DIVERGENCE STUDIES IN SALAD CUCUMBER
(*Cucumis sativus* L.)

By

SMITHA SARA ABRAHAM

THESIS

Submitted in partial fulfilment of the requirement for the degree of

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Faculty of Agriculture
Kerala Agricultural University

Department of Olericulture

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680 656
KERALA, INDIA

2006

DECLARATION

I, hereby declare that this thesis entitled **"Divergence studies of salad cucumber(*Cucumis sativus* L)"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

Smitha Sara Abraham

CERTIFICATE

Certified that this thesis entitled "Divergence studies in salad cucumber (*Cucumis sativus* L)"is a bonafide record of research work done independently by **Ms. Smitha Sara Abraham** my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Dr.T.R Gopalakrishnan
Chief Executive Officer, VFPCK
(Former Associate Proferssor and Head)
Department of Olericulture
Vellanikkara

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I convey my affection and heart felt gratitude to my dear seniors especially Ambily, Srikrishna, Sujatha for timely advices.

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Smitha Sara Abraham,** a candidate for the degree of **Master of Science in Horticulture,** with major field in Olericulture, agree that the thesis entitled **"Divergence studies in salad cucumber(*Cucumis sativus* L)"** may be submitted by **Ms. Smitha Sara Abraham,** in partial fulfillment of the requirement for the degree.

Dr.T.R Gopalakrishan
(Major Advisor, Advisory Committee)
Chief Executive officer, VFPCK
(Former Associate Professor and Head)
Department of Olericulture
College of Horticulture
Vellanikkara.

Dr. T.E.George
Associate Professor and Head
Department of Olericulture
College of Horticulture
Vellanikkara.
(Member)

Mr. S. Krishnan
Assistant professor
Dept. of Agricultural Statistics
College of Horticulture
Vellanikkara
(Member)

Dr. P.Indira
Associate Professor
Department Olericulture
College of Horticulture
Vellanikkara
(Member)

(EXTERNAL EXAMINER)
(S. NATARAJAN)

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Smitha Sara Abraham

To my beloved parents and sister

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Introduction

1. INTRODUCTION

Vegetables are rich and comparatively cheaper sources of vitamins, minerals and natural fibre essential for a balanced diet of human beings. They are considered as protective foods, as regular consumption of vegetables can overcome many deficiency diseases. The importance of vegetables, particularly raw vegetables as sources of antioxidants, that countering the adverse effects of free radicals is fully realized now. The use of vegetables for protection against new generation diseases like diabetes, hypertension etc. is gaining momentum. Growing awareness on the human health also leads to increase in consumption of raw vegetables like cucumber.

Diverse climatic conditions prevailing in different parts of India offers scope for cultivation of a variety of crops either in one season or the other. India is the second largest producer of vegetables in the world, next only to China with an estimated production of 88.86 million tonnes from an area of 6.89 million hectares (Survey of Indian agriculture, 2005). Our country witnessed a quantum jump in production of vegetables during the last decade. This was achieved through the use of improved high yielding vegetable varieties and hybrids with specific advantages.

The Productivity of vegetables in Kerala is only 22.2 tonnes per hectare (Survey of Indian agriculture, 2005). Major share of the state is met by import from neighboring states, Tamil Nadu and Karnataka. The per capita consumption is only 148g, which is just half of the recommended percapita consumption rate. The consumption of vegetables in the state is on a rise due to growing health awareness among the people. Consumption of raw vegetables like salad cucumber is also on a rise. The demand of vegetables has been increasing fast in the state with improvement in the standard of living and health awareness.

Cucumber (*Cucumis sativus* L.) is an important and popular member of family cucurbitaceae with maximum number of economic vegetables in tropics and sub

tropics. Though cucumber is mainly used as salad, it is also used as cooked vegetable. Various processed and pickled products are also made of cucumber in various parts of country. Fruit is not much valued for its nutrient content. However many medicinal, cosmetic and tonic properties are ascribed to cucumber fruits.

Despite its economic, medicinal and nutritional values, not much work has been done on genetic improvement of this crop in Kerala. Majority of works are limited to evaluation of varieties or cultivars collected from different parts of country. The present investigation aims at collecting and evaluating germplasm from different parts of the country. Lack of inbreeding depression, easiness in cultivation, comparatively large sized flowers, monoecious condition and presence of large number of seeds per fruit makes it an ideal crop for commercial exploitation of hybrid vigour. The present investigation aims at collecting and evaluating germplasm from different parts of country and estimating variability and divergence with ultimate objective of selecting superior lines or parents for exploitation of hybrid vigour.

Review of literature

2. REVIEW OF LITERATURE

Cucumber is an important crop cultivated in almost all states of India. Only a little work has been done in India on its crop improvement. Available literature on cucurbitaceous vegetables related to the topic 'Divergence Studies in Salad Cucumber' is reviewed under the following heads:

1. Variability studies
2. Correlation and path coefficient analysis
3. Divergence studies

2.1 VARIABILITY STUDIES

Success of any crop improvement programme depends on genetic variability existing in the population. Ranges are indicators of the extent of variations for a particular character.

Phenotypic coefficient of variation (PCV) is the measure of total variability which is observable. It includes both genotypic and environmental variations and hence, changes under different environmental conditions. Genotypic coefficient of variation (GCV) is the measure of inherent genotypic variability, which remains unaltered by environmental conditions. This kind of variation is more useful to a breeder for exploitation in selection or hybridization. Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) are ratios of genotypic and phenotypic standard deviations, respectively, with mean and expressed in percentage.

The ratio of genotypic variance to phenotypic variance or total variance is heritability. Heritability is the heritable portion of phenotypic variance and is a good index of transmission of characters from parents to offsprings (Falconer, 1989). Heritability thus abstracted is broad sense heritability, while the ratio of

additive component of variance to total phenotypic variance is "Narrow sense heritability" (Lush, 1949). If heritability of a character is very high, selections for this character would be more effective and there is a close correspondence between genotype and phenotype (Singh, 1991).

Improvement in the mean genotypic values of selected plants over the parental populations is known as genetic advance (GA) and the measure of genetic gain under selection depends on level of genetic variability, heritability and selection intensity (Allard, 1960). Genetic advance is usually measured at 5 per cent of selection intensity.

The character with high heritability and high genetic advance implies additive gene effects, which can be improved by selection (Burton, 1952; Panse, 1957; Solanki and Seth, 1980). In conditions of high heritability and high genetic advance, prevalence of additive gene effects was indicated by Panse (1957) and Smith (1971). If the heritability is mainly due to non additive gene effects, the genetic advance may be low (Panse, 1957). This implies that the high estimate of heritability is not always a sign of increase in genetic advance (Swarup and Changale, 1942; Johnson *et al.*, 1955; Hill, 1975). According to Hansen (1961), both heritability and genetic advance are complementary effects.

Miller and Quisenberry (1976) worked on cucumber and reported that days to opening of the first female flower was controlled by relatively fewer genes and heritability for this trait was moderately high. Mc Creight (1977) studied heritability estimates of fruit sugar concentration in a population of 50 cucumber introductions and heritability calculated through half sib family variance method was 0.03 and after correction for genotypic x environmental interactions was worked out as 0.05. The heritability estimate calculated through parent offspring regression analysis was 0.04. The expected genetic gain in altering sugar concentration per cycle of half sib progeny testing was 0.21 mg reducing sugar/g fresh weight.

Joshi *et al.* (1981) estimated variability in 20 genotypes of cucumber at Agricultural Research Station, Almora. Significant variation was observed for all the characters studied. Wide range of variations was observed for characters like

vine length (1.6 – 4.10 m), node at which first fruit arises (2.7 – 30.6), fruit length (15.7 – 39.1 cm), fruit circumference (13.8 – 40.5 cm), number of fruits per plant (2.2 – 13.9) and flesh to seed ratio (52.5 to 75.0). Number of primary branches had only a narrow range (2.0 – 3.8). GCV was the maximum for node at which first fruit emerges (93.76) and minimum in flesh to seed ratio (9.48). Number of nodes to first fruit, number of fruits per plant, fruit yield per plant, fruit circumference and fruit length had high GCV values while vine length, number of primary branches and node number had low GCV values. Heritability and genetic advance were high for all characters except flesh to seed ratio.

Mariappan and Pappaiah (1990) studied variability among 45 genotypes of cucumber at Regional Research Station, Tamil Nadu Agriculture University. All the characters studied exhibited wide range of variation and it was maximum for number of seeds per fruit (307.5-1640.0). Characters like number of seeds per fruit, weight of seeds per fruit and vine length had high phenotypic variance. Characters like TSS, pulp thickness, days to first male flower anthesis and days to first female flower emergence recorded low values. Heritability in broad sense was maximum for fruit girth (97.5%). Characters like fruit length, days to first male flower anthesis, number of seeds per fruit, weight of seeds per fruit, days to first female flower emergence and TSS (85.7-97.5) also had high heritability, above 85 percent. Genetic advance was maximum for average fruit weight (105.2%) followed by TSS (69.6%). Chhonkar *et al.* (1979) also observed high genetic advance for fruit weight and TSS in muskmelon.

Singh *et al.* (2002) estimated variability in 98 hybrids of cucumber at IARI Regional Station, Katrain. Maximum range of variation was recorded for weight per fruit (209.0 – 495.7 g). High values of variation were also recorded for days to 50 percent male flowering (47.3 – 64.7) and days to 50 percent female flowering (47.7-63.7). The lowest variation was recorded in yield per plot. Heritability of various characters showed a range of 59.6 to 92.4 percent. Heritability was the highest for yield per plot (92.4%). GCV value was high for

50 percent male flowering (55.9%) and PCV value was high for yield per plot (26.7%).

Kalyanasundaram (1976) worked on three musk melon varieties, namely, Annamalai, Haramadhu and Arka Rajhans. He observed significant differences among the three varieties for branches per plant, hermaphrodite flowers per vine, percentage of hermaphrodite flower production, fruit weight, fruits per plot, fruit cavity diameter, fruit thickness and seeds per fruit. However, the variances for days to maturity from the time of anthesis, fruit yield and total soluble solids were not significantly different among the varieties.

Smith and Lower (1977) estimated heritability and variance components for yield in pickling cucumber. Heritability estimated for fruit number calculated from full sib families, grown in two replications and environments were 0.14 percent and 0.22 percent, respectively. In muskmelon highest GCV and PCV were recorded for marketable yield per plant followed by total yield per plant and average fruit weight (Swamy., 1986).

Kalloo, *et al.* (1993) evaluated 45 diverse genetic stocks of muskmelon. Phenotypic coefficient of variation ranged from 10.9 – 26.8 percent. Maximum variability was observed for number of fruits per plant. Yield per plant and average weight of fruits also exhibited high variability. Variety Punjab Hybrid-1 and S-445 exhibited maximum yield per plant (2.5 and 2.1 kg, respectively). Highest number of fruits per plant was noted in Punjab Hybrid-1 (3.58) followed by Kanpur-1 (3.55). Maximum weight per fruit was observed in the variety 78-9 (810 g). Yield per plant had high GCV. Length of vine and length of cavity also exhibited high GCV values. Estimates of heritability ranged from 11.0 to 74.0 percent. High heritability was observed for fruit cavity (74.0 %).

Rakhi and Rajamony (2005) evaluated 42 land races of melons (*Cucumis melo* L) at College of Agriculture, Thiruvananthapuram. Significant differences were observed in all characters except number of primary branches

and branches of first male and female flowers produced. High GCV and PCV were recorded for yield/plant, fruits/plant, keeping quality of fruits, 100 seed weight, leaf area index and sex ratio. Comparatively wide range of PCV and GCV estimates for vine length, number of primary and secondary branches and leaf petiole length indicates a greater degree of environmental control for these traits. Lowest GCV was noted for days to first harvest. High values of heritability associated with high genetic advance was observed for average fruit weight, 100 seed weight and keeping quality of fruits.

Krishnaprasad and Singh (1997) evaluated ridge gourd at Central Horticultural Experiment Station, Ranchi. Highest range was observed in vine length (131.3 – 324.7 cm). Number of nodes (13.1 – 28.8) and node on which first flower appeared (7.0 – 15.1) also showed high range of variability. PCV ranged from 10.5-59.8 per cent. GCV ranged from 3.72-50.9 per cent. High genotypic and phenotypic coefficients of variation was noticed for characters like yield/plot (50.4 and 59.8) and number of fruits (26.3 and 40.4) indicating maximum amount of variability. Very high genotypic and phenotypic variances were recorded for yield in quintals/ha (18025.1 and 24354.0), number of fruits (202.3 and 476.0) and for vine length (38.4 and 7816.4); high heritability and low genetic advance for number of nodes (12.1 and 1.7); high heritability coupled with high genetic advance for yield in quintals/ha (74% and 240.2); and low heritability for vine length (5 %).

Krishnaprasad *et al.* (2004) evaluated 34 musk melon varieties and found significant variation with regard to all the characters except node at which female flowers appeared. Highest coefficients of variation was shown by node at which male flowers appeared. Highest coefficient of variations was shown by yield/plot, number of fruits, days to male flower appearance and node at which female flower appeared.

Singh *et al.* (1976) found that the additive component of total genetic variance was high for days to opening of first female flower, picking maturity, fruits per vine and TSS. Dominance component of genetic variance was high for fruit weight, flesh thickness and total yield in muskmelon.

Reddy and Rao (1984) studied 6 parents and 7 hybrids of ridge gourd at RRS, Tirupati. PCV ranged from 14.4 to 162.6 and GCV from 13.6 to 112.0. The highest value for PCV and GCV was observed for fruit weight per plant. Lowest value of PCV and GCV were realised for days to first marketable fruit and fruit diameter. The highest value of heritability was recorded for individual fruit weight (49.74%) and lowest value for days to first fruit harvest (4%). The green fruit yield per plant, fruit size and fruit number per plant showed high values of heritability in broad sense. The highest genetic advance was recorded for fruit yield per plant (157.1).

In ridge gourd, number of fruits, yield per plant and average fruit weight exhibited high PCV and GCV. Earlier, Prasunna and Rao (1989) and Varalakshmi *et al.* (1995) had reported that yield per plant, fruits per plant, average fruit weight and length of fruit exhibited high PCV, GCV, heritability and genetic gain. The high heritability coupled with low genetic gain was observed for days to female flower (Anitha, 1998).

Gopalakrishnan (1979) estimated variability in 18 pumpkin genotypes. Significant variation with wide range was recorded for all 25 quantitative characters studied. Maximum value of GCV was observed for male flowers per plant and fruits per plant. Sureshbabu (1989) evaluated 50 pumpkin varieties and observed significant variation in all the characters studied. GCV was maximum for seeds per fruit followed by average fruit weight and productive branches per plant. Highest heritability estimate was observed for 100 seed weight (95.5%). High heritability along with high genetic gain was observed for 100 seed weight (95.9% and 55.5%).

Mohanty and Mishra (1995) evaluated eight genetically diverse inbred lines of pumpkin and found that additive (D) and dominance (H_1) variance were significant for average fruit weight and flesh thickness indicating prevalence of both additive and non-additive gene actions. Magnitude of dominance component (H_1) was higher than that of additive (D) for all the characters except average fruit weight. Doijode and Sulladmath (1985) recorded almost equal estimates of H_1 and D for fruit weight and flesh thickness in pumpkin

Srivasthava and Srivasthava (1976) evaluated 10 lines of bitter gourd and the lines showed significant difference for all the characters under study except for number of male flowers per plant. GCV value was the maximum for number of fruits per plant (37.5) and minimum for number of male flowers per plant (11.5). Singh *et al.* (1977) evaluated 20 bitter gourd varieties and observed highest GCV for yield per plant, fruits per plant and fruit length.

Ramachandran (1978) worked on 25 bitter gourd accessions. The 25 types studied were significantly different for all 21 characters studied. The highest estimates of PCV and GCV were observed for yield per plant (39.9 and 39.8, respectively). Vitamin C content, iron content and fruits per plant have high genotypic and phenotypic coefficients of variations (PCV=7.8; GCV=7.1).

Mangal *et al.* (1981) evaluated 21varieties of bitter gourd. GCV value was the maximum (38.1) for yield per plant and minimum (3.2) for days to first female flower anthesis. Characters like number of branches and fruit weight exhibited high estimates of GCV. Average fruit weight exhibited maximum phenotypic and genotypic variance followed by vine length. The lowest PCV and GCV were observed in number of lobes per leaf. Heritability values ranged from 67.3 percent (average periphery of fruit) to 99.9 percent (number of lobes per leaf). Characters like number of lobes and number of days to female flowers showed high values of heritability and very low values of genetic advance. Number of

branches, vine length, weight of fruit, number of fruits and yield per plant showed high values of genetic advance, indicating additive gene effects.

Pynadath (1975) studied variability in a collection of 25 genotypes of snake gourd. High variation was observed for days to first male and female flower anthesis, fruits per plant, yield per plant, fruit length, girth and weight, flesh thickness, seeds per fruit and 100 seed weight. High GCV was reported for fruit weight and fruit girth.

Joseph (1978) estimated the heritability and genetic advance for 21 characters in snake gourd. Heritability in broad sense was quite high for most of the characters. Length of fruit had high heritability of 99.9 percent closely followed by girth of fruit (98.6%) and vitamin C content (97.6%). Yield per plant had low estimate of heritability (45.9%) and lowest was recorded for fruits per plant. Highest genetic advance was observed for ash content (56.9%). Varghese (1991) conducted variability studies in 48 genotypes of snake gourd. High variance was recorded for days to first female flowers, fruit harvest, yield per plant, number of fruits and seeds per fruit. High PCV and GCV were recorded for fruiting nodes on main vine and lowest for crop duration. Varghese and Rajan (1993) observed high GCV for fruiting nodes on main vine, male flowers per plant, sex ratio, fruits per plant and crude fibre content in snake gourd.

Singh and Prasad (1986) estimated variability in 25 cultivars of pointed gourd. The analysis of variance indicated significant differences among the cultivars for the characters such as number of nodes, number of shoots, number of fruits, fruit length, fruit volume and yield per plant. Fruit width exhibited narrow range of variability. Genotypic coefficient of variation was the maximum in fruit weight (62.5). High GCV was also found in fruit volume (34.7) and number of nodes (262.9). High PCV was also recorded for fruit weight (233.4) and number of fruits (190.2). Minimum phenotypic variance was recorded in fruit width

(0.11), yield per plant (0.2) and fruit length (2.45). High heritability and high genetic advance were observed for yield and number of fruits per plant.

Pariari *et al.* (2000) evaluated 21 accessions of pointed gourd. All the characters varied significantly except length of internode, fruit length and fruit diameter. High heritability was observed in almost all the characters except number of primary branches per plant (25.7%). Highest heritability was found for fruit weight (99.6%) and fruit volume (99.2%). Singh *et al.* (1992) studied 36 F_1s of pointed gourd. Highest GCV was recorded for yield per plant. High values of GCV and PCV were recorded for fruits per plant, diameter of fruit, length of fruit and average fruit weight. High heritability coupled with high genetic advance was recorded for yield and number of fruits per plant.

