83	UD747	84.53	109.96	114.12	6.06	13.86	21.07	4.91	31.33	7.10	272.61	0.04	1751.50	14.05
84	UD748	85.53	85.26	107.12	4.68	13.63	19.87	4.21	25.63	4.50	112.61	0.01	538.50	12.50
85	UD750	87.53	85.33	104.12	4.68	12.73	24.05	5.81	32.23	6.90	247.61	0.03	1451.50	10.66
86	UD752	83.03	86.06	109.02	5.48	11.46	22.37	5.51	30.23	5.70	127.61	0.01	665.00	10.84
87	UD753	83.03	90.16	100.29	4.68	11.76	20.37	4.81	28.13	4.70	207.61	0.02	1305.00	10.95
88	UD768	86.03	85.06	105.12	5.08	12.46	27.37	5.51	29.73	7.40	142.61	0.01	771.50	12.78
89	UD772	94.53	123.66	137.12	5.38	12.36	26.17	5.29	33.03	5.90	227.61	0.03	1351.50	10.44
90	UD787	86.03	99.96	106.22	5.28	12.16	29.27	5.21	28.53	5.30	357.61	0.05	2278.50	10.81
91	UD788	94.03	119.36	135.72	5.38	12.06	21.37	4.51	33.23	5.90	167.61	0.03	965.00	11.32
92	UD789	92.53	113.96	124.92	5.78	15.26	29.87	4.81	27.53	4.30	262.61	0.03	1738.50	11.07
93	sc-13	98.53	111.36	119.72	5.73	15.66	28.27	5.41	26.53	5.00	257.61	0.03	1638.50	11.07

Vitae

VITA

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ABSTRACT

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Thesis title : **"EVALUATION OF CORIANDER (*Coriandrum sativum* L.) GERMPLASM FOR GROWTH AND YIELD CHARACTERS UNDER *TARAI* CONDITIONS OF UTTARAKHAND"**

Ninety genotypes and three checks (Pant Haritima, Hisar Anand and ACr-728) of coriander (*coriandrum sativum* L.) were evaluated in Augmented Block Design during *Rabi* season of 2009-10 and 2010-11 at Vegetable Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar,to study the genetic variation for thirteen growth and yield characters namely, days to 50 per cent 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),

The pooled data were subjected to statistical analysis. The results of analysis of variance revealed highly significant differences for number of fruits per umbel and significant differences were observed between checks for plant height upto main umbel and number of umbels per plant in 2009-10. In 2010-11 highly significant difference was observed between block for number of umbellates per umbel and highly significant difference was observed between check for plant height upto main umbel, number of secondary branches per plant, number of umbellates per umbel, seed yield per plot(g), seed yield kg per ha, and weight of 1000-seed and significant diffeferance for plant height including main umbels. The analysis of variance showed highly significant differences among genotypes indicating sufficient amount of variation for those characters in the germplasm collection. Character association indicate seed yield (kg per hectare) have significant and positive correlation with plant height upto mainumbel (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). The 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 per cent flowering (0.0281), number of primary branches per plant (0.0734) and plant height upto main umbels. The principal component analysis was done on correlation matrix of important economic traits. First 10 principal components explain 94.72 per cent of total variation. Present investigation germplasm of coriander the maximum variation of 21.67 per cent was explained by first latent vector followed by 16.79 per cent (second vector) and 12.31 per cent (third vector). Ninety genotypes and three checks were classified into six non-over lapping clusters on the basis of non-hierarchical Euclidean cluster analysis for yield and growth traits. The maximum (2.997) intra cluster distance was seen in cluster III and minimum (0.000) was observed in VI and V. The maximum inter cluster distance 13.414 was found in between clusters VI and V, followed by 10.279 between clusters I and VI than 10.047 between clusters II and VI. Whereas, minimum inter cluster distance 2.694 between clusters IV and II, followed by 2.890 between clusters III and I and 3.085 between clusters II and I. Cluster I have the maximum number of genotypes (25) followed by cluster II and III have 23 genotypes in each cluster. The minimum numbers of genotypes i.e. one were present in cluster V and VI.

