PERFORMANCE EVALUATION AND VARIABILITY STUDIES IN SPINE GOURD (*Momordica dioica* Roxb.)

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DECLARATION

I hereby declare that this thesis entitled Performance evaluation and variability studies in spine gourd (*Momordica dioica* Roxb.) is a bonafied record of the research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or others similar title, of other university or society.

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Introduction

INTRODUCTION

India is gifted with heterogeneous land terrains and a variety of climatic conditions such as the lofty mountains, raverine deltas, high altitude forests, peninsular plateaus, variety of geological formations endowed with temperature varying from arctic cold to equatorial hot and rainfall from extreme aridity with a few cm (<10 cm) to perhumid with world's maximum rainfall (134.70 cm) of several hundred cm. This varying environmental situations in the country have resulted in a greater variety of crops including a number of vegetables.

Vegetables are so common in human diet that a meal without a vegetable is supposed to be incomplete in any part of the world. India is the second largest producer of vegetables in the world, next to China. These are grown in about six million hectares forming 3% of the total cropped area. Our country is gifted with a wide range of agro-climatic conditions which enables the production of vegetables throughout the year in one part of the country or the other, thus maintaining a continuous supply of fresh vegetables.

In India, about 40 vegetable crops of varying significance are grown. These include solanaceous, cucurbitaceous, leguminous and cruciferous vegetables, root crops, bulb crops and leaf vegetables. Major vegetable crops grown in the country are tomato, potato, onion, brinjal, cabbage, cauliflower, okra, cucurbits and peas.

Cucurbit vegetables (family Cucurbitaceae), comprising cucumbers, melons, pumpkins, gourds, etc. are important crops of India. The Indian subcontinent represents one of the richest diverse genetic resources for cucurbitaceous vegetables.

The genus *Momordica* L. (family Cucurbitaceae) offers wild and cultivated vegetables of high nutritional value which has very rich ethanobotanical

history (Joseph and Antony, 2007). In this genus sixty species are reported world wide of which seven species occur in India (Ram *et al*., 2001). Except cultivated bitter gourd other species occur in the wild state and are gathered by tribal communities as vegetables.

Spine gourd (*Momordica dioica* Roxb.) is a medicinally and economically important dioecious and perennial cucurbitaceous vegetable of this genus. It is native to South East Asia, especially India and Bangladesh (Thiruvengadam and Chung, 2011). The crop is locally known as Kartoli, Khekhsa, Padora and Bhaat Karela, among others, in different regions (Joseph *et al.*, 2009). Initially spine gourd was consumed by tribal groups living around the forest areas. But this vegetable did not gain much popularity until it was discovered to have high nutritional and medicinal values. The crop is popular among the farmers due to its nutritional value and perennial nature . If kankoda seeds are once sown in the field and plants are raised, it will form tubers and these tubers sprout at the onset of monsoon every year. A good green yield can be harvested every year and up to five-six years from the same tubers or plants. Immature green fruits are cooked as vegetable. Young leaves and flowers are also eaten (Ram *et al*., 2001). Tubers are also edible.

Spine gourd contains good amount of carotene (162 mg/100 g) and protein (3.1 g/100 g) amongst all cucurbitaceous vegetables (Gopalan *et al*., 1982). It is of high market demand with a special delicacy for the people of Eastern India.

The whole plant is used for treatment of eye diseases, poisoning and fever (Reddy *et al*., 2006). Plant is claimed to be expectorant, analgesic and soothing agent. The roots are used in head trouble, urinary calculi and as an errhine in jaundice (Jain and Singhai, 2010). Fruits are rich in vitamins and minerals and are ascribed with many medicinal properties (Joseph and Antony, 2008).

The plant was reported to posses antidiabetic, analgesic, postcoital anti-fertility (Shreedhar *et al*., 2004), nematocidal, anti-allergic, anti-malarial, anti-feedant, antibacterial (Nabi *et al*., 2002), anti-oxidant and hepatoprotective (Jain *et al*., 2008) properties.