Prasad *et al.* (1993) evaluated 30 genotypes of bottle gourd and significant differences were obtained for the 19 characters observed. The maximum GCV was recorded for yield per plant followed by number of flowers on primary laterals. Minimum value for GCV was recorded for size of cotyledonary leaves. High heritability coupled with high genetic advance as percent of mean was recorded for number of fruits per vine, length of vine at maturity, node number and yield of fruits.

Lovely (2001) evaluated mean performance of 25 genotypes of ash gourd. A wide range of variation was noted for all the characters studied. Days to first male and female flower anthesis were minimum for Kottayam WC-3. Highest mean fruit weight was for Alleppey local. A wide range (0.8–7.7) was noticed for this character. Flesh thickness was the highest for KAU Local. Highest PCV was recorded for mean fruit weight, fruit yield per plant, flesh thickness, branches per plant, fruits per plant, fruit length, fruit girth and fruit thickness. Low PCV and GCV were observed for days to first female and male flower emergence. Highest heritability was recorded for seeds per fruit. High genetic advance was noted for

node to first male and female flower. Node to female and male flower emergence recorded low genetic advance.

Singh *et al.* (2002) studied 60 genotypes of ash gourd. They found higher estimates of PCV and GCV for total fruit yield, average fruit weight and dry fruit weight. The lowest values of PCV and GCV were obtained for fruit length and skin thickness. The highest value of heritability was recorded for seed cavity (97.1%) and lowest for skin thickness (60.0%). Genetic advance ranged from 0.6 (skin thickness) to 49.8 (dry weight of fruit). Panwar *et al.* (1977) studied 40 varieties of sponge gourd (*Luffa cylindrica*) to estimate heritability and expected genetic advance. Fruit length and days to flower had higher estimates of heritability and expected genetic advance. Fruit length and days to flower had high estimates of heritability and expected genetic advance.

Joseph (1999) evaluated 20 accessions of ivy gourd (*Coccinia indica*) and observed high value of GCV combined with high heritability for characters like primary branches per plant, fruit yield per plant and nodes to first flower. High heritability along with high genetic genetic gain was shown by primary branches per plant, fruit yield per plant, nodes to first female flowers, average fruit weight and carotene and calcium contents.

2.2 CORRELATION AND PATH COEFFICIENT ANALYSIS

Correlation coefficient is a statistical measure of the degree and direction of relationship between two or more variables. Association between two variables, which can be directly observed, is termed as phenotypic correlation. This includes both genotypic and environmental effects and therefore differs under different environmental conditions. Inherent or heritable association between two variables is known as genotypic correlation. This type of correlation may be either due to pleotropic action of genes or due to linkage or more likely both

Table 2.1 Correlation between yield and component characters

Crop	Characters	Effect	References
Cucumber	Vine length	Positive	Joshi *et al.* 1981, Haribabu 1985, Abusaleha and Dutta 1988, Sathyanarayana 1991, Prasad and Singh 1992, Saikia *et al.* 1995.
	Internodal length	Positive	Solanki and Shah 1992.
	Primary branches	Positive	Joshi *et al.* 1981, Abusaleha and Dutta 1988, Rajput *et al.* 1991, Saikia *et al.* 1995.
	Secondary branches	Positive	Saikia *et al.* 1995.
	Leaf area	Positive	Saikia *et al.* 1995.
	Days to male flowering	Negative	Abusaleha and Dutta 1988.
	50 percent male flowering	Positive	Singh *et al.* 2002.
	Male flower per plant	Positive	Choudhary and Mandal 1987.
	Days to first female flower opening	Positive	Prasunna and Rao 1989.
		Negative	Choudhury *et al.* 1985, Abusaleha and Dutta 1988, Prasunna and Rao 1989, Rao *et al.* 2004.
	Node number with first female flower	Positive	Joshi *et al.* 1981, Prasunna and Rao 1989.
		Negative	Abusaleha and Dutta 1988, Rao *et al.* 2004.
	Female flowers per vine	Positive	Choudhury *et al.* 1985, Prasunna and Rao 1989, Solanki and Shah 1992, Chen *et al.* 1994.
	Days to first harvest	Positive	Solanki and Shah 1992.
		Negative	Rao *et al.* 2004.
	Fruit length	Positive	Joshi *et al.* 1981, Choudhury *et al.* 1985, Abusaleha and Dutta 1988, Prasad and Singh 1992, Sing *et al.* 2002, Prudek and Wolf 1985, Saikia *et al.* 1995.

	Fruit diameter	Positive	Choudhury *et al.* 1985,Choudhary and Mandal 1987,Prasad and Singh 1992
	Fruit circumference	Positive	Joshi *et al.* 1981.
	Fruit weight	Positive	Haribabu 1985, Rastogi and Deep 1990, Prasad and Singh 1992, Chen at al. 1994, Saikia *et al.* 1995, Sing *et al.* 2002.
	Flesh thickness	Positive	Abusaleha and Dutta 1988, Prasad and Singh 1992.
	Placental thickness	Positive	Prasad and Singh 1992.
	Seed cavity	Negative	Sathyanarayana 1991.
	Fresh seed ratio	Negative	Joshi *et al.* 1981.
	Fruits per plant	Positive	Joshi *et al.* 1981, Haribabu 1985, Prudek and Wolf 1985, Abusaleha and Dutta 1988, Sathyanarayana 1991, Rajput *et al.* 1991, Chen *et al.* 1994, Saikia *et al.* 1995, Rastogi and Deep 1990.
	Marketable fruits per vine	Positive	Sathyanarayana 1991, Saikia *et al.* 1995.
	Percentage of deformed fruits	Negative	Sathyanarayana 1991, Saikia *et al.* 1995.
	Sex ratio	Positive	Prasunna and Rao 1989.
	Nodes per vine	Positive	Sathyanarayana 1991.
	Harvest period	Positive	Rajput *et al.* 1991.

Muskmelon	Length of vines	Positive	Kalloo *et al.* 1993, Choudhury *et al.* 2004.
	Stem scar size	Positive	Yadav and Ram 2002.
	Days to first female flower	Negative	Kalloo *et al.* 1982.
	Node at which 1st hermaphrodite flower arises	Positive	Kalloo *et al.* 1993,Singh and Nandapuri 1978
	Fruits per plant	Positive	Kalloo *et al.* 1993, Choudhury *et al.* 2004.
	Fruit weight	Positive	Kalloo *et al.* 1993, Choudhury *et al.* 2004.
	Fruit equatorial diameter	Positive	Yadav and Ram 2002.
	Flesh weight	Positive	Yadav and Ram 2002.
	Seed weight	Positive	Yadav and Ram 2002,Vijay 1987.
	Size of seed cavity	Positive	Yadav and Ram 2002, Vijay 1987.
		Negative	Kalloo *et al.* 1982.
	Shelf life	Positive	Choudhury *et al.*, 2004 Vijay 1987.
Bitter gourd	Length of main vine	Positive	Ramachandran 1978.
	Primary branches per plant	Positive	Srivastava and Srivastava 1976.
		Negative	Ramachandran 1978, Mangal *et al.* 1981.
	No. of lobings	Negative	Mangal *et al.* 1981.
	Days to flowering	Negative	Mangal *et al.* 1981.
	Days to 1st female flower	Positive	Srivastava and Srivastava 1976.
	Fruits per plant	Positive	Ramachandran 1978, Mangal *et al.* 1981.
	Weight of fruit	Positive	Ramachandran 1978, Mangal *et al.* 1981.
	Length of fruit	Positive	Ramachandran 1978.

Snake gourd	Primary branches per plant	Positive	Joseph 1978, Raj *etal.*1981
	Days to opening of 1st female flower	Positive	Joseph 1978, Raj *etal.*1981
	Average fruit weight	Positive	Joseph 1978, Raj *etal.*1981
	No. of fruits	Positive	Joseph 1978.
Ridge gourd	Vine length	Positive	Reddy and Rao 1984, Anitha 1998.
		Negative	Karuppaiah *et al.* 2005.
	Internodal length	Positive	Reddy and Rao 1984, Anitha 1998.
	No. of primary branches	Positive	Anitha 1998.
	Number of male flowers	Positive	Reddy and Rao 1984, Karuppaiah *et al.* 2005.
	Number of female flowers	Positive	Reddy and Rao 1984.
	Days to 1st female flowering	Positive	Anitha 1998, Rao *et al.* 2000.
		Negative	Karuppaiah *et al.* 2005.
	Days to 50 percent flowering	Negative	Rao *et al.* 2000
	Sex ratio	Negative	Karuppaiah et al. 2005.
	Fruits per branch	Positive	Rao *et al.* 2000
	Volume of fruit	Positive	Rao *et al.* 2000
	Fruit weight	Positive	Anitha 1998, Rao *et al.* 2000, Karuppaiah *et al.* 2005.
	Fruit girth	Positive	Rao *et al.* 2000, Karuppaiah *et al.* 2005.
	Fruit size index	Positive	Karuppaiah et al. 2005.
	Days to fruit maturity	Negative	Karuppaiah et al. 2005.
	100 seed weight	Positive	Karuppaiah et al. 2005.
	Seeds per fruit	Positive	Anitha 1998, Karuppaiah *et al.* 2005.
	Crop duration	Positive	Anitha 1998.
	Incidence of mosaic	Positive	Anitha 1998.

Pointed gourd	No. of fruits	Positive	Singh and Krishnaprasad 1986.
	Fruit volume	Positive	Singh and Krishnaprasad 1986.
	Fruit weight	Positive	Singh and Krishnaprasad 1986.
Pumpkin	Length of main vine	Positive	Gopalakrishnan 1978.
	Average fruit weight	Positive	Gopalakrishnan 1978.
	Weight of 1st nature fruit	Positive	Gopalakrishnan 1978.
	Fruits per plant	Negative	Gopalakrishnan 1978.
Bottle gourd	Nodes at which 1st female flower emerges	Negative	Singh and Singh 1988.
	Days to 1st female flowering	Negative	Sharma *et al.* 1993, Singh and Singh 1988.
	Female flowers on primary branches	Positive	Prasad *et al.* 1993.
	Fruits per vine	Positive	Prasad *et al.* 1993, Sharma *et al.* 1993, Singh and Singh 1988.
	Average fruit weight	Positive	Prasad *et al.* 1993.
		Negative	Singh and Singh 1988.
	TSS	Positive	Singh and Singh 1988.
	Rind thickness	Negative	Singh and Singh 1988.
Water melon	Days to female flower	Negative	Rajendran and Thamburaj 1989
	Average fruit weight	Positive	Rajendran and Thamburaj 1989
Ash gourd	Days to 1st female flowering	Positive	Lovely 2001.
	Fruits per plant	Positive	Lovely 2001, Joseph 1998.
	Length of fruit	Positive	Joseph 1998
	Girth of fruit	Positive	Joseph 1998
	Average fruit weight	Positive	Joseph 1998

(Falconer, 1987). The positive and negative association of various plant characers on yield is given in Table 2.1

Path coefficient analysis is a standard partial regression, which splits the correlation coefficient into measures of direct and indirect effects. It was developed by Wright (1921) and first used in plant selection by Dewey and Lu (1959). Path analysis measures the direct and indirect contribution of various independent characters or a dependent character such as yield. This is the ratio of standard deviation of the effect and is based on all possible simple correlations among various characters.

Smith *et al.* (1978) reported a genotypic correlation of 1.0 and phenotypic correlation of 0.78 between fruit number and fruit yield in cucumber. Smith and Lower (1978) observed a genotypic correlation of 0.64 and phenotypic correlation of 0.85 for the same trait. From a study involving 20 cucumber varieties on association of economic characters, he found that number of fruits per plant had positive correlation with number of branches and negative correlation with node at which fruit is retained, fruit circumference and fruit length. Choudhury *et al.* (1985) observed negative correlation for days to first female flower opening with fruits per vine and yield per vine in cucumber.

Haribabu (1985) found positive correlation of vine length with branches per vine (0.66) and nodes per vine (0.59) in cucumber. Branches per vine was positively correlated with fruits per vine (0.70) and percentage of fruit set (0.49).

Prudek and Wolf (1985) reported significant correlations between yield and its components in monoecious lines in cucumber and its hybrids.

Path coefficient analysis in 30 diverse genotypes of cucumber revealed that fruit number, female flowers per plant, fruit length, fruit weight and fruit

diameter are important characters determining yield (Choudhary and Mandal, 1987).

In a path analysis involving 75 genotypes of cucumber, Abusaleha and Dutta (1988) reported highest direct effect for fruits per vine and fruit length on yield per plant. They also found negative direct effect for days to first female flower anthesis and percentage of unmarketable yield on total fruit yield. Vine length, branches per vine, fruit girth and flesh thickness exhibited high indirect effect.

Prasunna and Rao (1989) conducted path analysis in eight cucumber varieties and found fruits per vine and average fruit weight as most important yield contributing factors. From a study on cucumber, Sathyanarayana (1991) reported seed maturity had positive correlation with flesh thickness. Rajput *et al.* (1991) reported a significant positive correlation between harvest period and yield but its degree of association was reduced with increasing vine length.

In a path analysis conducted on 23 genotypes of cucumber, Prasad and Singh (1992) revealed positive direct effect of vine length, days to female flower appearance, fruit weight and fruit length on yield. Through path coefficient analysis of 11 components in cucumber, Solanki and Shah (1992) revealed positive and highly significant direct effect for internodal length, number of female flowers and days to maturity on fruit yield.

Chen *et al.* (1994) compared 7 monoecious cucumber cultivars. There were significant positive direct effects for fruits per vine, female flowers per vine on yield per plant. Fruits per vine was reported as the most important trait for yield in cucumber.

Saikia *et al.* (1995) conducted correlation and path analysis is eight genotypes of cucumber. Fruits per plant had maximum direct effect on yield

followed by average fruit weight. Singh *et al.* (2002) evaluated 98 hybrids of cucumber and found a negative correlation between 50 percent male flowering with fruit length and fruit girth, 50 percent female flowering with fruit length and fruit girth, but not significant. Path analysis revealed the highest direct effect (0.34) of weight per fruit on yield per plot. 50 percent male flowering has got comparatively strong direct effect on yield followed by fruit length.

Rao *et al.* (2004) evaluated 31 cucumber genotypes and found highly significant positive correlation between days to first female flower anthesis and days to first fruit harvest (0.86). Highly significant positive correlation was observed between node number for first female flower and days to first fruit harvest (0.69).

From an experiment involving 56 genotypes of muskmelon, Yadav and Ram (2002) found negative correlation between TSS and fruit polar diameter, fruit equatorial diameter, seed cavity size, flesh weight and fruit weight. Path analysis revealed positive direct effect of flesh weight towards yield per plant.

Choudhary *et al.* (2004) evaluated 8 parental lines and 23 F_1s of muskmelon. Path analysis revealed positive and direct effect on characters like fruit weight, number of fruits per plant, rind thickness, shelf life for fruit yield per plant. Characters like vine length, number of vines per plant, days to first female flower, harvest duration and size of seed cavity have negative direct effect on fruit yield (Kalloo *et al.*, 1982).

Srivasthava and Srivasthava (1976) conducted correlation and path analysis in 10 lines of bitter gourd. The studies revealed high positive correlation of number of lateral branches with number of fruits per plant both at genotypic and phenotypic level. The path coefficient analysis revealed maximum direct effect for number of female flowers per plant on yield (2.75) followed by number of fruits per plant (0.90) and number of lateral branches per plant (0.89). Mangal

et al. (1981) observed negative correlation of fruit number with number of days to female flower in 21 bitter gourd varieties

Joseph (1978) worked out path diagram in 25 snake gourd varieties. Individual fruit weight, girth of fruit, number of fruits per plant and node at which first female flower appeared were more important characters contributing to yield on account of their higher direct effect. Length of main vine, number of primary branches, days to maturity, number of female flowers per plant, length of fruit, flesh thickness and 100 seed weight were the characters having high indirect effect on yield. On evaluating 22 types of snake gourd, the number of fruits per plant, weight of fruits and number of female flowers per plant exerted maximum direct effect on yield (Rajput *et al.*, 1981) Number of fruits per plant, fruit weight and number of female flowers per plant had high positive indirect effect on yield.

Prasad and Singh (1989) evaluated 11 genotypes of ridge gourd. They reported significant positive correlation between fruit diameter and fruit length (0.66) and significant negative correlation between fruit length and number of fruits (0.63). Anitha (1998) conducted path analysis in 57 accessions of ridge gourd. Number of fruits per plant exhibited high positive direct effect on fruit yield. The direct effect of vine length on yield was negative. High positive correlation with yield was probably due to indirect effects through number of fruits per plant and days to harvest. Duration of crop had negative direct effect on yield.

Rao *et al.* (2000) worked on 8 diverse lines of ridge gourd and their 28 F_2 crosses. Fruits per vine was negatively correlated with days to first female flower, days to flowering, days to 50 percent flowering and node of first fruit. Path analysis of yield and its components revealed positive direct effect of fruit girth, fruits per branch, length of vine and fruits per vine exerted on yield. Days to 50percent flowering had high direct negative effect on yield per vine. They noticed low positive direct effect on yield whereas days to 50 percent flowering

and first female flower emergence exerted negative direct effect on yield, because of indirect effects through fruits per vine and weight of fruit.

From a path analysis study conducted on 12 genotypes of ridge gourd, Karuppaiah *et al.* (2005) reported highest positive direct effect of number of fruits per plant on yield followed by female flowers per plant, flesh thickness and number of male flowers per plant. Fruit girth had a high negative direct effect on yield followed by 100 seed weight. Days to first female flowering influenced the yield indirectly through fruit length, flesh thickness and number of seeds per fruit. Single fruit weight showed positive indirect effect on yield and flesh thickness.

Prasad and Singh (1989) evaluated 25 cultivars of pointed gourd. They found significant negative correlation between fruit width and number of nodes (0.62). High positive correlations were found between number of shoots and number of nodes (0.54), number of fruits and number of shoots (0.48) and between fruit length and number of fruits (0.53), but they were non-significant.

Prasad *et al.* (1993) evaluated 30 genotypes of bottle gourd. They found positive and significant correlation for days to appearance of fist male flower with days to appearance of first female flower. Male flowers on primary laterals with high sex ratio had positive correlation while that with female flowers on primary laterals was negative. Number of primary laterals exhibited positive correlation with both number of male and female flowers. Node number of first fruit set was positively correlated with node number of first female flower.

Sharma *et al.* (1993) evaluated 35 genotypes of bitter gourd. Vine length was positively correlated with first female flowering node and days to first female flower emergence. Number of fruits exerted positive direct effect on yield. Days to first female flower exerted negative direct effect on yield.

Singh and Singh (1988) evaluated 11 watermelon genotypes. Number of fruits per vine was positively correlated with TSS, node number and number of days to appearance of first female flower with number of fruits per vine.

Number of fruits per vine had high direct effect as well as indirect effect via node number of first female flower appearance and TSS on yield. The highest direct effect was recorded for number of days for first female flower appearance. The indirect effect on yield was negative for most of the characters except fruit weight and rind thickness. Average fruit weight had positive direct effect on yield.

2.3. DIVERGENCE AND CLUSTER ANALYSIS

Knowledge of genetic distances is of much use in plant breeding since it gives an insight into the amount of heterosis that could be derived up on crossing. Majority of the genetic diversity studies deal with the character specific variability in most of crop plants.