The performance of genotypes is evaluated on the basis their performance with respect to best check for that character. Genotypes UD-725, ACr-10 and UD-752, showed best performance for seed yield and its components in 2009-10 and in 2010-11 genotypes ACr-23, UD-601, MKSM-1117 and UD-789 showsed best performance. Based on the average performance of two years UD-787 is best genotype for yield and its components.

best genotype for yield and its components.

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Advisor

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Author

नामः- सुनील कुमार
सत्र एवं प्रवेश वर्ष :- प्रथम 2009—10
मुख्य विषय :-सब्जी विज्ञान
सलाहकार :-डा0 जे0पी0 सिंह

परिचयांकः- 39359
उपाधि :-पी.एच.डी.
अमुख्य विषयः-अनुवंशिकी एवं पादप प्रजनन विभाग
विभाग :— सब्जी विज्ञान विभाग

शोध शीर्षक : ''उत्तराखण्ड में तराई स्थिति के अन्तर्गत धनिया (कोरियनडरम सटाइभम एल.) के प्रजनक द्रव्यों का वृद्धि एवं उपज कारकों हेतु मूल्यांकन''

सारांश

वर्तमान अन्वेषण गो0 ब0 पन्त कृषि एवं प्रौद्योगिक वि"वविद्यालय पन्तनगर, ऊधमसिंहनगर उत्तराखण्ड के सब्जी अनुसंधान केन्द्र में किया गया है। इस शोध में धनिया के 90 प्रजनक द्रव्यों और तीन मानक (पन्त धनिया, हिसार आनन्द एवं ए.सी आर 728) का मूल्यांकन सांख्यिकी, आगमेंटिक रूप रेखा के अनुसार रबी मौसम 2009—10 एवम् सन् 2010—11 में 13 विकास एवं उपज मानकों के लिए किया गया। जो इस प्रकार है। 50 प्रति"ात पुष्प आने में लगा समय, "ीर्ष तक पौधे की ऊँचाई, मुख्य पुष्प तक पौधे की ऊँचाई, प्राथमिक "ाखाओं की संख्या प्रति पौध, द्वितीयक "ाखाओं की संख्या प्रति पौध, अम्बेल की संख्या प्रति पौध, अम्बलेट की संख्या प्रति अम्बेल, बीज की संख्या प्रति अम्बेल, बीज की संख्या प्रति अम्बलेट, बीज उपज प्रति क्यारी ,बीज उपज प्रति पौध, बीज उपज (कि0ग्रा0 प्रति हैक्टेयर) एवंम् 1000 बीज का वजन।