The hexane extract and ethyl acetate soluble fraction of methanolic extract of the fruit pulp of *Momordica dioica* exhibited moderate and concentration dependent antifeedant activity against *Spodoptera litura* (Narasimha *et al.*, 2005).

In addition, the seed kernel oil of spine gourd is used as such or as a source of drying oil in the paint and varnish industry.

This important indigenous vegetable has high demand in market, but still remain underutilized and underexploited due to lack of popularity of the vegetable. Commercial cultivation of spine gourd is lacking, despite its demand, mainly due to its short harvesting period, low yield, tuber dormancy and lack of standard propagation technique (Bharathi *et al*., 2010).

Kartoli shows enormous diversity in shape, size of the leaf, fruit shape and fruit colour which occurs in semi domesticated and wild forms in local pockets. As this crop is strictly cross pollinated, high genetic variation is available in this crop (Bharathi *et al*., 2006). Hence the present investigation was carried out to elicit information on the nature and magnitude of variability existing in the genotypes collected from different parts of Western Ghats.

In this study an attempt was made to collect and evaluate available genetic diversity of spine gourd germplasm. The success of any breeding programme depends on the quantum of genetic variability for exploitation, the genetic coefficient of variation together with the heritability estimates, genetic advance, genetic divergence and association of different traits among themselves and with yield.

With these views in mind the present study was undertaken with the following objectives:

- Genetic cataloguing of germplasm based on the descriptor
- Assessing the genetic parameters, *viz*. heritability, genetic advance and genetic gain
- Estimating the phenotypic and genotypic coefficient of variation
- Estimating the direct and indirect effects of yield using path coefficient analysis
- Identifying the elite genotypes on the basis of selection indices

Review of Literature

2. REVIEW OF LITERATURE

Horticultural crops are gaining importance throughout the world not only as food or economic crops but also for their importance as raw material for value-added products and industrial uses. Many of the minor cucurbitaceous vegetables are very nutritious with high vitamins and minerals. The genus *Momordica* L. offers wild as well as cultivated species. Spine gourd is a medicinally and economically important vegetable found in the forest and semiforest areas of southern India, West Bengal, Assam, Maharashtra, Madhya Pradesh and Orissa. This vegetable did not gain much popularity until it was discovered to have high nutritional and medicinal value. Its immature tender green fruits are cooked as vegetable. Young leaves, flowers, and seeds are also edible. No systematic attempt has been made for its domestication and improvement and thus yield is poor. Hence the present study was aimed to evaluate the field performance of the crop and to record the variability among the collected germplam.

The biometrical aspects of yield components had been attempted by few workers in spine gourd. The pertinent literature relevant in this aspect is reviewed under the following sub heads.

2. 1 Performance evaluation of *Momordica dioica* germplasm

2. 2 Genetic variability

2. 3 Heritability and genetic advance

2.4 Correlation and path coefficient analysis

2.5 Genetic divergence and selection index

2. 1 Performance evaluation of *Momordica dioica* germplasm

The performance evaluation is the screening of the germplasm lines for high yield and fruit characters. Qualitative and quantitative measurements are taken at the correct vegetable maturity stage.

India is the centre of origin and diversity of a number of underutilized vegetable crops like spine gourd (*Momordica dioica*), sweet gourd (*Momordica cochinchinensis*), Kachari (*Cucumis callosus*), ivy gourd (*Coccinia grandis*) and melothria (*Solena amplexicaulis*). Serious threat to the genetic diversity of these species was found while they are important for food, nutritional and economic security. Genetic variation in underutilized vegetables is of prime importance for the successful breeding of improved cultivars with added value and desirable resistance to diseases and pests.

Singh (1983) confirmed the absence of parthenocarpic fruit development in spine gourd. For this he left female flowers in spine gourd for natural pollination, covered the flowers with butter paper cover before anthesis, pollinated the female flowers with pollen from *Momordica charantia* and in others pollen from *Lagenaria leucantha*. He could not get fruits when female flowers were covered with butter paper before anthesis or pollinating flowers with pollen either from *Momordica charantia* or *Lagenaria leucantha*. He obtained fruits when the flowers were left for natural pollination.