Cluster analysis technique, which reduces the dimensionality of multivariate data by removing inter-correlations among variables, has a number of potentially useful applications in horticultural research. It can be used to order multivariate data in one or two orthogonal dimensions called principal components (PCs), which express most of the variance of the original data. Plotting of multivariate data in two or three dimensional principal component space can be useful for displaying relationships among cultivars or species in taxonomic studies.

2.3.1.Genetic Divergence

Importance of genetic divergence in selection of parents for hybridization was stressed by many workers. According to Singh and Gupta (1968), the more diverse the parents within a reasonable range, the more would be the chance of improving the characters in question. Major source of origin of genetic diversity in plants could be enumerated as mutations, recombination and polyploidization whether they are accomplished through natural agencies or through artificially

controlled conditions (Rai, 1979). Usually in most of conventional heterosis breeding programmes, geographical diversity at times and phenotypic diversity in many times are taken as the criteria for choosing genetically divergent populations for isolation of inbred lines. Phenotypic divergence in a population has also been considered as a criterion of genetic diversity.

Generally geographic diversity has been considered as an index of genetic variability in crop plants. However, this may not be true for every case as many workers postulate that geographic diversity need not necessarily be related to genetic diversity. Varieties from widely separated localities are usually included in hybridization programmes pressurising genetic divergence and greater likelihood of yielding better segregants. Validity of above presumption depends on the association between geographic diversity and divergence (Singh and Bain, 1968). Since eco-graphical divergence is not necessarily related with genetic diversity, the phenotypic diversity could not be taken as an index of selection of diverse lines for productive heterosis breeding. Hence, plant breeders are interested to estimate the range of genetic diversity among different genotypes, which will help them to select parents in hybridization programme to achieve the set goals. In addition to quantitative estimation of genetic diversity, Mahalanobis D^2 analysis also provides a means to assess the relative contribution of different characters.

In a study involving 45 diverse lines of musk melon, Kalloo *et al.* (1982) observed high diversity as indicated by ranges of D^2 values from 2.52 - 210.14 among the lines. Depending on the genetic divergence the 45 strains were grouped into 14 clusters. The maximum distance at inter-cluster level was 14.50 followed by 13.29. Intra-cluster divergence ranged from 9.36 to19.86. They also found that the genotypes usually did not cluster according to the geographical origin.

Mathew *et al.* (1986) studied the genetic distance among four botanical varieties of *Cucumis melo,* namely *C. melo* var. *conomon, C. melo* var. *inodorus, C. melo* var. *flexuosus, C. melo* var. *utilissimus and C. melo* var. *momordica.* Genetic distance was calculated considering four quantitative characters such as nodes to first female flower, fruit weight, seeds per fruit and fruits per plant.

Sukhija *et al.* (1982) studied the genetic divergence among 49 lines of watermelon. The D^2 values varied from 3.84 to 308.43 showing high divergence among the lines selected for study. The 46 lines were grouped into 12 clusters. Intra-cluster divergence ranged from zero to 19.40. They also reported that the lines did not cluster according to their geographical distribution. In some cases geographic origin influenced clustering. Average fruit weight contributed maximum towards genetic divergence (28.04%) followed by fruits per plant (23.28%), which together contributed 51.32percent of the divergence. The 28 populations were grouped into seven clusters. Inter-cluster values ranged from 12.88 to 39.39. Low intra-cluster and high inter-cluster values suggested that populations grouped were homogenous within and heterogeneous between clusters. However, results did not show any consistent relationship between divergence and heterosis for yield in watermelon.

Sidhu and Brar (1985) noticed average fruit weight and fruits per plant contributed maximum towards genetic divergence in watermelon followed by fruits per plant. Seeds per fruit did not contribute to total divergence while fruits per plant contributed maximum of 80 percent.

Ramachandran *et al.* (1981) grouped 25 bitter gourd varieties into 10 clusters based on D^2 values. Cluster-II was found to be largest containing 6 genotypes followed by Cluster-IV (4 genotypes), V and VII (3 genotypes each). Cluster-I, III and VIII contained two varieties each and the rest formed independent clusters. Cluster-I with two varieties, had the lowest intra-cluster D^2 value (102.43), while Cluster-IV comprising 4 genotypes had the highest intra-

cluster D^2 (360.50). Inter-cluster value observed was the maximum between Cluster-VI and VIII (8569.31) and minimum was between Cluster-II and III (343.62). The coefficient of variation estimated for different characters among the 10 clusters showed the greater role of yield per plant (38.84), fruits per plant (25.65), female flowers per plant (19.82) and length of fruit (19.05) is determining the inter-cluster distance. Cluster-II, VI, VII, VIII, IX and X exhibited comparatively larger divergence among them.

Vahab (1989) grouped 50 bitter gourd genotypes into five clusters. Cluster-III was the biggest (23 genotypes), followed by Cluster-II (14 genotypes) and Cluster-V (9 genotypes). Cluster-I was the smallest with a single genotype. Intra-cluster distance was maximum between Cluster-IV and V and minimum between Cluster-II and III. It was seen that Cluster-I had lines of less economic importance while the high yielding types fell into Cluster-III irrespective of geographic sources.

In snake gourd, 48 genotypes were grouped into 10 clusters (Varghese, 1991). Cluster-I contained the maximum genotypes (13) followed by Cluster-III and V. Inter-cluster distance ranged from 6.04 to 6.62 and was the maximum between Cluster I and X (6.46).

Kadam and Kale (1985) estimated genetic divergence in a collection of 30 diverse lines of ridge gourd. Cultivars were grouped into 20 clusters. Clusters A and I having 2 cultivars each recorded the lowest and highest intra-cluster distance, respectively. The highest intra-cluster distance was observed between clusters E and H, whereas it was the minimum between clusters D and G. Varalakshmi *et al.* (1994) grouped 58 genotypes into five clusters and observed substantial variations in cluster mean for fruits per plant and fruit yield. Inter-cluster D^2 values indicated that Cluster II was the most divergent from others. There was no association between geographic distance and genetic distance. Fruit

number per vine and yield per vine were the important factors contributing towards divergence.

In pumpkin, 50 genotypes were classified into five clusters (comprising 2, 7, 9, 12 and 20 genotypes) based on Mahalanobis D^2 statistics by Sureshbabu *et al.* (1996). Maximum contribution to total divergence was by days to first flower, first fruit harvest, crop duration and 100 seed weight.

Materials and Methods

3.MATERIALS AND METHODS

The present investigation 'Divergence studies in salad cucumber (*Cucumis sativus* L)' was carried out at Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during 2005-06 (December-April). Field experiment was conducted at Block I of the department.

Experiment site is located at an altitude of 22.5 m above MSL between 10°32'N latitude and 75°16' longitude. The location experiences warm humid tropical climate. Soil of experimental site comes under textured class of sandy loam and is acidic in pH (5.7).

3.A. EXPERIMENTAL MATERIALS AND METHODS

3.A.1.Experimental Materials

Experimental materials consisted of 28 cucumber (*Cucumis sativus*) genotypes, collected from different parts of India. Source and morphological description of genotypes are presented in Table-3.1

Table 3.1 List of cucumber accessions/varieties collected from different parts of the country

Sl.No	Accession No.	Variety	Source
1.	CS-3	Swarna Sheetal	Indian Institute of Horticultural Research, Bangalore
2.	CS-4	Swarna Agati	Indian Institute of Horticultural Research, Bangalore
3.	CS-5	Swarna Poorna	Indian Institute of Horticultural Research, Bangalore
4.	CS-11	NDCU 403	Narendra Dev University for Agriculture and Technology, Faizabad, U.P
5.	CS-13	NDCU 407-2	Narendra Dev University for Agriculture and Technology, Faizabad,U.P

6.	CS-14	NDCU 407	Narendra Dev University for Agriculture and Technology, Faizabad,U.P
7.	CS-15	NDCU 407-1	Narendra Dev University for Agriculture and Technology, Faizabad,U.P
8.	CS-16	Phule Himangi	Mahatma Phule Krishi Vidyalaya, Rahuri
9.	CS-17	Phule Subhangi	Mahatma Phule Krishi Vidyalaya, Rahuri
10.	CS-18	DARL Loc-1	Defence Agricultural Research Laboratory, Pithorgarh, Jharkand
11.	CS-19	DARL 105	Defence Agricultural Research Laboratory, Pithorgarh, Jharkand
12.	CS-20	DARL 106	Defence Agricultural Research Laboratory, Pithorgarh, Jharkand
13.	CS-22	DARL 102	Defence Agricultural Research Laboratory, Pithorgarh, Jharkand
14.	CS-23	DARL Local-2	Defence Agricultural Research Laboratory, Pithorgarh, Jharkand
15.	CS-24	DARL Local-3	Defence Agricultural Research Laboratory, Pithorgarh, Jharkand
16.	CS-25	AAUC-2	Kerala Agricultural University, Thrissur
17.	CS-26	Green Long	Maharashtra Hybrid Seed Company
18.	CS-27	Japanese Long Green	Indian Agricultural Research Institute, Katrain
19.	CS-28	Pusa Sanyog	Indian Agricultural Research Institute, Katrain
20.	CS-29	Puneri Khira	Mahagujarat Seeds Pvt. Ltd.
21.	CS-30	Sheethal	Dr. Balasaheb Sawant Krishividyalaya, Dapoli
22.	CS-35	Kasargod Local	Chemnad, Kasaragod, Kerala
23.	CS-44	Himachal Loc-1	CSKHPK, Palampur,Himachal Pradesh
24.	CS-45	Himachal Loc-2	CSKHPK, Palampur, Himachal Pradesh
25.	CS-47	C-10	CSKHPK, Palampur, Himachal Pradesh
26.	CS-50	Pusa Uday	CSKHPK, Palampur, Himachal Pradesh
27.	CS-51	K-75	CSKHPK, Palampur, Himachal Pradesh
28.	CS-54	Sikkim cucumber	CSKHPK, Palampur, Himachal Pradesh

3.A.2 Experimental methods

The twenty-eight cucumber genotypes were evaluated in a randomized block design (RBD) with two replications. There were 10 plants/genotype/replication with an area of 5 m^2 per plot. Seeds were sown in shallow channels made at a distance of 1.5 m. Distance between plants in a row was 0.3 m. Three seeds were sown at a point. After thinning, one plant was retained. During cropping period various cultural operations and prophylactic plant protection measures were adopted as per KAU Package of Practices (2003).

3.B. PLANT CHARACTERS STUDIED

Observations on important vegetative, fruit and yield characters were recorded as per standard procedures. Five plants randomly selected from each plot was considered for taking observations. Procedures followed or recording observations on quantitative and qualitative traits are furnished below.

3.B.1 Quantitative characters

For taking observations on fruit characters five fruits were selected randomly from each plant. Average values of characters per plant for every type were worked out for each plot. These values were used for further statistical analysis.

1. Length of main vine(cm): Plants were pulled out after final harvest and length of the vine of five plants measured from the collar region up to the tip of main vine. Length of vine was measured in metre.
2. Branches/plant: Number of branches originating from the main vine were counted at final harvest after pulling out plants.
3. Days to first male flower anthesis: Number of days was counted from the date of sowing to the date when the first male flower opened.
4. Days to first female flower anthesis: Number of days was counted from the date of sowing to the date when first female flower was opened.

5. Node at which first female flower emerged: Nodes were counted from the lowest to the one at which first female flower emerged.

6. Days to first harvest: Number of days taken from sowing to the harvest of first formed fruit at tender in each plant was recorded.

7. Duration of crop: Days were counted from date of sowing to the date of last harvest for five plants in each variety.

8. Number of harvests: Total number of harvests made from each plant till the end of crop.

9. Fruits per plant: Number of fruits in each plant was counted at tender stage harvested from each plant.

10. Yield per plant (kg): Weights of fruits harvested from each plant at different dates were recorded separately. These were added to get total yield/plant.

11. Average fruit weight (g): Weight of five fruits from each plant at third harvest was recorded and average was calculated.

12. Fruit length (cm): Length of five fruits from each plant at third harvest was recorded separately and average was calculated.

13. Fruit girth (cm): Girth of five fruits from each plant at third harvest was recorded separately and average was calculated.

14. Flesh thickness (cm): Flesh thickness of fruits at central part from five plants after cutting vertically was recorded separately and average was calculated.

15. Number of seeds per fruit: The fruits were harvested after full maturity and number of seeds per fruit was counted.

3.B.2 Qualitative Characters

Five plants randomly selected at edible maturity were harvested from each plot and were considered for recording the following fruit characters. NBPGR (2002)

1. Density of prickles at harvestable maturity: Prickles present on the fruit surface at harvestable maturity (dense/ sparse).
2. Sex form: Androecious/ gynoecious/ andromonoecious/ gynomonoecious/ hermaphrodite.
3. Fruiting pattern: Branches on which fruits are borne (primary/ secondary/ tertiary).
4. Colour of prickles on fruit at emergence and senescence: Colour of prickles vary from cream/ brown/ black
5. Stem pubescence: Plant surface, i.e., stem and leaves (pubescent/ non-pubescent).
6. Colour of rind at tender harvestable maturity: Colour of fruit rind after 7 days of emergence, i.e., tender harvestable stage (cream/ yellow/ light green/ green/ dark green).
7. Colour of rind at mature stage: Colour of rind after attaining physiological maturity (dark green/ orange/ pink/ brown/ others).
8. Fruit skin lustre: Colour of fruit skin at edible maturity (smooth/ warty/ matt/ intermediate/ glossy/ others).
9. Stem-end shape: Shape of fruit at pedicel end at harvestable maturity (depressed/ flattened/ rounded/ pointed/ others).
10. Blossom-end shape: Shape of the fruit at stylar end at harvestable maturity (depressed/ flattened/ rounded/ pointed/ others).
11. Presence or absence of cavity: Cavity present at the centre of fruit at harvestable maturity (present/ absent).
12. Incidence of pests and diseases: Various diseases and pests like downy mildew, mosaic, serpentine leaf miner, etc. and their occurrence in various genotypes (severe/ moderate/ mild/ very low/ nil).

3.C. STATISTICAL ANALYSIS

The details of statistical analysis followed in the present experiment are as following :

3.C.1.Analysis of variance

Variability for various quantitative characters was estimated by variability, heritability and genetic advance (Burton, 1952). The formulae used in the estimation of the variability at genotypic, phenotypic and environmental levels are given below:

a. Genotypic coefficient of variation (GCV):

$$\frac{\text{Genotypic standard deviation}}{\text{Mean of character under study}} \times 100$$

b. Phenotypic coefficient of variation (PCV):

$$\frac{\text{Phenotypic standard deviation}}{\text{Mean of character under study}} \times 100$$

c. Environmental coefficient of variation (ECV):

$$\frac{\text{Environmental standard deviation}}{\text{Mean of character under study}} \times 100$$

d. Standard error of mean:

$$\frac{\text{Environmental standard deviation}}{(\text{No. of replications})^{1/2}} \times 100$$

The above estimated genotypic, phenotypic and environmental standard deviations were obtained by solving the following equations from the respective analysis of variance table for different characters.

M_3 = Error variance

M_2 = Error variance + No. of replications x genotypic variance

$$\text{Genotypic variance} = \frac{M_2 - M_3}{\text{No. of replications}}$$

Phenotypic variance = Genotypic variance + error variance

M_2 and M_3 was obtained from the analysis of variances and covariances as given in Table 3.2

e. Heritability:

Heritability in the broad sense was found by ratio of genotypic variance to phenotypic variance. It was estimated as per Burton and Devane (1953).

$$h^2(b) = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}}$$

Heritability in the narrow sense was calculated by ratio of additive genetic variance to phenotypic variance.

$$h^2(n) = \frac{\text{Additive genetic variance}}{\text{Phenotypic variance}}$$

f. Expected genetic advance:

Expected genetic advance of the available germplasm at 5 percent intensity of selection was calculated using the formulae suggested by Lush (1949) and Johnson *et al.* (1955).

$GA = h^2 \times \sigma p \times i$,

where 'σp' refers to phenotypic standard deviation and 'i' to intensity of selection.

3.C.2. Correlation analysis

Correlation between yield and its components was calculated from the quantitative observations at genotypic and phenotypic levels as given by Searle (1961)

a. Genotypic correlation between characters x and y:

$$r_{xy}(g) \quad \frac{Cov_{xy}(g)}{Var_x(g).Var_y(g)^{1/2}}$$

b. Phenotypic correlation between characters x and y:

$$r_{xy}(p) \quad \frac{Cov_{xy}(p)}{Var_x(g).Var_y(g)^{1/2}}$$

where Cov_{xy} (g), Cov_{xy} (p) denote genotypic and phenotypic co-variances, respectively, between characters x and y. $Var._x$ (g), $Var._x$ (p) denote genotypic and phenotypic variances for character x and $Var._y$ (g), $Var._y$ (p) denote genotypic and phenotypic variances for character y, respectively. Phenotypic correlation coefficient was tested for significance.

]

3.C.3. Path coefficient analysis

Total yield was considered as the effect factor in a closed system of "cause and effect" variable. The causal variables being vine length,

number of branches, nodes to first female flower, days to first male and female flower anthesis, fruit length, fruit girth, flesh thickness, fruit weight, seed number, days to harvest, number of harvests, duration and fruits per plant. The estimtes of direct and indirect effects in a closed system of variables were calculated by the path coefficient analysis by Dewey and Lu (1959). Path coefficient was worked out by the method suggested by Wright (1921). Simultaneous equations which give estimate the path coefficient with 'k' independent characters are:

$$\begin{vmatrix} r_{1y} \\ r_{2y} \\ r_{3y} \\ . \\ . \\ . \\ r_{ky} \end{vmatrix} = \begin{vmatrix} 1 & r_{12} & r_{13} \ldots\ldots\ldots\ldots\ldots\ldots & r_{1k} \\ & 1 & r_{23} \ldots\ldots\ldots\ldots\ldots\ldots & r_{2k} \\ & & 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots & r_{3k} \\ & & & . \\ & & & . \\ & & & . \\ & & & 1 \end{vmatrix} \times \begin{vmatrix} P_{1y} \\ P_{2y} \\ P_{3y} \\ . \\ . \\ . \\ P_{ky} \end{vmatrix}$$

The genotypic path coefficients were obtained by replacing the corresponding elements in the matrices by genotypic correlation coefficients.

Residual factor (P_{xy}) that measures the contributions of other factors not considered in the causal scheme was estimated as:

Residual factor (x), $P_{xy} = (1 - R^2)$

Where $R^2 = {}^{k}\Sigma_{i=1} + P_{iy}{}^2 + 2\,{}^{k}\Sigma_{i=1}\, P_{iy}\, P_{jy}\, r_{ij}$

$i \neq j$

$i < j$

3.C.4 **Estimation of genetic divergence**

Genetic divergence among 28 genotypes of salad cucumber was calculated considering 16 quantitative characters. Method suggested by

Mahalanobis (1928) was used to estimate D^2 with $x_1, x_2, x_3, \ldots x_p$ as the multiple measurements available on each individual and $d_1, d_2, d_3, \ldots d_p$ as $x_1^{-1}, x_2^{-2}, \ldots x_p^{-p}$, respectively, being the difference in the means of the two populations where superscripts denotes genotypes and suffix denotes characters.