एकत्रित अंकड़ों का अध्ययन करने के लिए कम्प्युटर साफ्टवेयर एसटीपीआर 155, एएसपीआर 1 एवं एसएएस के द्वारा सांख्यिकीय वि"लेषण किया गया। प्रसरण के वि"लेषण में सन् 2009—10 ब्लक के बीच बीज की संख्या प्रति अम्बेल में महत्वपूर्ण अन्तर पाया गया और "ीर्ष तक पौधे की ऊँचाई एवम् अम्बेल की संख्या प्रति पौध का चेक के बीच में पर्याप्त मात्रा में भिन्नता पाई गई है।सन् 2010—11 में ब्लाक के बीच अम्बलेट की संख्या प्रति अम्बेल महत्वपूर्ण अन्तर पाया गया और मुख्य पुष्प तक पौधे की ऊँचाई, द्वितीयक "ाखाओं की संख्या प्रति पौध, अम्बेल की संख्या प्रति अम्बेल, बीज की उपज प्रति क्यारी, बीज उपज किलो प्रति हैक्टेयर एवम् 100 बीजों का भार चेक के बीच में अत्यन्त महत्वपूर्ण अन्तर पाया गया है।कुछ लक्षण के लिए पसरण के वि"लेषण में जीनोटाइप के बीच में अत्यधिक अन्तर देखा गया है। जिससे कि यह संकेत मिलता है कि प्रजनक द्रव्यों के संग्रह में उन मानकों में पर्याप्त मात्रा में भिन्नता है।वि"लेषण अध्ययन यह सूचित करता है कि उपज (किलो प्रति है0) का मुख्य "ीर्ष तक पौधे की ऊँचाई (0.290), मुख्य पुष्प तक पौधे की ऊँचाई (0.331), बीजों की संख्या प्रति अम्बलेट (0.290), बीज उपज प्रति क्यारी (0.743) और बीज उपज प्रति पौध (0.361) के साथ सकारात्मक एवम् सार्थक सम्बन्ध है। पाच गुणांक वि"लेषण क अनुसार बीज उपज (किला प्रति है0) सर्वाधिक प्रत्यक्ष प्रभाव बीज उपज प्रति क्यारी (0.6975), बीजों की संख्या प्रति अम्बेल (0. 2716), बीज उपज प्रति पौध (0.1143), 1000 बीज का वजन (0.0895), 50 प्रति"ात पुष्प आने में लगा समय, प्राथमिक "ाखाओं की संख्या प्रति पौध (0.0734) एवम् मुख्य पुष्प तक पौध की ऊँचाई (0.0703) पर प्रद"ित हुआ।सह सम्बन्ध में मैट्रिक्स के महत्वपूर्ण आर्थिक तत्वों में प्रमुख घटक वि"लेषण किया गया था। पहले 10 प्रमुख घटक में कुल 94.72 प्रति"ात भिन्नता प्रद"ात होती हुई है। पहले लेटेंट वैक्टर में 21.67 प्रति"ात सर्वाधिक भिन्नता, 16.79 प्रति"ात द्वितीय वेक्टर में एवं 12.31 प्रति"ात तीसरे वेक्टर में पाई गई है।ना हेरारफियल यूकलीडियन कलस्टर वि"लेषण का प्रयोग करके उपज आध्रे विकास स्वभाव के आधार पर 90 प्रजनक द्रव्यों और तीन मानकों को 6 अ"ाछादन समूह में बांटा गया है।अधिकतम आन्तरिक अन्तर कलस्टर 111 (2.997) में एवम् निम्नतम आन्तरिक अन्तर कलस्टर V, VI (0.00) में पाया गया।अधिकतम परस्पर अन्तर का फासला (13.144) कलस्टर VI, V में पाया गया उसके बाद कलस्टर 1, VI के बीच में 10.279 इसके बाद कलस्टर 11, VI के बीच (10.047) इसके बाद कलस्टर 111, VI के बीच 10.022 एवम् कलस्टर 11, V के बीच 9.288 के बीच में परस्पर फासला पाया गया है। कलस्टर 1 में (25) अधिकतम और कलस्टर V एवम् VI में एक—एक जीनोटाइप्स संख्या पाई गयी है।

प्रजनक द्रव्यों के प्रद"ान का मुल्यांकन उसके प्रद"ान के आधार पर व सर्वश्रेष्ठ मानक के साथ किया गया। वर्ष 2009 में जनक द्रव्यों प्रजनक द्रव्यों के प्रद"ान का मूल्यांकन उनके प्रद"ान के आधार पर व सर्वश्रेष्ठ मानक के साथ किया गया। वर्ष 2009—10 में प्रजनक द्रव्यों यू. डी.—725, ए.सी.आर.—10, यू. डी.—752 एवं यू. डी.—789, में उपज तत्व हेतु सर्वश्रेष्ठ प्रद"ान रहा और वर्ष 2010—11 में प्रजनक द्रव्यों यू. डी.—601, एम.के.एस.एम.—1117,एवं यू.डी.—787 में सर्वश्रेष्ठ प्रद"ान रहा। वर्ष 2009—10 एंव वर्ष 2010—11 के औसतन प्रद"ान के अनुसार यू. डी.—787, उपज तत्व हेतु सर्वश्रेष्ठ प्रजनक द्रव्य सिद्ध हुए।

डा० जे०पी० सिंह
सलाहकार

सुनील कुमार
लेखक