Jha and Roy (1989) observed one hermaphrodite plant among their 35 male accessions from various parts of north eastern India. But during its reproductive phase the plant could not set fruits on any of these hermaphrodite plants. Thus they concluded the cross pollination nature in spine gourd.

In another experiment with 38 genotypes of spine gourd artificial pollination resulted in 87.67% fruit set compared with 25.67% under natural pollination. Fruits took 27 days to reach maturity. Marketable fruits were obtained 12 days after fruit set (Sachan *et al*., 1990).

An experiment was done by Rajput *et al*. (1994) to find out the healthy male female ratio in field for proper fruit set. They confirmed that 10% male plants are required for good fruit set. They also found out that spraying silver nitrate at 400, 500 and 600 ppm at pre-flowering stage on male plants help

inducing hermaphrodite flowers. But these flowers did not set fruits, thus confirming cross pollination.

In another experiment done at Department of Genetics and Plant Breeding, Institute of Postgraduate Studies in Agriculture (IPSA), Salna, Gazipur, Bangladesh, among the different genotypes collected, only one female accession produced hermaphrodite flowers which were smaller in size and deep yellow in colour . No fruit set occurred in hermaphrodite flowers and only sterile pollen was produced in them (Ali *et al*., 2001).

From a study undertaken in Akola, Maharashtra, India during 2000-01, Kale *et al*. (2003) confirmed that flower bud development of spine gourd was earlier in male plants (25 days from sprouting to bloom) than female plants (34 days). Male and female flower buds took 14-15 and 17-18 days to full blooming, respectively. Anthesis was earlier in male flowers than in female flowers. Anthesis in male flowers started between 20.00 to 20.30 h and continued up to 21.00 and 21.30 h. More than 90% of male flowers opened between 20.30 and 21.30 h. Anthesis in female flowers commenced from 20.00 to 21.30 h, peaked at 21.30 to 22.00 h, and continued up to 22.00 to 22.30 h. Dehiscence commenced at 20.00 h and continued up to 20.50 h, i.e. prior to anthesis. Pollen grain viability in acetocarmine test was very high (97.70%) at the time of anthesis up to 12 h after anthesis (96%). Pollen viability decreased to 70% after 36 h and to 25.5% after 48 h of anthesis. Pollen grain viability was zero after 60 h of anthesis. Hand pollination from the time of anthesis up to 4 h gave 98.50% fruit set. Fruit set declined to 90.16, 82.00 and 15.20% receptivity after 8, 12 and 16 h of anthesis. After 22 h from anthesis, fruit set was zero.

Dipali *et al*. (2006) opined that the highly cross pollinated dioecious nature of kartoli exhibits genetic variation for morphological and growth parameters. Tubers are suitable for propagation, but it has some limitations. It has got dormancy and multiplication rate of tuber is very slow. Seeds inside fruits are also

dormant due to hard seed coat. They germinate only after years in the soil. From these results they concluded that high multiplication ratio can be achieved through stem cuttings. And even faster multiplication can be achieved through micro propagation techniques.

A network project was launched on "Improvement of underutilized vegetable crops" under which a total of 2000 accessions of different underutilized vegetable crops have been collected and are being evaluated for important agri-horticultural traits and abiotic stress (Chadha *et al*., 2007).

Maurya *et al*. (2007) found out that southern part of Rajasthan is predominantly a tribal dominated area having harsh climate, hence, only indigenous vegetables (IVs) which are hardy, drought resistant and have short duration grow well. One among them they got is spine gourd (*Momordica dioica* Roxb.). The crop grows naturally during rainy season and generate good source of income for the tribals. This vegetable possesses very good nutritive and medicinal value with resistance to biotic and abiotic stresses. They also opined that till now no systematic efforts have been made to improve the existing land races of these indigenous vegetables.

According to Mili *et al.* (2007) spine gourd (*Momordica dioica* Roxb.) is a minor crop and a number of types are available in India. Of late, this vegetable has become popular in the metropolis like Delhi and some traders have already started marketing this vegetable. The crop however, does not remain fresh more than two days and gets shriveled within 2-3 days. Moreover, the farmers harvest the produce either at immature stage or at a stage which is not acceptable to the consumers.