Mahalanobis D^2 statistics is defined as:

$PD^2 = b_1d_1 + b_2d_2 + \ldots b_pd_p$

Here the b value is to be estimated as the ratio of variance between the populations to the variance within the population is maximised. In terms of variances and co-variances, the D^2 value is obtained as follows:

$PD^2 = \Sigma\omega^{ij} (x_1^{-1}, x_1^{-2}) (x_j^{-1}, x_j^{-2})$

where, ω^{ij} is the I, j^{th} element of the inverse of the estimated variance co-variance matrix.

The square root of D^2 value was calculated to obtain generalised statistical distance between two genotypes. All the genotypes were grouped into a number of clusters by the computer oriented interactive algorithm proposed by Suresh (1986) as follows:

i. The two genotypes having maximum D^2 values between them were identified and they were termed the nuclei of two clusters.
ii. Each genotype was considered in turn and allowed to the cluster for which its D^2 value with the nuclear genotypes was the minimum.
iii. To increase the number of clusters by one, the maximum D^2 within the above two clusters was found and the genotype having maximum D^2 was considered as the nuclei in addition to the nucleus genotype of the remaining clusters. Genotypes were reassigned as in (ii).

The initial clusters thus obtained were further optimized using the iterative algorithm as described below:

Numbered the genotypes from 1-28 where there are 28 genotypes. Took out genotype No. 1 from the cluster to which it was allocated and calculated average D^2 values between this genotypes and each cluster. Allocated this genotype to the cluster for which the average D^2 value was the minimum.

Repeated (b) for all genotypes numbered from 1-28 with clustering obtained in step (i) a second iteration may be started if necessary.

Iterations were continued till two successive iterations ended up with the same configurations of clusters. To decide on the optimum numbers of clusters, a graph was drawn with weighted arithmetic mean of average intra-cluster D^2 values against the number of clusters. The point just beyond the maximum curvature was taken as the optimum number of cluster to be formed.

Table 3.2 Analysis of variances and covariances of the design

Source of variation	Degrees of freedom	Mean Square			
		Observed	Expected	Observed	Expected
Total	55				
Between replications	1	M_1		MP1	
Between genotypes	27	M_2	Error variance + (number of replication x genetic variance)	MP2	Error covariance + (number of replication x genetic covariance)
Error	27	M_3	Error variance	MP3	Error covariance

Results

4. RESULTS

Data collected from the present experiment were statistically analysed and results are presented under the following heads:

A. Estimation of variability, heritability and genetic advance

B. Correlation studies and path coefficient analysis

C. Estimation of divergence

4. A. ESTIMATION OF VARIABILITY, HERITABILITY AND GENETIC ADVANCE

Analysis of variance among 28 salad cucumber genotypes revealed significant variation for all the 15 characters, *viz.*, fruit length, fruit girth, fruit flesh thickness, fruit weight, vine length, number of branches, number of seeds, first female flowering node, days to first male flower anthesis, days to first female flower anthesis, days to harvest, duration of crop, fruits per plant, number of harvests and yield per plot. The extent of variability present in the 28 salad cucumber genotypes with respect to yield and 15 component characters was measured in terms of range, mean and it's standard error and coefficient of variation at genotypic, phenotypic and environmental levels (Table 4.1 and 4.2).

4. A. 1. Vegetative characters

4. A. 1. 1. Vine length

Vine length of plant measured from the collar region to the vine tip was maximum in CS 20 (309.25 cm) followed by CS 44 (291.65 cm), CS 51 (278.30 cm) and Japanese Long Green (261.65 cm). The minimum vine length was recorded in CS 13(61.30 cm). The mean value for vine length was 195.30 cm. PCV and GCV values were 36.64 and 36.37, respectively, and genetic gain was 68.89. Heritability estimated for the character was 98.5%.

4. A. 1. 2. Number of branches per plant

Fig.1 Comparison of heritabilities of yield and its components

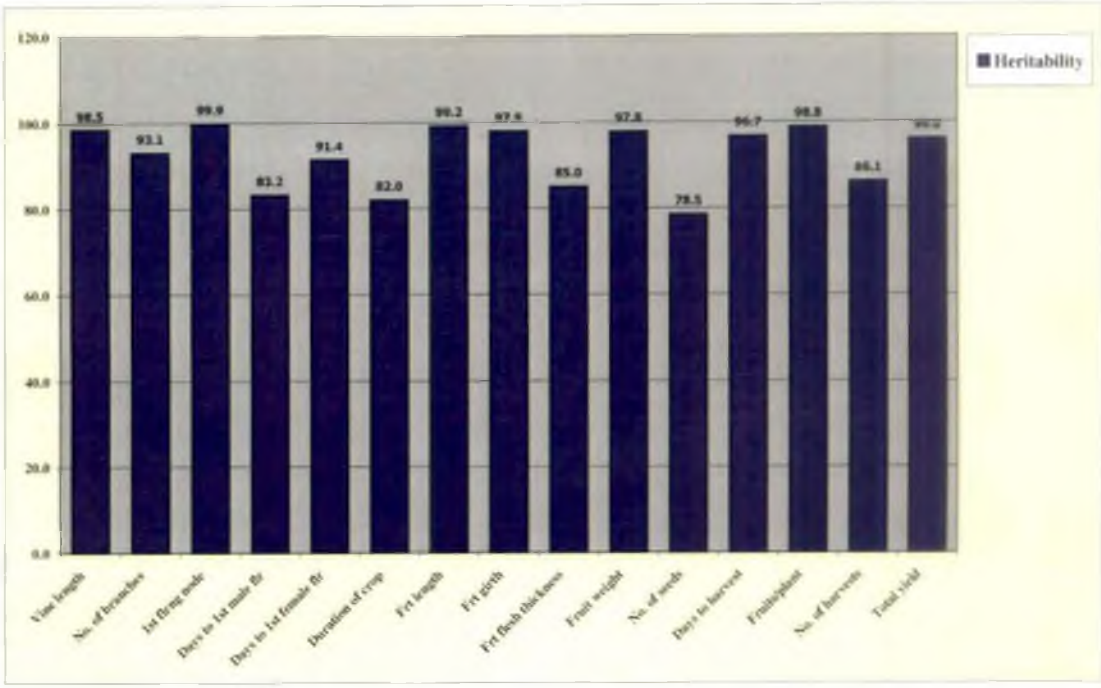


Fig.2 Variation in PCV and GCV for yield and its components

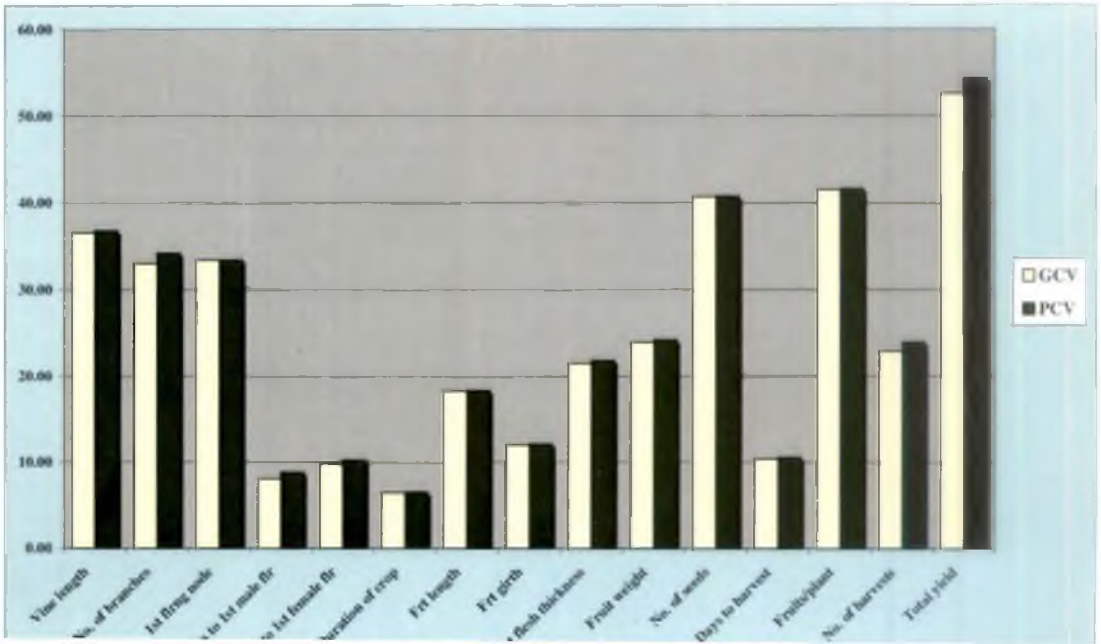


Table 4.2 Range, mean, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance and genetic gain for 15 component characters

Si. no.	Characters	Range	Mean ± SEM	GCV (%)	PCV (%)	ECV (%)	Herit-ability (%)	Genetic advance	Genetic gain (%)
1.	Vine length (cm)	61.3 – 309.3	180.17 ± 5.684	36.37	36.64	0.27	98.5	133.37	68.89
2.	No. of branches	2.4 – 9.2	4.36 ± 0.292	34.80	36.06	1.26	93.1	3.02	69.23
3.	Node to first flower emergence	2.2 – 11.3	5.46 ± 0.028	33.43	33.44	0.01	99.9	3.76	68.83
4.	Days to first male flower anthesis	27.5 – 41.0	32.43 ± 0.832	8.08	8.85	0.77	83.2	4.92	15.17
5.	Days to first female flower anthesis	31.0 – 44.0	35.93 ± 0.762	9.81	10.26	0.45	91.4	6.94	19.32
6.	Duration of crop	69.0 – 88.0	77.46 ± 1.576	6.14	6.78	0.64	82.0	8.87	11.45
7.	Fruit length (cm)	11.7 – 27.1	16.38 ± 0.189	18.41	18.48	0.07	99.2	6.19	37.78
8.	Fruit girth (cm)	12.5 – 19.7	15.61 ± 0.199	11.99	12.12	0.13	97.9	3.82	24.48
9.	Fruit flesh thickness (cm)	0.6 – 1.9	1.38 ± 0.127	19.96	21.65	1.69	85.0	0.52	37.82
10.	Fruit weight (g)	86.0 – 360.0	232.12 ± 5.921	23.98	24.25	0.27	97.8	113.41	48.86
11.	No. of seeds/fruit	98.0 – 590.0	267.73 ±0 .427	43.07	48.63	5.56	78.5	210.44	78.60
12.	Days to harvest	41.0 – 61.0	45.34 ± 0.673	10.41	10.59	0.18	96.7	10.40	21.08
13.	Fruits/plant (g)	1.9 – 12.0	5.88 ± 1.266	55.40	55.75	0.35	98.8	32.75	88.50
14.	No. of harvests	2.5 – 12.5	7.61 ± 0.750	34.69	37.38	2.79	86.1	5.04	66.20
15.	Total yield (kg/5m^{1})	2.3 – 20.2	9.35 ± 0.542	40.01	40.84	0.83	96.0	7.54	80.64

Table-4.1 General analysis of variance of yield and its component characters

Source	Mean sum of squares			Critical Difference	Critical Variance
	Genotypes	Replications	Error		
Vine length	8650.67	457.62	64.61	16.50	4.46
No. of branches	4.78	0.15	0.17	0.85	9.40
Node of 1st flower emergence	6.67	0.002	0.0016	0.082	0.73
Days to 1st male flower anthesis	15.00	8.64	1.38	2.41	3.63
Days to 1st female flower anthesis	25.99	0.64	1.16	2.21	2.99
Crop duration	53.66	13.01	0.91	1.95	1.93
Fruit length	18.25	0.002	0.071	0.548	1.63
Fruit girth	70.84	0.08	0.074	0.560	1.75
Flesh thickness	0.16	0.021	0.031	0.236	8.37
Fruit weight	6268.89	141.25	70.10	17.18	3.61
Seeds /fruit	32049.68	58.00	36.49	23.90	22.59
Days to first harvest	50.22	5.81	4.97	4.56	2.88
Fruits /plant	514.98	15.02	3.20	3.67	6.19
Number of harvests	15.00	6.43	1.12	2.18	13.93
Total yield / plot	28.54	1.09	0.598	2.18	8.2

Number of branches per plant was maximum in Japanese Long Green (9.15) and minimum in Pusa Uday (2.40). The mean value for number of branches was 4.36. PCV and GCV values were 36.06 and 34.80, respectively. Heritability and genetic advance estimated as percentage of mean were high for branch number (93.1% and 69.23%, respectively).

4. A. 2. Flowering characters

4. A. 2. 1. Node of first female flower appeared

Node number at which the first female flower formed exhibited high variation. Female flowers were borne in a farther node in CS 35 (11.30) followed by CS 44, AAUC 2 and Pusa Sanyog (7.0). The lowest node number for female flower appearance was recorded in CS 13 (2.20). The mean value for node number was 5.46. GCV and PCV values were 33.43 and 33.44, respectively. Heritability for the character was the maximum and it was as high as 99.9%. Genetic gain estimated was also high (68.83%).

4. A. 2. 2. Days to first male flower anthesis

Genotype, which produced male flowers at the earliest, was CS 54 (27.5 days). AAUC-2 took the maximum days (41 days) for male flower anthesis. On an average, genotypes produced male flowers 32.4 days after sowing. Heritability and genetic gain were 83.2% and 15.17%, respectively, which was lowest among all characters. GCV and PCV values estimated for the characters were low. (8.08 and 8.85, respectively). The lowest GCV was observed for this character (8.08).

4. A. 2. 3. Days to first female flower anthesis

CS 14 was the earliest genotype to produce female flowers (31.0 days). CS 35 took maximum days (44.0 days) for female flower anthesis. The mean value was 35.9 days. GCV and PCV values were 9.81 and 10.26, respectively. Heritability and genetic gain were 91.4% and 19.32% respectively.

4. A. 2. 4. Duration of crop

Fig.5 Comparison of lengths of 28 cucumber varieties

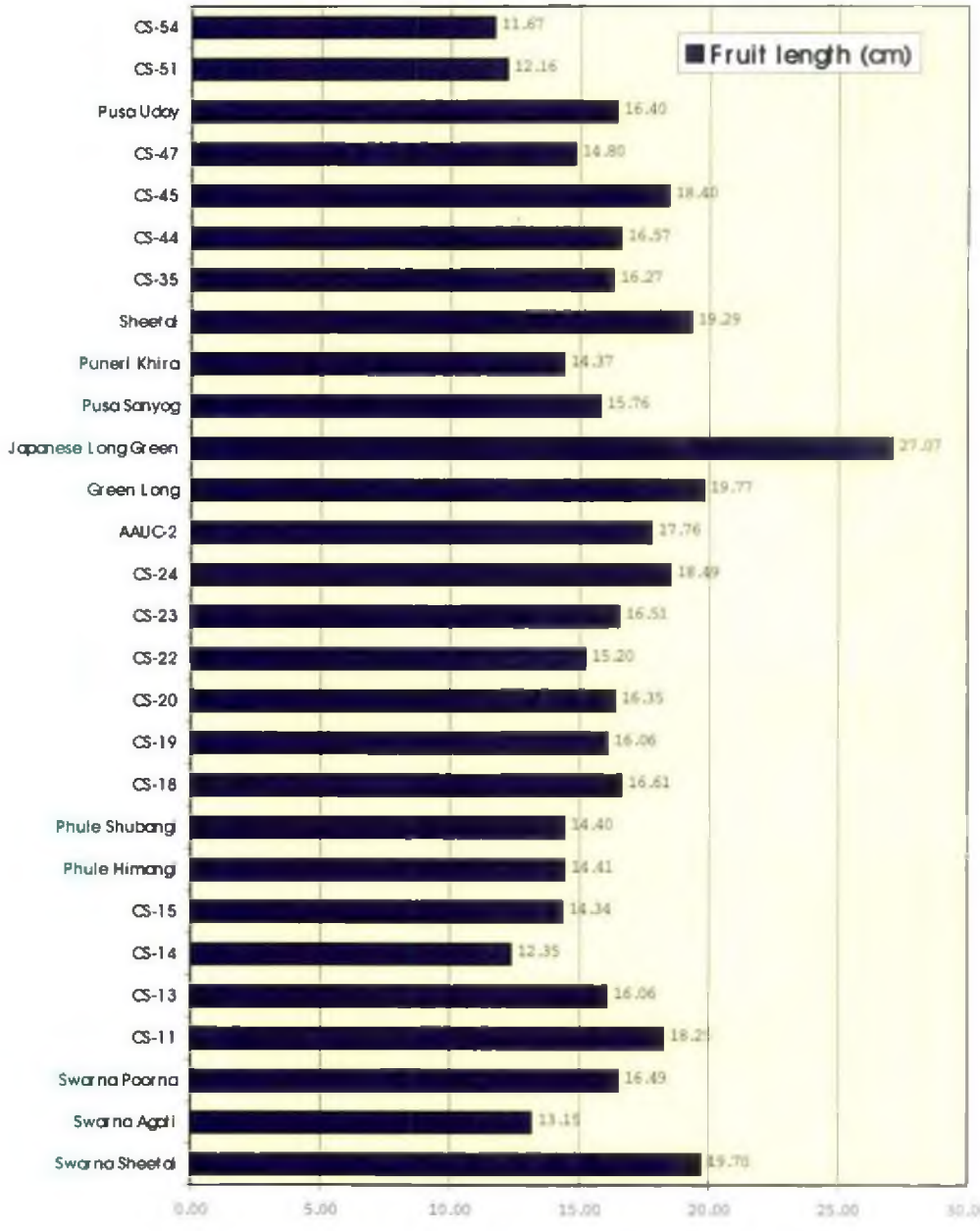
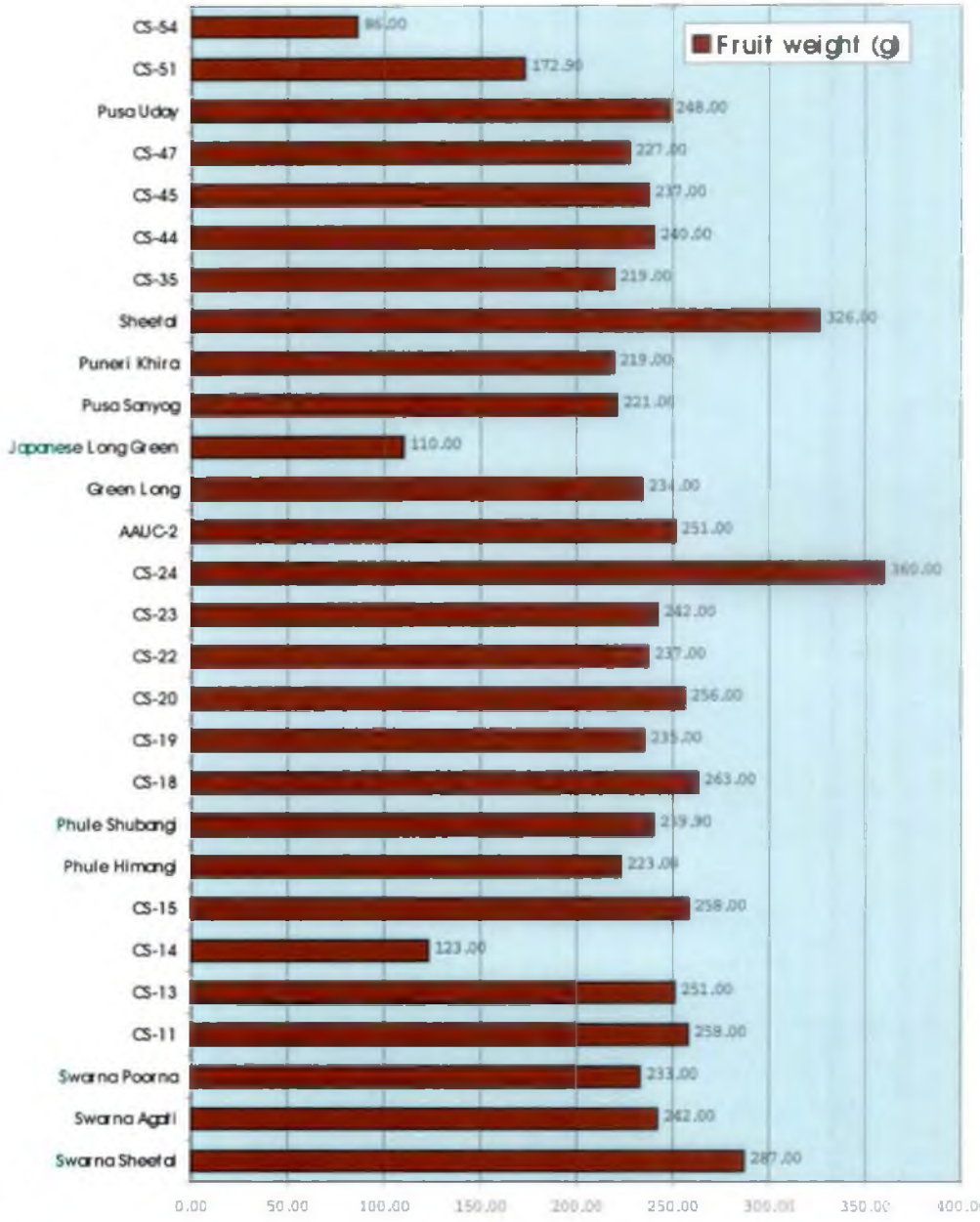


Fig. 4 Comparison of weight of Fruit weight of 28 cucumber varieties



Duration of crop counted from the date of sowing till date of last harvest, was maximum in CS 35 (88.0 days) followed by AAUC 2 (86.50 days). The minimum duration was for CS 54 (69.0 days). The mean duration of cucumber genotypes were estimated as 77.46 days. PCV and GCV values for the character were low (6.78 and 6.14, respectively). Though heritability was high (82%), genetic gain estimated was low (11.45 %).

4. A. 3. Fruit characters

4. A. 3. 1. Length of fruit

Fruit length among varieties exhibited high variation as indicated by wide range (11.67 cm to 27.07 cm). Fruit length was maximum in Japanese Long Green (27.07 cm) followed by Swarna Sheethal (19.70 cm). Shortest fruits were observed in CS 54 (11.67cm). GCV and PCV values were 18.41 and 18.48, respectively. Length of fruit exhibited high heritability (99.2%) and moderate genetic gain (37.78%).

4. A. 3. 2. Girth of fruit

The overall mean for fruit girth was 15.6 cm. Girth of fruit was the maximum in CS 44 (19.72 cm) followed by CS 22 (19.18 cm). The minimum girth was observed in Japanese Long Green (12.45 cm). GCV and PCV values were low (11.99 and 12.12, respectively). Heritability value for fruit girth was 97.9% and genetic gain was 24.48%.

4. A. 3. 3. Fruit flesh thickness

The genotype Pusa Uday had maximum flesh thickness (1.89 cm) followed by Green Long (1.74 cm). Minimum flesh thickness was observed in CS 47 (0.65 cm). Average fruit flesh thickness was 1.38 cm. GCV and PCV values were 19.96 and 21.65, respectively. Heritability was 85% and genetic gain was 37.82%.

4. A. 3. 4. Average fruit weight

Average fruit weight ranged from 86.0g in CS 54 to 360 g in CS 24. Sheethal also had heavy fruits (328 g). Mean value computed for this character was 232.12 g. GCV and PCV values for fruit weight were 23.98 and 24.25, respectively. Fruit weight had high estimate of heritability (97.8%) and moderate estimate of genetic gain (48.86%).

4. A. 3. 5. Number of seeds per fruit

Number of seeds/fruit was the maximum in CS 13 (590.0) followed by Swarna Sheethal (488.0). The minimum number of seeds per fruit was observed in Swarna Poorna (98.0). GCV and PCV values were 43.07 and 48.63, respectively. Low heritability (78.5%) coupled with moderate genetic gain (78.6%) were recorded for this character.

4. A. 3. 6. Days to first fruit harvest

Pusa Uday took maximum days for first fruit harvest (61 days). The earliest harvested genotype was CS 15 (41 days). GCV and PCV values for days to first fruit harvest were 10.41 and 10.59, respectively. High heritability (96.70%) and low genetic gain (21.08%) were recorded for this character.

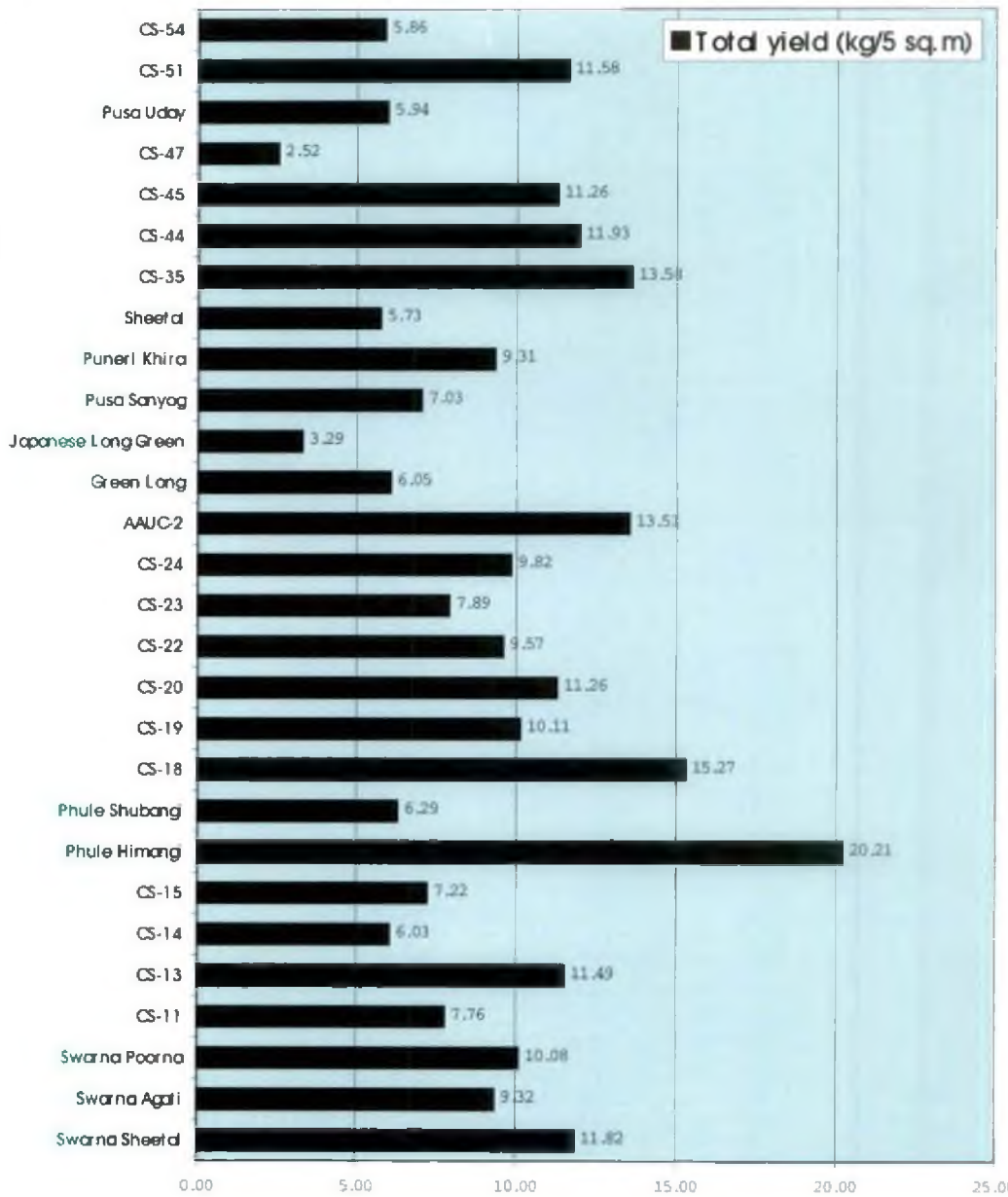
4. A. 3. 7. Fruits per plant

Number of fruits per plant ranged from 1.99 in CS 47 to 12.0 each in Phule Himangi. The mean value for fruits per plant was 5.87. GCV and PCV values were high (55.40 and 55.75, respectively). High heritability (98.8%) coupled with high genetic gain (88.5%) was observed for this character.

4. A. 3. 9. Number of harvests

Number of harvests ranged from 2.50 to 12.50. Maximum number of harvests was obtained in AAUC 2 (12.50) and the minimum in Pusa Uday (2.50) GCV and PCV values recorded for the character were 34.69 and 37.38, respectively. Moderate estimates of heritability (86.1%) and variability (GCV=34.69) were observed for number of harvest.

Fig. 3 Comparison of total yields of various cucumber varieties



4. A. 3. 10. Total yield per plot (Kg/5m^2)

The maximum yield per plot was recorded in Phule Himangi (20.21 kg) followed by CS 35 (13.58 kg) and AAUC-2 (13.51 kg). CS 47 recorded the lowest yield per plot (2.25 kg). The mean value for yield per plot was 9.84 kg. GCV and PCV values calculated were moderate (40.01 and 40.84, respectively). Heritability and genetic gain were 96 percent and 80.64 percent respectively.

4 A.4 Qualitative Characters

Qualitative or discrete characters had a great role in identification of varieties. Important qualitative characters which exhibited variation among accessions were intensity and colour of prickles, sex form, stem end and blossom end shape of fruit and fruit skin lustre (Table 4.3).

All the accessions produced caducous prickles on fruit surface. Most of the genotypes were densely prickled (≥5/cm^2). In Swarna Poorna, CS 11, CS 14, Phule Subhangi, CS 18, CS 22, CS 23, Green Long, Japanese Long Green, Pusa Sanyog, etc. entire fruit surface was densely covered with caducous prickles. Genotypes CS 44 and CS 45 had dense prickles only on neck region. Remaining portion was only sparsely covered with prickles. Accessions like CS 15, CS 19, CS 44 and CS 45 had negligible spines on fruit surface. All the fruits except that of Swarna Agati had blunt spines. The spines were sharp in Swarna Agati.

Majority of accessions had black prickles while Swarna Agati, CS 15, CS 18, CS 19, CS 22, CS 23 and CS 51 had brown prickles and CS 44, Phule Himangi and Puneri Khira had white coloured prickles. Japanese Long Green produced green prickles, which were borne on slight protruberances while in the remaining accessions they were on smooth surfaces.

During maturation prickles of all accessions changed to black colour except CS 44, which retained white colour. At harvestable maturity spines will shed with a slight touch.

All genotypes were monoecious and produced both male and female flowers in the same plant. Flowers were yellowish in colour. Male flowers

Table-4.1 Morphological characters of 28 cucumber genotypes

Sl. no	Accessions/ Varieties.	Density of prickles	Colour of Prickles at emergence	senescence	Stem pubescence	Fruit skin lustre
1.	Swarna Sheetal	Sparse	Black	Black	Dense	Glossy
2.	Swarna Agati	Sparse	Brown	Black	Dense	Glossy
3.	Swarna Poorna	Dense	Black	Black	Dense	Glossy
4.	CS-11	Dense	Black	Black	Dense	Glossy
5.	CS-13	Sparse	Black	Black	Dense	Glossy
6.	CS-14	Dense	Black	Black	Dense	Glossy
7.	CS-15	Sparse	Brown	Black	Dense	Glossy
8.	Phule Himangi	Sparse	White	Black	Dense	Glossy
9.	Phule Subhangi	Dense	Black	Black	Dense	Glossy
10.	CS-18	Dense	Brown	Black	Dense	Glossy
11.	CS-19	Sparse	Brown	Black	Dense	Glossy
12.	CS-20	Sparse	Black	Black	Dense	Glossy
13.	CS-22	Dense	Brown	Black	Dense	Glossy
14.	CS-23	Dense	Brown	Brown	Dense	Glossy
15.	CS-24	Sparse	Black	Black	Dense	Glossy
16.	AAUC-2	Sparse	Black	Black	Dense	Glossy
17.	Mahyco Green Long	Dense	Black	Black	Dense	Glossy
18.	Japanese Long green	Dense	Green	Brown	Dense	Glossy
19.	Pusa Sanyog	Dense	Black	Black	Dense	Glossy
20.	Puneri Khira	Sparse	White	Black	Dense	Glossy
21.	Sheetal	Sparse	Black	Black	Dense	Glossy
22.	CS-35	Sparse	Black	Black	Dense	Glossy
23.	CS-44	Rare	White	White	Dense	Glossy
24.	CS-45	Rare	Light green	Black	Dense	Glossy
25.	CS-47	Sparse	Brown	Black	Dense	Glossy
26.	Pusa Uday	Sparse	Black	Black	Dense	Glossy
27.	CS-51	Sparse	White	Brown	Dense	Glossy
28.	CS-54	Sparse	White	Black	Dense	Glossy

PLATE 4: SELECTED CUCUMBER VARIETIES/ACCESSIONS

JAPANESE LONG GREEN

K-75

AAUC-2

DARL LOCAL 3

DARL LOCAL 2

DARL 105

Table 4.1 Morphological characters of 28 cucumber genotypes

Sl. no	Accn./Var	Stem-end shape	Blossom-end shape	Cavity	Colour of rind at	
					Tender stage	Mature stage
1.	Swarna Sheetal	Depressed	Flat	Absent	Dark Green	Brown warty
2.	Swarna Agati	Depressed	Pointed	Present	Dark Green	Brown warty
3.	Swarna Poorna	Depressed	Round	Absent	Light Green	Brown warty with red tinge
4.	CS-11	Depressed	Pointed	Absent	Light Green	Brownish orange
5.	CS-13	Depressed	Round	Absent	Light Green	Brown warty with orange tinge
6.	CS-14	Depressed	Pointed	Absent	Light Green	Brown warty
7.	CS-15	Depressed	Round	Present	Light Green	Brown
8.	CS-16	Depressed	Flat	Absent	White	Yellow-orange
9.	CS-17	Depressed	Round	Absent	Green	Orange with yellowish tinge
10.	CS-18	Depressed	Round	Absent	Dark Green	Brown warty
11.	CS-19	Depressed	Pointed	Absent	Light Green	Brown warty with orange tinge
12.	CS-20	Depressed	Round	Absent	Light Green	Brown
13.	CS-22	Depressed	Round	Absent	Light Green	Brown warty
14.	CS-23	Depressed	Round	Absent	Dark Green	Brown warty
15.	CS-24	Depressed	Pointed	Absent	Dark Green	Brown warty
16.	AAUC-2	Depressed	Round	Absent	Light Green	Orange with green patches
17.	Mahyco Green Long	Depressed	Round	Absent	White with green patches	Brown warty
18.	Japanese Long Green	Depressed	Round	Absent	Light Green	Brown
19.	Pusa Sanyog	Depressed	Pointed	Absent	Light Green	Brown
20.	Puneri Khira	Depressed	Round	Absent	White with green tinge	Orange warty
21.	Sheetal	Depressed	Flat	Absent	Dark Green with yellow tinge	Brown
22.	CS-35	Depressed	Flat	Absent	White with green tinge	Orange
23.	CS-44	Depressed	Round	Absent	White with green tinge	
24.	CS-45	Depressed	Flat	Absent	White with green tinge	Brown warty
25.	CS-47	Depressed	Flat	Absent	White with green tinge	Brown warty
26.	Pusa Uday	Depressed	Pointed	Absent	Light Green	Brown warty
27.	CS-51	Depressed	Round	Absent	White with green tinge	Brown warty
28.	CS-54	Depressed	Round	Absent	Green with white tinge	Brown warty

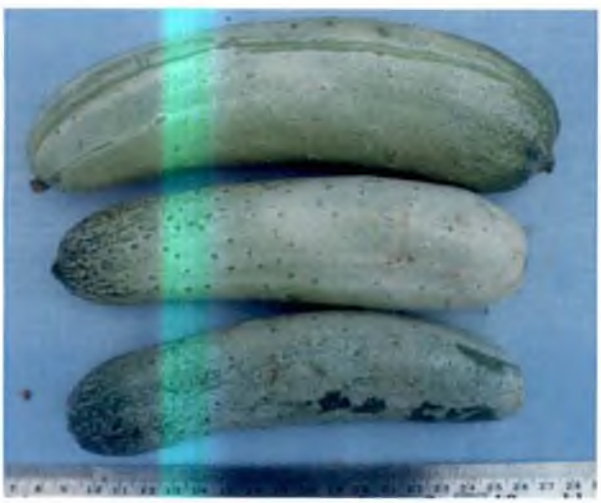
PLATE 5: SELECTED CUCUMBER VARIETIES / ACCESSIONS

DARL LOCAL 1

PUNERI KHIRA

HIMACHAL LOCAL 1

NDCU 407-1



NDCU 407 - 2

PUSA SANYOG

Plate 4: Selected cucumber varieties / accessions

SHEETAL

GREEN LONG

SWARNAPOORNA

SWARNA AGATI

PHULE HIMANGI

PHULE SHUBHANGI

emerged earlier than female flowers. Fruits were produced on primary branches arising from the main vine. Genotypes exhibited high pubescence on leaf as well as stem region. Fruit surface was glossy in all the cases at tender stage. High glossiness was observed in Japanese Long Green. Fruit surface was covered with white powdery coating at earlier stage.

Stem end shape showed little variation. All genotypes had depressed stem end. Blossom end shape exhibited variation. Genotypes Swarna Poorna, CS 13, CS 15, Phule Subangi, CS 18, CS 20, CS 22, CS 23, AAUC-2, Green Long, Japanese Long Green, Puneri Khira, CS 44, CS 51 and CS 54 had round blossom end. Pointed blossom end shape was observed in Swarna Agati, CS 11, CS 14, CS 19, CS 24, Pusa Sanyog and Pusa Uday. Flat blossom end was seen in genotypes Swarna Sheetal, Phule Subhangi, Sheetal, CS 35, CS 45 and CS 47. Fruit cavity, which is an undesirable character was present in CS 14.