They also conducted a study to standardize the harvest maturity of this crop. Experimental findings revealed that the colour of the pedicel, pericarp and spine remained green till 12-13 days after flowering (DAF) and thereafter the

colour changes. The highest specific gravity was found when the spine gourd was harvested on 14 days after flowering and thereafter it decreased. Variation in respiration and chlorophyll content was also observed at different stages of maturity. Pedicel colour, spine colour, respiration rate, chlorophyll content and dry weight may be considered as the suitable maturity indices of spine gourd.

Singh *et al.* (2009a) conducted an experiment to identify growth characteristics including propagation methods, best time of planting, productivity and the economics of cultivation of spine gourd. The experiment consisted of 18 genotypes collected from various naturally growing forest areas. These were planted during July-August 2006. Growth and yield attributes and their correlations were observed. Growth parameters like the number of fruits/plant and fruit yield/plant exhibited high heritability, which coupled with high genetic advance as a percent of mean, indicated criteria for selection of suitable genotypes. The genotypes AAI/S-1 and AAI/S-4 were found to be high yielding with an average yield of 606 g and 649 g/plant, respectively. All the genotypes were tested for nutritional value, but there were no significant difference among the genotypes. The average nutritional value per 100 g edible fruit was found to contain 84.1% moisture, 7.7 g carbohydrate, 3.1 g protein, 3.1 g fat, 3.0 g fibre and 1.1 g minerals. It also contained small quantities of essential vitamins like ascorbic acid, carotene, thiamin, riboflavin and niacin. It was concluded that this crop can be successfully cultivated in rural and urban areas, as well as in countries where sub-tropical and tropical conditions prevail. This crop can provide additional nutrients and help the body develop natural immunity from many common ailments.

Karuppaiyan *et al*. (2009) observed the growth pattern of the spine gourd. They opined the seed dormancy and the dioecious nature are the major obstacles in domestication of this vegetable. After a period of active growth and with the advent of unfavourable season for growth, the plants show symptoms of senescence; leaves become yellow and dry up, vines also wither and the plant

perennates with the help of storage root(s) underneath. We can expect for an economic life of maximum three to four months duration.

In a study conducted at Kumarganj, Faizabad, Uttar Pradesh, to find out the general resisitance of spine gourd to insect pests, eight species of insect-pests were tested. Among them two species were sap suckers, namely the green bug, *Nezara viridula* L., and painted bug, *Bagrada cruciferarum* Burm., four defoliators, namely the epilachna beetle, *Henoepilachna vigintioctopunctata* (L.), red pumpkin beetle, *Aulacophora foevicollis* Lucas, grasshopper, *Poekilocerus pictus* F., and cotton grey weevil, *Myllcerus muculosus* Desb., and two species of fruit borers, namely the tobacco caterpillar, *Spodoptera litura* L. and leaf eating caterpillar, *Diaphania indica* Saunders. Among these species, only the epilachnid beetles were recognized as serious pests of spine gourd which needed control interventions (Singh *et al*., 2009b).

Acoording to Thiruvengadam and Chung (2011) commercial propagation of spine gourd largely depends on tuberous roots , followed by stem cuttings, and seeds. Propagation by tuberous roots is limited due to the low multiplication rate and germination of seeds is very difficult or impossible because of its hard seed coat. Stem cuttings can be recommended as propagule. But, for confirmed and fast root initiation, treatment with 100ppm IBA for 15-20 minutes is recommended.

2. 2 Genetic variability

Estimation of variability, heritability and correlation among polygenic characters are vital exercises done by the breeders to choose appropriate breeding method for the improvement of specific characters. Being an underutilized vegetable, only limited work has been conducted to collect the germplasm and evaluate the variability in *Momordica dioica*. Hence the results of studies on the genetic variability, heritability, correlation and selection index of related species, *Momordica chrantia* are also reported here.

A variability study was done for 34 spine gourd genotypes at Bhubaneswar. Information on variability and heritability is derived from data on internodal length, petiole length, leaf area, fruit weight, total number of fruits per plant and yield per plant in these genotypes grown. Maximum variability was observed in the charcters like total number of fruits per plant and yield per plant (Maharana *et al*., 1995).