Colour of rind at harvestable maturity showed wide variation. Dark green fruits with white stripes were observed in Swarna Sheetal and Swarna Agathi and also had golden yellow spots at stem end. In Swarna Poorna, fruits are light green with golden yellow spots at pedicel end and slight ridges were present. Light green fruits with white stripes and dark green pedicel end were observed in CS 11 and CS 54. Fruits of CS 13 were light green with white stripes and dark green colour was observed at pedicel end and slight yellow colour at blossom end. Yellow colour spread to middle on maturity. Light green fruits with white stripes and dark green pedicel end were observed in CS 14,CS 15, CS 22 and Pusa Sanyog. Fruits of Phule Himangi were stout and white with slight yellowish tinge at blossom end.

Fruits were white with slight green tinge in Phule Subhangi, CS 23 and Puneri Khira. The intensity of green tinge was more at pedicel end and fade towards lower side. CS 18 and CS 24 had dark green fruits with white patches and white long stripes and dark green pedicel end. Slightly ridged, light green fruits with a slight whitish tinge were borne in Pusa Sanyog and CS 20. Light green fruits with white tinge and dark green colour at pedicel end were observed in genotypes AAUC-2 and Green Long. Long dark green fruits were produced in

Table 4.2 Incidence of pests and diseases in 28 cucumber genotypes

Sl no	Accession No.	Incidence of pests & diseases				
		Serpentine leaf miner	Downy mildew	Powdery mildew	Cucumber mosaic	Fruit fly
1.	Swarna Sheetal	Severe	Mild	Mild	Moderate	Very low
2.	Swarna Agati	Moderate	Mild	Moderate	Mild	Moderate
3.	Swarna Poorna	Moderate	Mild	Moderate	Severe	--
4.	CS-11	Severe	Mild	--	Severe	--
5.	CS-13	Severe	Mild	Moderate	Very low	Very low
6.	CS-14	Mild	Mild	--	--	--
7.	CS-15	Severe	Very low	Moderate	--	--
8.	CS-16	Severe	Severe	--	--	--
9.	CS-17	Severe	Moderate	Mild	Mild	--
10.	CS-18	Mild	Mild	Moderate	--	--
11.	CS-19	Moderate	--	Moderate	--	--
12.	CS-20	Moderate	Very low	Mild	Moderate	Very low
13.	CS-22	Severe	--	Mild	Moderate	--
14.	CS-23	Moderate	--	Mild	Moderate	--
15.	CS-24	Very low	Mild	--	Moderate	--
16.	AAUC-2	Mild	--	--	Moderate	--
17.	Mahyco Green Long	Severe	Moderate	--	Mild	--
18.	Japanese Long Green	Very low	Very low	--	Moderate	Moderate
19.	Pusa Sanyog	Severe	Moderate	--	--	--
20.	Puneri Khira	Severe	Mild	--	Severe	--
21.	Sheetal	Severe	Severe	--	Mild	--
22.	CS-35	Severe	--	--	Severe	--
23.	CS-44	Mild	Very low	Moderate	Severe	--
24.	CS-45	Moderate	--	Moderate	Severe	--
25.	CS-47	Mild	--	Very low	Moderate	--
26.	Pusa Uday	Severe	--	Mild	--	--
27.	CS-51	Moderate	Very low	Moderate	Mild	--
28.	CS-54	Moderate	Moderate	Very low	Mild	--

PLATE 6: INCIDENCE OF PESTS AND DISEASES

SERPENTINE LEAF MINER

CUCUMBER MOSAIC DISEASE

POWDERY MILDEW

Japanese Long Green. In Sheethal, fruits were light green coloured with yellowish tinge and pedicel was green mottled, while fruits with greenish tinge .were observed in CS 35, CS 44, K-75 and CS 45. Green colour was observed at pedicel end and white at blossom end. CS 47 had fruits, which were white with a greenish tinge. White stripes on fruits were slightly ridged and green spots appeared at pedicel end.

After harvestable maturity, fruits turned to yellow or brown. Fruits of Swarna Sheethal turn to yellow skin. CS 20, CS 24, Pusa Sanyog, CS 44 and Pusa Uday, fruits turn brown warty with a reddish tinge. Fruits of CS 11,CS 13 and CS 14 turn brownish orange. Fruits of Phule Himangi and Phule Subhangi turn to yellowish colour with orange tinge on maturity. Sheethal, CS 45,CS 47, CS 51 and CS 54 turn yellow and later brown warty on maturity. All the genotypes exhibited un-branched tendrils. Leaf margins were multi-fid and were almost cordate shaped.

Variations on incidence of pests and diseases were also noticed (Table 4.4). Swarna Sheethal, CS 11,CS 13,CS 15, Phule Himangi, Phule Subhangi, CS 22, Green Long, Pusa Sanyog, Puneri Khira, Sheethal, CS 35 and Pusa Uday were severely affected by serpentine leaf miner infestation. Symptoms appeared as characteristic white serpentine markings on leaf lamina. Towards later stage, leaves dried off. Swarna Agati, Swarna Poorna, CS 20, CS 23, CS 44,CS 51 and CS 54 were moderately infested by leaf miner.

Symptoms of downy mildew appeared as pale green areas/patches on leaf. Later it changed into angular spots in Phule Himangi and Sheethal. Genotypes CS 15, CS 20, Japanese Long Green, CS 44 and CS 51 were less infected by downy mildew.

Mild infestation of powdery mildew characterised as white or greyish spots were observed in field. Swarna Agati, Swarna Poorna, CS 15, CS 13, CS 18, CS 19, Phule Subhangi, Cs 45, CS 47 and Pusa Uday recorded mild infestation of powdery mildew.

Incidence of mosaic was also noticed during cropping period. Disease was characterised by light yellow mosaic mottling and reduction in size

of younger leaves. Varietal variation was not noticed on the incidence of mosaic. However, CS 15, Phule Himangi, CS 14, CS 18, CS 19, Pusa Sanyog, Pusa Uday were not affected by the disease.

CS 25 and CS 35 were comparatively free from biotic factors, except mosaic and serpentine leaf miner.

4. B. 1. CORRELATION BETWEEN YIELD AND COMPONENTS

Correlation studies indicate, association of various characters with yield per plot and interrelationship among various component characters at genotypic and phenotypic levels (Table 4.5 and Table 4.6). Fruits per plant had maximum positive and significant correlation (r_g= 0.713) with yield per plot. Duration of crop and number of harvests also had significant positive correlation with yield per plot (r_g= 0.382 and 0.343 respectively).

Though characters like flesh thickness, days to first female flower anthesis, average fruit weight, days to first male flower anthesis, vine length, fruit girth exhibited positive correlation with yield, they were not significant. Days to first fruit harvest exhibited significant correlation with plot yield (r_g= 0.713). Length of fruit and number of branches exhibited negative association with yield per plot (r_g = -0.162 and -0.260). Seeds per fruit and days to first harvest did not exhibit any relation with yield per plot.

Fruits per plant, days to first female flower anthesis, days to first male flower anthesis and duration of crop had significant positive correlation with number of harvests (0.741, 0.640, 0.637 and 0.480 respectively). Node at which first female flower is formed and seeds per fruit (-0.377) exhibited negative correlation with number of harvests.

Number of fruits per plant which is an important yield contributing factor for higher productivity, is significantly influenced by characters like number of harvests, duration of crop and days to first male flower anthesis (0.741,0.461, 0.364 respectively). Length of fruit and days to first female flower anthesis had significant negative association with fruits per plant. (-0.86 and -0.382 respectively).

Table-4.5: Phenotypic Correlation coefficients for yield and component characters

Characters	Vine length	No. of branches	Node to first female flower	Days to male flower anthesis	Days to female flower anthesis	Crop duration	Fruit length	Fruit girth	Flesh thickness	Average fruit weight	Seeds/ fruit	Days to harvest	Fruits/ plant	No. of harvests	Total yield/ plot
Vine length	1	0.560*	0.294	0.199	0.223	0.208	0.044	0.121	-0.185	-0.205	0.066	0.487	0.214	0.152	0.141
No. of branches		1	0.084	0.367	0.193	0.210	0.568*	-0.073	-0.184	-0.151	0.064	0.136	0.036	0.262	-0.238
Node to first female flower			1	0.187	0.424	0.296	-0.043	0.126	-0.006	0.004	-0.264	0.423	0.181	0.223	0.266
Days to male flower anthesis				1	0.652*	0.481	0.309	-0.374	-0.043	0.277	0.187	0.193	0.333	0.495	0.174
Days to fem. flower anthesis					1	0.387	0.198	-0.146	0.069	0.186	-0.237	0.241	0.365	0.537*	0.243
Duration						1	0.334	0.276	0.037	0.171	0.142	0.104	0.370	0.387	0.318
Fruit length							1	-0.259	0.045	0.185	0.097	0.027	-0.085	0.151	-0.156
Fruit girth								1	0.148	0.112	0.228	-0.043	-0.088	-0.223	0.106
Flesh thickness									1	0.276	0.047	0.078	0.208	0.150	0.270
Average fruit weight										1	-0.140	-0.114	0.245	0.226	0.245
Seeds/ fruit											1	0.030	-0.124	-0.253	0.007
Days to harvest												1	-0.101	-0.173	0.095
Fruits/ plant													1	0.702*	0.707*
No. of harvests														1	0.356

* P = 0.05

Table-4.6: Genotypic Correlation coefficients for yield and component characters

Characters	Vine length	No. of branches	Node to first female flower	Days to male flower anthesis	Days to female flower anthesis	Crop duration	Fruit length	Fruit girth	Flesh thickness	Average fruit weight	Seeds/ fruit	Days to harvest	Fruits/ plant	No. of harvests	Total yield/ plot
Vine length	1	0.583**	0.295	0.224	0.248	0.228	0.046	0.126	-0.223	-0.214	0.077	0.499**	0.218	0.171	0.141
No. of branches		1	0.085	0.442**	0.235	0.214	0.599**	-0.057	0.206	-0.144	0.069	0.148	0.036	0.248	-0.260
Node to first female flower			1	0.204	0.444**	0.295	-0.043	0.129	-0.012	0.003	-0.296	0.012	-0.150	-0.377*	0.002
Days to male flower anthesis				1	0.638**	0.590**	0.331	-0.406*	0.001	0.301	-0.195	0.183	0.364*	0.637**	0.218
Days to fem. flower anthesis					1	-0.454**	0.201	-0.190	0.118	0.193	-0.274	0.238	-0.382*	0.640**	0.286
Duration						1	0.376*	-0.302	0.042	0.211	0.148	0.119	0.461**	0.480**	0.382*
Fruit length							1	-0.262	0.049	0.186	0.097	0.024	-0.860**	0.151	-0.162
Fruit girth								1	0.165	0.116	0.260	0.036	0.087	-0.238	0.113
Flesh thickness									1	0.286	0.128	0.088	0.243	0.206	0.305
Average fruit weight										1	-0.165	-0.124	0.251	0.241	0.255
Seeds/ fruit											1	0.012	-0.150	-0.377*	0.002
Days to harvest												1	-0.019	-0.199	-0.96**
Fruits/ plant													1	0.741**	0.713**
No. of harvests														1	0.343*

* G = 0.05
** G = 0.01

Table 4.7 Path coefficient analyses of yield and 15 component characters

Characters	r_g	Direct effect	Indirect effect												
			No. of branches	Node to first female flower	Days to first male flower	Days to first female flower	Crop duration	Fruit length	Fruit girth	Flesh thickness	Av. fruit weight	No. of seeds/ fruit	Days to harvest	Fruits/ plant	No. of harvests
Vine length	0.141	0.391	0.465	0.040	-0.172	0.001	0.069	-0.023	-0.029	-0.022	-0.132	0.022	0.007	0.029	0.118
No. of branches	-0.26	-0.789	–	0.010	0.279	0.010	0.011	0.243	-0.018	-0.039	0.038	-0.010	-0.039	0.035	-0.218
Node to first female flower	0.272	0.118	-0.067	–	0.129	0.019	0.015	-0.017	0.041	-0.002	-0.001	0.044	-0.113	0.177	-0.186
Days to first male flower	0.218	0.630	-0.349	0.024	–	0.028	0.030	0.134	-0.131	0.0	-0.081	0.029	-0.048	0.362	-0.489
Days to first female flower	0.286	0.044	-0.185	0.052	0.402	–	0.123	0.082	0.061	0.022	-0.052	0.041	0.063	0.370	-0.486
Crop duration	0.382	0.051	-0.169	0.035	0.372	0.020	–	0.153	-0.097	0.097	0.008	-0.056	-0.031	0.399	-0.368
Fruit length	-0.162	0.406	0.473	-0.005	0.209	0.009	0.019	–	-0.084	0.009	-0.050	0.014	-0.006	-0.08	-0.116
Fruit girth	0.113	0.322	-0.045	0.015	-0.256	-0.008	-0.015	-0.016	–	0.032	-0.031	-0.041	0.009	-0.084	0.183
Flesh thickness	0.305	0.191	-0.087	-0.001	0.001	0.005	0.012	0.020	0.053	–	-0.076	-0.019	-0.023	0.235	-0.158
Average fruit weight	0.255	-0.267	0.024	0.019	0.008	0.033	0.244	0.075	0.037	0.055	–	0.0	0.011	-0.185	0.096
No. of seeds/ fruit	0.002	-0.148	0.055	-0.035	-0.123	-0.012	0.007	0.039	0.089	0.024	0.044	–	-0.003	-0.146	0.289
Days to harvest	0.960	-0.263	-0.117	0.051	0.116	0.010	0.006	0.153	-0.012	0.017	0.033	-0.002	–	-0.106	0.152
Fruits/ plant	0.713	0.969	-0.028	0.022	0.229	0.017	0.021	-0.035	-0.028	0.046	-0.067	0.022	-0.029	–	-0.569
No. of harvests	0.343	-0.767	-0.224	0.061	-0.077	0.039	0.024	0.061	-0.077	0.039	-0.064	-0.056	0.052	0.718	–

Residual value = 0.1741

Days to first fruit harvest is the best indicator of earliness and is significantly influenced by vine length (0.499). Average fruit weight and fruit flesh thickness did not exhibit significant association with any of the other characters. However average fruit weight is positively and non significantly correlated to male flower anthesis, fruit flesh thickness and crop duration. Characters like number of branches and duration of crop had significant positive association with length of fruit (0.599 and 0.376). Duration of crop had significant and positive correlation with days to male flower anthesis (0.590) and significant negative correlation with days to female flower anthesis (-0.454). In majority of the cases the genotypic correlation was higher than phenotypic correlation coefficients.

Vine length, an important yield-contributing factor is positively and significantly correlated to number of branches and days to harvest (0.583 and 0.499 respectively). It had positive but non-significant correlation with node to first female flower appearance, days to first female flower anthesis and days to first male flower anthesis.

4. B. 2. PATH COEFFICIENT ANALYSIS

Genotypic correlation between total yield and its component characters were partitioned into its different components (Table 4.7). The direct and indirect contribution of component characters alone and in combinations contributed more than 96.6% of variability in total yield per plot ($R^2 = 0.966$).

As in the case of genotypic correlation, fruits per plant exhibited maximum direct effect on yield per plot (0.969). This was followed by days to male flower anthesis (0.630), fruit length (0.460) and vine length (0.391).

Crop duration which exhibited significant positive correlation with yield per plot (r_g =0.382) had only a low direct effect on yield per plot (0.051). The significant positive correlation was mainly due to its indirect effect through days to first male flower anthesis (0.372) and fruits per plant (0.399).

The characters days to first harvest which had high negative and significant correlation (r_g = 0.960) with yield per plot had negative direct effect (-0.263). It

also imparted negative influence or yield per plot through number of branches (-0.117), fruit girth (-0.012) and seeds per fruit (-0.002) and fruits per plant (-0.016).

Number of harvests which exhibited significant positive correlation with yield per plot (r_g = 0.343) had high negative direct effect (-0.767). The positive correlation is mainly through its high indirect effect through fruits per plant (0.718) and low but positive indirect effect through days to first harvest flesh thickness, fruit length, crop duration, days to first female flower anthesis, first flowering node and vine length (0.039, 0.061, 0.024, 0.039, 0.061, 0.067 respectively).

Average fruit weight had positive correlation (0.255) but direct effect was negative (-0.267) with yield per plot. Fruit length which exhibited negative correlation (-0.162) with yield per plot had positive direct effect (0.406).

Number of branches which exhibited low negative correlation with yield per plot (0.260) had high negative direct effect (-0.789). It also imparted negative indirect effects through fruit girth (-0.018), fruit flesh thickness (-0.022) and fruit weight (-0.132).

Days to first female flower anthesis had high genotypic correlation with yield per plot (0.286) and low direct effect (0.044). The high correlation value was contributed by indirect effects through days to first male flower emergence (0.372) and fruits per plant (0.370).

Vine length exhibited high positive direct effect and low correlation coefficient to total yield (0.391 and 0.141 respectively). Inspite of the high direct effect, the low correlation coefficient was contributed due to negative indirect effect through fruit length, fruit girth, flesh thickness, fruit weight, days to first male flower anthesis (-0.023, -0.029, -0.022, -0.132, -0.172 respectively).

4. C. ESTIMATION OF DIVERGENCE

4. C. 1. Assessment of genetic divergence and clustering of genotypes

The 28 cucumber genotypes included in the study were grouped in to 5 clusters, Cluster I, II, III, IV and V comprising 13,4,8,2 and 1 genotypes, respectively (Table 4.8). Intra and inter-cluster D values of the 5 clusters were worked out. From the table 4.9 it could be observed that the intra-cluster D values were lower than that of inter-cluster D values.

Intra-cluster distances in the 5 clusters ranged from 2212.9 in Cluster I to 5695.35 in Cluster IV. Remaining intra-cluster distances (D) were in the order of 2242.31,2276.64 and zero in Cluster II, III and V, respectively. Cluster V was found to show maximum average inter-cluster distance with other clusters and it was the cluster having the maximum distance in all the three combinations it could make. (D values 64635.12 with cluster IV, 8096.3 with Cluster II, 9361.71 with Cluster III and 48731.77 with Cluster I). Cluster III, which comprised 8 genotypes showed the lowest inter-cluster distance with other clusters (D values 8415.55 with Cluster V). Inter-cluster distance was the maximum between Cluster IV and V (64635.12). Genotypes CS 14,CS 22, CS 23, AAUC 2, CS 28, CS 44, CS 45, CS 47, CS 51, Swarna Sheethal , Swarna Agathi , Swarna Poorna and Phule Himangi were included in Cluster I. Genotypes CS 13, CS 15, CS 20 and Pusa Uday were included in cluster II.The prominent genotypes included in cluter III were CS 11, Phule Subhangi, CS 18, CS 19,Green Long, Puneri Khira, Sheethal and CS 54. Genotypes CS 24 and Japanese Long Green were major ones belonging to Cluster IV. The promising genotype, CS 35 was included in cluster V.

4.C. 2 Clustering of genotypes

The overall means of clusters I, II, III, IV and V are presented in table 4.10. The results of the means of each clusters are furnished character wise below

4.C.2.1. Vegetative characters

4.C.2.1.1. Vine length

Maximum mean value for vine length was shown by cluster IV (203.03 cm) followed by cluster I (202.92 cm) and minimum by cluster II (145.24 cm)

4.C.2.1.2 Number of branches

Cluster II (3.31) exhibited minimum mean value for number of branches and maximum value was in cluster IV (7.3)

4.C.2.2 Flowering characters

4.C.2.2.1Node to first female flower emergence

Cluster V exhibited maximum mean value for node to first female flower emergence (11.3) and cluster II exhibited the minimum value (2.69)

4.C.2.2.2 Days to first male flower anthesis

The maximum mean value for male flower anthesis was shown by cluster V (36.00). The mean value for male flower anthesis was shown by cluster III (31.88).

4.C.2.2.3 Days to first female flower anthesis

Cluster V exhibited maximum mean value for female flower anthesis (44.00) followed by cluster III (36.5). The minimum value for female flower anthesis was observed in cluster II (34.80).

4.C.2.2.4 Duration of crop

Cluster V (88.00) had maximum value for crop duration. Cluster III (75.63) exhibited minimum value for crop duration.

4.C.2.3 Fruit characters

4.C.2.3.1 Length of fruit

The maximum mean value for fruit length was observed in cluster IV (22.78cm). The minimum mean value for fruit length was observed in cluster I (15.64cm).

4.C.2.3.2 Girth of fruit

The maximum mean value for fruit girth was observed in cluster I (16.27cm) followed by cluster IV (15.35 cm). The maximum mean value was observed in cluster V (13.29cm).

4.C.2.3.3 Fruit flesh thickness

Cluster III exhibited maximum mean value for flesh thickness (1.42 cm). Cluster IV and Cluster V exhibited minimum mean value for fruit flesh thickness (1.16 cm)

4.C.2.3.4 Fruit weight

The maximum mean value for fruit weight was observed in cluster II (253.3g) and minimum mean value was shown by cluster V (219.0g)

4.C.2.3.5 Number of seeds per fruit

Cluster II exhibited maximum mean value for number of seeds per fruit (356.8) followed by cluster I (283.5). The minimum mean value for number of seeds per fruit was shown by cluster V (140.5)

4.C.2.3.6 Days to first fruit harvest

Cluster V (58.0) showed maximum values for days to first fruit harvest. The minimum mean value was exhibited by cluster III (46.94)

4.C.2.3.7 Number of fruits per plant

The maximum and minimum mean values for number of fruits per plant was exhibited by cluster I (3.32) and cluster II (1.93) respctively.

4.C.2.3.8 Number of harvests

Cluster V showed maximum mean value for number of harvests (9.0) followed by cluster III (8.13) and cluster II (5.63) exhibited minimum mean value.

4.C.2.3.9 Total yield per $5m^2$

The maximum mean value for total yield was exhibited by cluster V (13.58 kg/plot). The minimum mean value for total yield was exhibited by cluster III (6.55 kg/plot).

Table 4.6 List of salad cucumber genotypes included in different clusters

	Accessions	No. of accessions
Cluster I	Swarna Sheethal , Swarna Agathi , Swarna Poorna , CS 14, Phule Himangi, CS 22, CS 23, AAUC 2, CS 28, CS 44, CS 45, CS 47, CS 51	13
Cluster II	CS 13, CS 15, CS 20, Pusa Uday	4
Cluster III	CS 11, Phule Subhangi, CS 18, CS 19,Green Long, Puneri Khira, Sheetal, CS 54	8
Cluster IV	CS 24, Japanese Long Green	2
Cluster V	CS 35	1

Table 4.7 Cluster means for varietal quantitative characters.

Sl no	Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
1.	Vine length	202.98	145.24	152.68	203.03	198.30
2.	No. of branches	4.37	3.31	4.24	7.30	3.53
3.	Nodes to 1st female flower	6.32	2.69	4.59	6.00	11.30
4.	Days to male flower	32.08	32.50	31.88	35.00	36.00
5.	Days to female flower	36.12	34.87	35.00	36.50	44.00
6.	Crop duration	77.65	77.25	75.63	78.75	88.00
7.	Fruit length	15.64	15.79	16.30	22.78	16.27
8.	Fruit girth	16.27	14.96	15.21	15.36	13.29
9.	Fruit thickness	1.39	1.40	1.43	1.16	1.16
10.	Fruit weight	225.88	253.30	232.61	235.00	219.00
11.	Seeds/fruit	283.50	356.75	221.06	237.50	140.50
12.	Days to harvest	50.46	48.25	46.94	49.50	58.00
13.	Fruits/plant	3.32	1.93	2.91	2.03	2.70
14.	No. of harvests	7.81	5.63	8.13	7.50	9.00
15.	Total yield/plot	10.21	8.97	8.29	6.55	13.58

Table 4.8 Average intra and inter-cluster D values of five clusters of salad cucumber considering the 15 characters

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Cluster I	2212.99				
Cluster II	29833.89	2242.31			
Cluster III	8415.55	9594.66	2276.64		
Cluster IV	9697.11	31564.31	12995.90	5695.35	
Cluster V	48731.77	8096.30	9361.71	64635.12	0.0

* Values in diagonals indicate intra cluster distances

Fig.6 Statistical distance (D) among different clusters of 28 salad cucumber accessions

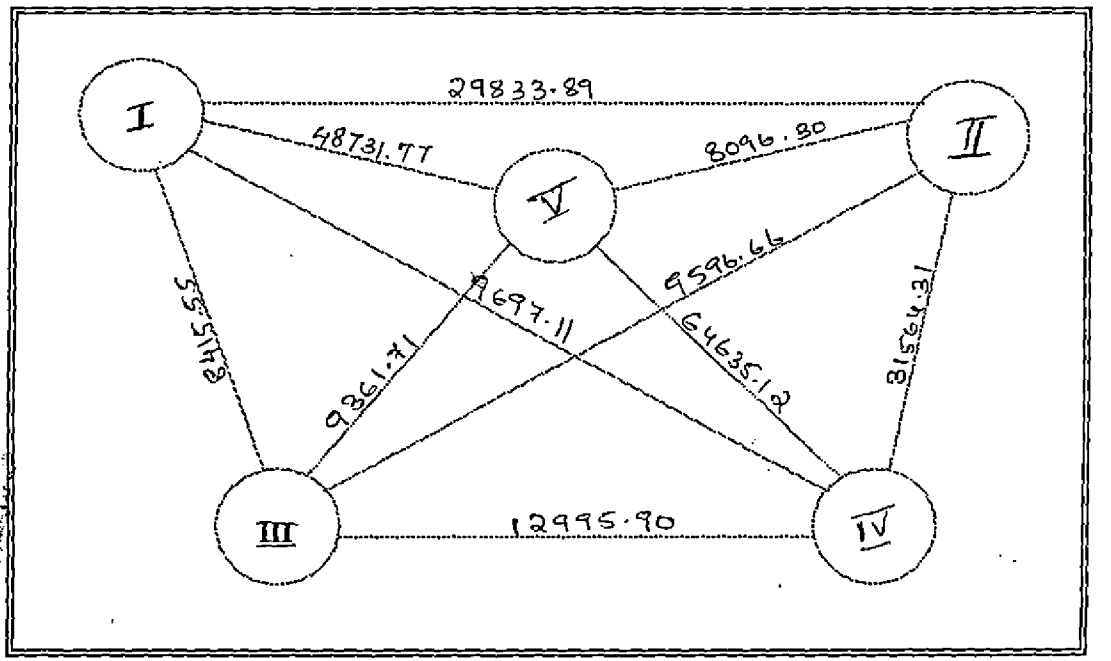


PLATE 1

VIEW OF EXPERIMENTAL PLOT AT VEGETABLE RESEARCH / SEED PRODUCTION FIELD, BLOCK NO. 1, DEPT. OF OLERICULTURE

PLATE 2

VARIABILITY FOR FRUIT CHARACTER IN CUCUMBER

VARIABILITY FOR LEAF CHARACTER IN CUCUMBER

Discussion

5. DISCUSSION

Cucumber (*Cucumis sativus*) is one of the popular cucurbitaceous vegetables grown in India. The fruits at tender stage are used for salad purpose. Due to its cooling effect and cosmetic values, it is used in face masks as well as in creams. Cucumber is consumed by people largely in summer season and it acts as an excellent mitigant for dehydration in hot summer. Due to the high medicinal values, fruits are largely used in ayurvedic treatments. Low cost of production and diverse use in salad and culinary purpose points to the potentiality of the crop. In spite of the popularity and importance of the crop, very little effort is made to upgrade the genetic make up of salad cucumber in the country.

In any plant improvement programme, the main objective is the development of elite varieties through production breeding. The basic information a breeder usually requires as a prerequisite to any breeding programme is the extent of variability in the available germplasm and gene action of the characters to be improved. Basic information on genetic variability, heritability and genetic advance that could be achieved in the next cycle of selections are of vital importance to the breeders for formulating appropriate breeding strategy.

Showy flowers, monoecious and cross-pollinated nature and more seeds per fruit offer great scope for exploitation of hybrid vigour in cucumber. Importance of genetic diversity of parents in hybridization programme was emphasised by many workers. The more diverse the parents within a reasonable range, the more would be the chances of improving characters in question. Mahalanobis D^2 Statistics is a powerful tool in the hands of plant breeders to assess degree of relationship among the genotypes and to group them based on their phenotypic expressions.

The present investigation deals with collection of information as a prerequisite to production breeding programme in cucumber and results obtained on the study are discussed in the following pages.

Success of any breeding programme depends primarily on the extent of variability, heritability and expected genetic advances which are primary

prerequisites for all crop improvement programmes (Johnson *et al.*, 1955). In the present investigation, the genetic contribution in the phenotypic expressions was studied to realise the performance of salad cucumber genotypes. Among the 15 characters studied the 28 cucumber accessions exhibited significant difference for all the characters studied. The accessions showed significant variation for vine length, number of branches, node number at which first female flower is formed, days to first male and female flower anthesis, crop duration, fruit length, fruit girth, flesh thickness, fruit weight, days to harvest, fruits/plant, number of harvests and total yield. Gopalakrishnan (1979), Rana (1982) and Dojide (1983) also observed significant variation for all the characters studied in various cucurbitaceous vegetables. Studies by Rajendran (1989) in water melon, Srivasthava and Srivasthava (1976), Ramachandran (1978) and Vahab (1989) in bitter gourd also found significant variation for all the characters studied.

Mean, range and variation around the mean are various estimates of quantitative variability. In the present investigation, wide range was observed for almost all the characters studied. Maximum vine length was observed in CS 20 (309.25 cm) and the shortest in CS 13 (61.30 cm). Maximum number of branches was produced in Japanese Long Green (9.15) whereas the least was observed in Pusa Uday (2.44). Female flowers were produced at the earliest in CS 14 (31.0 days) and CS 35 took the maximum number of days for female flower opening (44.0 days). In AAUC-2, male flower emergence was late (41 days) and CS 54 was the earliest variety (27.5 days) by considering male flower anthesis. Crop duration was the maximum in AAUC-2 with 86.5 days. CS 54 was with shortest duration (69 days). The longest fruits were produced in Japanese Long Green (27.07 cm) and shortest fruits in CS 54 (11.67 cm). Girth of fruit was the maximum in CS 44 (19.72 cm) and minimum in Japanese Long Green (12.45 cm). Sheetal produced heaviest fruits (328 g) among all varieties. Phule Himangi produced the maximum number of fruits/plant (12.0). The maximum number of harvests was observed in AAUC-2 (12.8). Yield per plot was maximum in Phule Himangi (20.22 kg/plot) followed by AAUC-2(15.11 kg/plot) and CS 47 recorded the lowest yield/plot (2.25 kg/plot).

5.1.MORPHOLOGICAL CHARACTERS

All the accessions produced prickles on the surface. But accessions like CS15, CS19, CS44 and CS45 had negligible spines on fruit surface which is an acceptable character. Swarna Agati had sharp spines. At harvestable maturity, spines will be shed with a slight touch. Majority of accessions had black prickles while Swarna Agati, CS15, CS19, CS22, CS23 and CS51 had brown prickles. CS44, Phule Himangi and Puneri Khira had white coloured prickles. Japanese Long Green had green coloured prickles.

All genotypes were monoecious and flowers were yellowish in colour. Fruits of Japanese Long Green were glossy. All the genotypes exhibited high pubescence on leaf and stem region. Fruits were produced from primary branches of main vine.

All genotypes exhibited round blossom end shape except Swarna Sheetal, Phule Subhangi, Sheetal, CS35, CS45 and CS47, which exhibited flat blossom end. All genotypes exhibited depressed stem end shape.

Dark green fruits with white stripes or golden yellow stripes were observed in Swarna Sheetal and Swarna Agati. Swarna Poorna is also identified by yellow spots but ridges are present on fruit surface. Light green fruits with white stripes and dark green pedicel end were observed in CS14, CS15, CS22 and Pusa Sanyog. The fruits of CS13 also had same characters but slight yellow colour is present at blossom end. On the contrary, fruits of Phule Himangi were white stout and yellowish tinge at blossom end.

Fruits were white with slight green tinge in Phule Subhangi, CS23 and Puneri Khira. Dark green fruits with white patches and white long stripes and dark green pedicel end were observed in CS18 and CS24. Pusa Sanyog and CS20 also had light green fruits with whitish tinge and slight ridges. Light green fruits with white tinge and dark green colour at pedicel end were observed in genotypes AAUC-2 and green long. Japanese Long green had the largest fruits. In Sheetal, light green fruits with yellowish tinge and green mottled pedicel was observed while green tinged fruits were observed

pedicel was observed while green tinged fruits were observed in CS35, CS44, K-75 and CS45, while fruits with green tinge and ridges were observed in CS47.

Fruits of Swarna Sheetal turn yellow on maturity. Brown warty fruits with reddish tinge was observed in fruits of CS20, CS24, Pusa Sanyog, CS44 and Pusa Uday. Brownish orange fruits on maturity were observed in CS11, CS13 and CS14. Phule Himangi and Phule Subhangi turn yellow with orange tinge on maturity. All genotypes had unbranched tendrils and multi-fid leaves with cordate shape.

5.2.QUALITATIVE CHARACTERS

Estimates of qualitative variations like range, standard error around the mean, etc., do not indicate the relative amount of variability for which coefficient of variation appears to be a better index, when the characters with different units of measurements are to be compared. Phenotypic coefficient of variation was the maximum for fruits/plant (55.75) followed by the number of seeds/fruit (48.63) and total yield (40.84). Rakhi and Rajamony (2005) also observed high PCV values for fruits/plant and total yield in melons. Anitha (1998) and Ramachandran (1976) also observed the same in ridge gourd and bitter gourd, respectively. Singh *et al.* (1992) observed high PCV for fruits per plant in pointed gourd. Lovely (2001) and Singh *et al.* (2002) observed high PCV for total yield and fruits/plant in ash gourd. The highest GCV was observed in fruits/plant (55.40) followed by the number of seeds (43.03) and total yield/plot (40.01). Krishnaprasad *et al.* (2004) observed high GCV for fruits per plant and total yield/plot in musk melon. In pumpkin, Gopalakrishnan (1979) observed high GCV for fruits per plant. Pynadath (1975) observed high variation for seeds per fruit. Lower PCV and GCV values were observed for crop duration, days to male and female flower anthesis. Lovely (2005) observed low PCV and GCV values for days to first male and female flower anthesis in ash gourd. Mangal *et al.* (1981), Srivasthava and Srivasthava (1978) also observed lower values of GCV for days to male and female flowering.

A character can be improved only if it is highly heritable. The magnitude of heritability indicates effectiveness with which the selection of genotypes can be made based on phenotypic performance (Johnson *et al.*, 1955). The highest heritability estimate in the study was observed for first node at which female flower originated (99.9%). High heritability was also observed for fruit length (99.2%), fruits/plant (98.8%) and vine length (98.5%). This indicates the low impact of environment on expression of these characters. Joseph (1978) observed high value of heritability for fruit length in snake gourd. Singh and Prasad (1986) and Singh *et al.* (1992) also observed the same in pointed gourd. Prasad *et al.* (1993) observed high heritability for the number of fruits/plant in bottle gourd.

Even though heritability values give an indication of effectiveness of selection based on phenotypic performance, it does not necessarily mean a high genetic advance for a particular character. Heritability along with estimates of expected genetic advance should be considered while making selections.

In the present investigation, genetic advance was estimated in absolute values and also in percentage of mean (genetic gain) for comparing different characters. High heritability along with high genetic gain was observed for fruits per plant (98.8 and 88.5%) and total yield per plot (96.0 and 80.6%). Joshi *et al.* (1981) also observed high heritability coupled with high genetic gain for fruits per plant in cucumber. Singh and Prasad (1986) and Singh *et al.* (1992) also estimated high heritability and high genetic gain for yield and the number of fruits per plant in pointed gourd. This indicates that the number of fruits per plant and yield per plot is governed by additive gene action and can be improved by simple selection.

Though heritability was high for fruit length, fruit girth and days to first female flower anthesis, the genetic gain was of low magnitude indicating influence of non-additive gene action. Non-additive gene action for days to first female flower anthesis was reported by Srivasthava and Srivasthava (1976), Ramachandran (1978) and Vahab (1989) in bottle gourd. This implies

greater scope for development of early varieties by utilising transgressive segregants in the breeding programme. Cucumber, though a highly cross-pollinated crop, because of hermaphrodite origin, does not exhibit inbreeding depression and the production of inbreds is thus a practicable task. In cucumber, the monoecious nature and large flowers make the emasculation process simple and reveals scope for developing early hybrids with large fruits.

5.3. GENETIC DIVERGENCE AND CLUSTERING OF GENOTYPES

Selection of parents for hybridization programme is mainly based on genetic diversity. More divergent the parents, the more will be the expression of heterosis. Mahalanobis D^2 Statistics is a powerful tool for measuring genetic distance in plant breeding experiments. It permits precise comparison of all the genotypes by considering large number of characters simultaneously.

Main objective of present study is to assess genetic diversity among 28 salad cucumber genotypes and to group them into clusters based on genetic distance. On the basis of genetic distance compared with reference to 15 quantitative characters, the 28 genotypes were classified in 5 clusters. The distribution of genotypes into clusters showed no regularity. Cluster-I was the largest containing 13 genotypes. Cluster-III contained 8 genotypes, cluster-II contained 4 genotypes, cluster-IV and V contained 2 and 1 genotype, respectively. Such an irregular pattern of distribution was reported by Ramachandran *et al.* (1981), Kadam and Kale (1985), Vahab (1989) and Varghese (1991).

Out of 5 clusters, cluster V, comprised only 1 genotype, showed high mean values for 7 characters – node to first female flower, days to first male flower anthesis, days to first female flower anthesis, crop duration, days to harvest, number of harvests and total yield. Cluster-V had low mean values for the rest of the characters, *viz.*, vine length, number of branches, fruit length, fruit girth, flesh thickness, fruit weight, seeds/fruit and fruits/plant.

Cluster-IV showed superiority for three characters, *viz.*, vine length, number of branches and fruit length. Cluster-III exhibited higher cluster mean for fruit flesh thickness. Cluster-II exhibited higher cluster means for fruit weight and seeds per fruit.

Cluster-I containing maximum genotypes of 13, had high cluster means for fruit girth and number of fruits/vine. This indicates importance of cluster-I for further improvement.

Crossing among divergent parents is likely to yield heterotic hybrids. In the present study maximum genetic distance was exhibited between cluster-IV and V ($D^2 = 64635$, Table 4.8) clusters showing the largest intra-cluster distance show the maximum divergence. Cluster-IV consisted of CS 24 and Japanese Long Green. Japanese Long Green is characterised by long dark green fruits. Cluster-V comprised CS 35, which showed divergence from all the other genotypes in maximum number of characters.

The inter-cluster distance was also high between cluster-II and V (48,733.77). The minimum inter-cluster distance was observed between cluster-I and III (8415.55). This indicates the unsuitability of selecting male and female parents for hybridization from these two clusters.

The maximum intra-cluster distance was shown by cluster-IV (5695.35), followed by cluster-III (2276.44). High intra-cluster distance in the clusters indicated high degree of variability with the clusters offering scope for improvement by various selection methods.

The present investigation resulted in the identification of promising genotypes like Phule Himangi, CS 35 (Kasaragod Local) and AAUC-2. Performance of above genotypes is to be assured in different environments and growing situation for finding out the stability of genotypes. The study also indicated necessity of including characters like vine length, fruit weight, fruits per plant and yield per plot for increasing productivity of crops. Divergence studies also developed genetic divergence between genotypes and identified genotypes having maximum genetic distance value with maximum genetic distance is to be utilised for development of F_1 hybrids suited for the state.

5.4.CORRELATION

Plant characters do not exist in isolation but a complex association exists among them. These characters are often correlated with each other either due to pleotropy or due to linkage (Harland, 1939). The relationship between phenotypic, genotypic and environmental correlation as mentioned by Falconer (1989) emphasising that for the characters having high heritability, the environmental correlations are generally expected to be lower than genotypic correlations. Since the phenotypic correlations include a part of genotypic correlations, and a portion of variation in two characters, it is therefore expected that for highly heritable characters, genotypic correlations would be higher than phenotypic correlations, when the correlations are in the same direction. Further, Falconer (1989) stated that phenotypic correlation can exceed genotypic correlation only if the heritability of the two characters were low and environmental correlation was high. Hence, an important strategy designed to break the genetic barriers of yield is the study of character association through correlations. In other words, high positive correlation between two traits makes simultaneous improvement in two or more attributes, whereas negative association indicates the need to compromise between desirable characters.

In the present study, genotypic correlations among almost all characters were higher than phenotypic correlation indicating high heritable nature of characters. Total yield per plot showed positive and significant association with fruits per plant, duration of crop and number of harvests. The negative and significant association of fruit yield with length of fruit is undesirable since it points to shorter fruits.

Justifying the present results, positive and significant association of fruit yield with number of fruits per plant was reported by Joshi *et al.* (1981), Haribabu (1985), Prudek and Wolf (1985), Abusaleha and Dutta (1990), Sathyanarayana (1991), Rajput *et al.* (1991), Chen *et al.* (1994), Saikia *et al.* (1995), Rasthogi and Deep (1990), Joseph (1978), Gopalakrishnan (1978),

Prasad *et al.* (1993), Sharma *et al.* (1993) and Singh and Singh (1988). As it is observed in the study, a positive correlation of crop duration with total yield/plant was reported by Anitha (1998). Correlation of the number of harvests with total yield/plot is yet to be reported.

Though not significant, positive correlation was observed between total yield/plot and flesh thickness, days to first female flower anthesis, average fruit weight, days to first male flower anthesis, vine length and fruit girth. Positive correlation of vine length and total yield/plot was reported earlier by Joshi *et al.* (1981), Haribabu (1985), Abusaleha and Dutta (1988), Sathyanarayana (1991), Prasad and Singh (1992), Saikia *et al.* (1995), Kalloo *et al.* (1993), Choudhury *et al.* (2004), Ramachandran (1978), Reddy and Rao (1984), Anitha (1998) and Gopalakrishnan (1978). Similarly, positive correlation of days to first female flower per vine with yield was reported by Prasanna and Rao (1988), Kalloo *et al.* (1982), Srivasthava and Srivasthava (1976), Joseph (1978), Anitha (1998), Rao *et al.* (2000), Sharma *et al.* (1993), Singh and Singh (1988) and Lovely (2001).

Though insignificant, positive correlation was observed between average fruit weight and total yield/plot. This kind of a positive correlation was reported by Haribabu (1985), Rasthogi and Deep (1990), Prasad and Singh (1992), Chen *et al.* (1994), Saikia *et al.* (1995), Singh *et al.* (2002), Kalloo *et al.* (1993), Choudhury *et al.* (2004), Ramachandran (1978), Mangal *et al.* (1981), Anitha (1998), Rao *et al.* (2000), Karuppiah *et al.* (2005), Joseph (1978), Gopalakrishnan (1978) and Joseph (1998).

Significant negative association was observed between number of branches and total yield/plot. Such a negative association was earlier reported by Ramachandran (1978) and Mangal *et al.* (1981).

~~Thus, it is clear from the study that for obtaining higher yield,~~ plant characters like fruits/plant, duration of crop, number of harvests etc. should be considered in the selection programme. High level of positive correlation of fruits/plant, duration of crop and number of harvests and average fruit weight, along with high GCV, heritability and genetic advance made

these characters most important considerations in selection for higher total yield per plant.

5.5.PATH COEFFICIENT ANALYSIS

The correlation between two characters is not a simple relationship but is rather a product of interaction of direct and indirect effects. The indirect relationship becomes more complex as more and more variables are considered in the correlation. Path coefficient analysis separates direct and indirect effects through other variables and measures the relative importance of the causal factors involved. This was developed and discovered by Wright (1992) as a tool in genetic analysis, the utility of which in plant selection was demonstrated by Dewey and Lu (1959). In the present study, path analysis was performed for total yield per plot by taking it as a dependent variable and fourteen other characters such as vine length, number of branches, node to first female flower, days to first male flower, days to first female flower, crop duration, fruit length, fruit girth, flesh thickness, average fruit weight, number of seeds per fruit, days to harvest, fruits per plant and number of harvests as independent variables. Fruits per plant had maximum positive direct effect on total yield per plot. This was confirmed by Abusaleha and Dutta (1988), Prasunna and Rao (1988), Chen *et al.* (1994), Saikia *et al.* (1995), Choudhury *et al.* (2004), Joseph (1978) and Anitha (1998). Though its very high positive effect was reduced by negative indirect effects through days to first male flower anthesis, the final correlation with total yield per plot remained to be positive and high. Indirect positive effect through days to first male flower anthesis was moderately high. This result is quite obvious since large number of fruits per plant will definitely contribute to high total yield per plot.

High positive effect for days to first male flower anthesis was observed on total yield per plot. Though negative indirect effects through number of branches, fruit girth, average fruit weight, days to harvest and number of harvests reduced the correlation values, the positive indirect effect through fruit

length and number of fruits per plant retained a positive correlation with total yield per plot. Crop duration exhibited significant positive correlation with yield per plot but had only a low direct effect on yield per plot. The significant positive correlation was mainly due to its indirect effect through days to first male flower anthesis and fruits per plant.

Vine length exhibited high positive direct effect and low correlation coefficient to total yield per plot. The low correlation was contributed due to negative indirect effects through fruit length, fruit girth, flesh thickness, fruit weight and days to first male flower anthesis. The results of earlier workers such as Prasad and Singh (1992) are in conformity with the observations.

Number of harvests exhibited significant positive correlation with yield per plot but had high negative direct effect. The positive correlation is mainly through its high indirect effect through fruits per plant and low but positive indirect effect through days to first harvest, flesh thickness, fruit length, crop duration, days to first female flower anthesis, first flowering node and vine length.

Average fruit weight had positive correlation and negative direct effect with yield per plot. Fruit length also exhibited negative correlation and positive direct effect with yield per plot. The results obtained by Prasad and Singh (1992) and Rao *et al.* (2000) are in conformity with these observations.

Summary

6. SUMMARY

The present studies were conducted at the Department of Olericulture, College of Horticulture, Vellanikkara during December 2005.The experimental material consisted of 28 salad cucumber genotypes collected from different parts of India. The 28 genotypes were grown in a randomized block design to assess the extent of variability and divergence among genotypes and to group them based on D^2 values. Correlation of yield and contributing components and path analysis of yield and contributing factors were also studied in the experiment.

The findings of the study are summarized as follows;

The 28 genotypes differed significantly for all the characters, which clearly indicates the existence of abundant variability among the genotypes selected for the study. The coefficients of variation, heritability and genetic gain for the 15 characters were interpreted for studying the existing variation. The genotypic coefficient of variation was maximum for fruits per plant (55.40) followed by number of seeds per fruit (43.07) and total yield per plot (40.01) and it was minimum for duration of crop (6.14) and days to first male flower anthesis (8.08).

The highest heritability estimate in the study was for node to first female flower emergence (99.9 %),fruit length (99.2%),fruits per plant(98.8 %) and vine length. High heritability coupled with high genetic gain was observed for fruits per plant.

Correlation studies of yield with component characters indicated that number of fruits per plant had the highest genotypic correlation with yield per

plot (0.713). Days to harvest had highest negative correlation with yield per plot. Characters like number of harvests and crop duration also had positive and significant correlation with yield per plot. The phenotypic correlation was less than genotypic correlation in almost all the cases.

Path analysis studies conducted on 28 cucumber genotypes revealed that fruits per plant had highest positive direct effect on total yield per plot (0.713); followed by number of harvests (0.343) and fruit flesh thickness (0.305). The highest negative direct effect on yield per plot was exhibited by days to harvest (-0.960).

The genotypes were grouped in to 5 clusters based on Mahalanobis D^2 statistic and the clusters I, II, III, IV and V contained 13,4,8,2 and 1 genotypes respectively.

The intra cluster distance D was maximum in cluster IV (5695.35) and minimum in cluster V (0). Cluster V showed maximum inter cluster distance with any other cluster. Intercluster distance was maximum between cluster IV and V (64635.12) and minimum between cluster II and V (8096.30).

Out of the five clusters, cluster V showed high mean value for eight characters for all the 15 characters studied. It had the lowest mean value for seven characters. Cluster V had the maximum mean value for yield per plot where as cluster I showed maximum value for fruits per plant

Abstract

DIVERGENCE STUDIES IN SALAD CUCUMBER
(*Cucumis sativus* L.)

By

SMITHA SARA ABRAHAM

ABSTRACT OF THE THESIS

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Faculty of Agriculture
Kerala Agricultural University

Department Of Olericulture

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680 656
KERALA, INDIA

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ABSTRACT

The present investigation on " Divergence studies in salad cucumber (*Cucumis sativus* L)" was conducted at College of Horticulture, Vellanikkara, Thrissur during December 2005- April 2006.

Twenty-eight salad cucumber genotypes collected from different parts of India were utilized for the study. The extent of variability, correlation between yield and its component characters, path analysis and divergence among 28 genotypes were assessed. The 28 genotypes were significantly different for 15 characters studied. The genotype Phule Himangi (20.22 kg/plot) emerged as high yielder followed by AAUC 2 (15.11 kg/plot). Selection of plants based on yield/plot was observed to be efficient than selection of component characters.

All the accessions were prickled on the surface. All were monoecious and produced yellow flowers. Most of the genotypes produced light green fruits whereas Phule Himangi produced white stout fruits. Genotypes CS 25 and CS 35 were comparatively free from biotic factors except mosaic and serpentine leaf miner.

Total yield per plot showed positive correlation with fruits per plant, duration of crop and number of harvests. Negative correlation was observed between total yield per plot and number of branches. It is clear from the study that, for obtaining higher yield characters like fruits per plant, duration of crop, number of harvests etc should be considered in the selection programme. Fruits per plant had maximum positive direct effect on total yield per plot. Higher positive effects for days to first male flower anthesis was observed on total yield per plot.

The genotypes were grouped into 5 clusters based on Mahalanobis D^2 statistics. Cluster I, II, III, IV and V contained 13,8,4,2,1 genotypes respectively. Inter-cluster distance was maximum between cluster II and V (48733.77) and minimum between cluster I and III (8415.55). Cluster V showed maximum average inter-cluster distance with any another cluster.

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Appendices

APPENDIX – I Mean performance of 28 cucumber genotypes with respect to 16 characters

Accessions	Vine length (cm)	No. of branches	Node to first female flower	Days to male flower	Days to female flower	Crop duraton	Fruit length (cm)	Fruit girth (cm)
Swarna Sheethal	148.30	4.96	6.00	31.00	35.00	79.50	19.70	16.34
Swarna Agathi	190.00	3.75	6.95	35.00	43.50	78.00	13.15	14.92
Swarna Poorna	169.40	4.95	6.00	33.00	44.00	78.00	16.49	16.26
CS-11	108.70	2.65	5.00	29.00	33.50	73.50	18.25	13.69
CS-13	61.30	2.15	2.20	32.00	33.00	84.00	16.06	16.13
CS-14	108.50	3.17	6.00	30.50	31.00	73.50	12.35	16.16
CS-15	101.90	3.55	2.40	32.00	33.50	73.00	14.34	15.26
Phule Himangi	204.65	3.12	6.00	31.00	33.00	80.50	14.41	14.18
Phule Subhangi	183.60	4.25	4.00	33.00	34.50	81.50	14.40	13.23
CS-18	159.70	4.35	4.40	36.50	36.50	75.50	16.61	13.96
CS-19	194.90	4.25	4.70	31.00	35.00	75.00	16.06	19.17
CS-20	309.25	5.15	2.90	34.00	39.50	78.50	16.35	14.14
CS-22	258.10	4.15	6.00	31.00	34.00	81.00	15.20	19.10
CS-23	182.19	5.10	6.00	32.00	33.50	82.50	16.51	14.10
CS-24	144.40	5.50	7.50	35.00	36.50	74.50	18.49	18.26
AAUC-2	261.75	5.90	7.00	41.00	42.50	86.50	17.76	14.84
Green long	133.30	7.18	4.30	34.00	37.00	75.0	19.77	15.12
Japanese long green	261.65	9.15	4.50	35.00	36.50	83.00	27.07	12.45
Pusa Sanyog	143.55	3.38	7.00	31.00	34.50	76.50	15.76	15.20
Puneri Khira	96.65	2.53	4.30	31.00	35.50	74.50	14.37	16.36
Sheethal	149.30	4.27	5.00	33.00	35.00	81.00	19.29	14.22
CS-35	198.30	3.53	11.30	36.00	44.00	88.00	16.27	13.29
CS-44	291.65	5.90	7.00	29.50	35.00	81.50	16.57	19.70
CS-45	144.15	2.40	6.00	29.00	37.50	71.50	18.40	17.26
CS-47	257.50	5.38	6.00	32.00	33.50	69.50	14.80	16.30
Pusa Uday	108.50	2.40	3.25	32.00	33.50	73.50	16.40	14.30
CS-51	278.30	4.65	6.25	31.00	32.50	71.00	12.16	17.19
CS-54	195.30	4.44	5.00	27.50	33.00	69.00	11.67	15.94

Appendix 1 Mean performance of 28 cucumber genotypes with respect to 16 characters

Accessions	Flesh thickness(cm)	Fruit weight(g)	Seed no.	Days to harvest	Fruits/plant	Yield/plant (Kg /palnt)	Number of harvests	Total yield ($Kg/5m^2$)
Swarna Sheethal	1.76	287.00	488.00	46.50	6.75	47.00	10.00	11.82
Swarna Agathi	1.40	242.00	209.00	48.00	4.30	48.00	9.00	9.32
Swarna Poorna	1.32	233.00	98.00	47.50	8.10	40.50	12.00	10.08
CS-11	1.42	258.00	154.50	42.00	4.50	13.50	5.50	7.76
CS-13	1.39	251.00	590.00	43.00	5.40	9.00	3.00	11.49
CS-14	1.48	123.00	192.50	41.50	6.50	14.00	6.50	6.03
CS-15	0.74	258.00	202.50	41.00	5.10	20.50	6.00	7.22
Phule Himangi	1.30	223.00	194.00	50.00	12.00	74.00	8.00	20.21
Phule Subhangi	1.39	239.90	122.00	49.00	7.65	38.00	8.00	6.29
CS-18	1.51	263.00	141.00	49.00	8.70	47.00	11.50	15.27
CS-19	1.49	235.00	168.00	44.00	8.75	33.00	9.00	10.11
CS-20	1.60	256.00	323.00	48.00	4.15	40.00	11.00	11.26
CS-22	1.26	237.00	351.50	51.00	10.10	30.50	7.00	9.57
CS-23	1.25	242.00	300.50	48.50	6.30	28.50	10.50	7.89
CS-24	1.48	360.00	121.00	48.50	4.15	25.50	8.00	9.82
AAUC-2	1.53	251.00	318.00	56.50	11.50	49.50	12.50	13.51
Green long	1.74	234.00	285.50	46.00	5.10	26.00	8.00	6.05
Japanese long green	0.84	110.00	354.00	50.50	5.50	15.00	7.00	3.29
Pusa Sanyog	1.61	221.50	225.00	49.00	7.30	29.50	9.00	7.03
Puneri Khira	1.30	219.00	453.00	42.50	9.10	43.00	9.00	9.31
Sheethal	1.30	326.00	141.50	48.50	4.15	22.00	8.50	5.73
CS-35	1.16	219.00	140.50	58.00	4.21	27.00	9.00	13.58
CS-44	1.63	240.00	439.00	54.00	6.33	30.00	5.00	11.93
CS-45	1.63	237.00	244.50	55.00	4.18	14.00	4.50	11.26
CS-47	0.65	227.00	313.50	54.50	1.99	3.50	3.00	2.52
Pusa Uday	1.89	248.00	311.50	61.00	2.85	7.50	2.50	5.94
CS-51	1.21	172.90	312.00	54.00	3.47	22.50	4.50	11.58
CS-54	1.26	86.00	303.00	54.50	4.15	10.00	5.50	5.86

Appendix- II Meteorological data during the cropping period

Month	Week	Temperature (°c)		Mean relative humidity(%)	Total rainfall (mm)	Number of rainy days	Mean sunshine hours
		Maximum	Minimum				
January	1st	31.4	23.1	67	0.0	Nil	8.5
	2nd	32.0	24.4	70	0.0	Nil	7.1
	3rd	33.6	22.0	76	0.0	Nil	9.6
	4th	33.0	21.0	79	0.0	Nil	9.6
February	1st	33.5	22.7	60	0.0	Nil	9.8
	2nd	34.7	21.3	70	0.0	Nil	9.9
	3rd	35.6	22.2	79	0.0	Nil	9.0
	4th	34.7	23.1	87	20.0	Nil	7.4
March	1st	34.9	23.9	86	0.0	Nil	8.3
	2nd	34.6	22.2	85	0.0	Nil	8.3
	3rd	35.3	24.9	85	0.0	Nil	7.1
	4th	34.3	24.3	89	25.1	1	7.3
April	1st	33.6	25.0	91	0.0	Nil	7.3
	2nd	34.4	24.8	91	25.3	1	7.1
	3rd	33.3	24.1	91	14.0	Nil	7.5
	4th	32.3	24.8	90	0.0	Nil	5.8