Ram *et al*. (2004) conducted a study at Indian Institute of Vegetable Research, Varanasi to measure the extent of variability in spine gourd. They found that the widest range was recorded for fruit length, while narrowest range was observed for days to female flower anthesis. The characters like days to female flower anthesis, fruit set to edible maturity, plant height, fruit diameter, fruit length, number of fruits/plant and yield/plant expressed maximum variability at phenotypic and genotypic level. Estimates of genetic advance were high for yield/plant and number of branches/plant.

Genetic variability for 10 characters (days to flowering, vine length, number of nodes on which first flower appears, internode length, fruit length, girth, weight and volume, number of fruits, and yield per plant) was assessed in 32 genotypes of spine gourd (*Momordica dioica*) during 2003 - 04, in Bhubaneswar, Orissa, India. Analysis of variance revealed significant differences among the genotypes studied. Phenotypic coefficient of variation (PCV) ranged from 15.26% for fruit girth to 34.28% for fruit weight, while genotypic coefficient of variation (GCV) ranged from 14.38% for fruit girth to 33.52% for fruit weight (Bharathi *et al*., 2006).

Panchbhai *et al.* (2006) evaluated 113 *M. dioica* genotypes from different parts of India for genetic variation. Eleven yield characters were evaluated: sprout number/tuberous root, vine length, branch number, leaf area, days to initiation of flowering, days to fruit ripening, fruit number/vine, fruit weight, yield per plant,

yield/ha and seed number/fruit. They obtained maximum variation in characters like vine length, days to initiation of flowering, number of fruits per plant, fruit weight, yield per plant, etc.

Rathi *et al*. (2006) conducted survey and collection of spine gourd in Uttar Pradesh (Mirzapur, Sonbhadra, Bhadaiya, Karbi, Banda, Mohouba, Jhansi, Jalaun, Chittarkoot and Allahabad) and Madhya Pradesh (Rewa, Sidhi, Satna, and Chhatarpur), during August 2003. The tubers collected from stony or hard soil were smaller in size while those collected from sandy or sandy loam soil were bigger, soft and bearing finger-like structures. Tuber size was also related with the age and sex of the plant. An 8-year-old plant exhibited tuber weight of 2 to 2.5 kg. The female plants had bigger tubers compared to the male plants. Old plants also possessed higher number of fruits per plant than the younger ones. Differences were also observed for leaf and flower colour.

In another study with 38 bitter gourd genotypes, a wide range of variation was observed for all the 12 quantitative characters studied. High estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variations (PCV) was recorded for characters like average fruit weight (g), average fruit diameter (cm), average flesh thickness (cm) and yield per plant (g). PCV was higher than GCV for all the characters studied indicating influence of environment in the expression of characters. Heritability recorded moderate to high for all the traits. High heritability along with high genetic advance was revealed for traits like average fruit weight (g), average flesh thickness (cm), yield per plant (g) and node to first female flower indicating preponderance of additive gene action and effectiveness of improvement through selection for these economically important traits (Dey *et al*., 2009).

Bharathi *et al*. (2010) conducted genetic cataloguing of spine gourd. Twenty-six accessions of spine gourd (*M. dioica* Roxb.), collected from eastern India, were evaluated to study the diversity and other genetic parameters. The

estimates of genotypic coefficient of variation and phenotypic coefficient of variation for all the characters indicated that selection can be done on the basis of phenotype alone. On the basis of cluster analysis, spine gourd accessions can be categorized into three distinct groups. The accessions of spine gourd from eastern India showed an immense variation and can be used as a potential source of germplasm for crop improvement. The results presented here on nature and magnitude of genetic variability and diversity existing in this species will provide the foundation for designing an efficient spine gourd breeding programme. As spine gourd is distributed widely almost throughout India, further collections from Peninsular and Western India are suggested for maximum diversity sampling.

Bharati *et al*. (2011) conducted a study to understand the variabilities among the fruits of spine gourd. The length of the fruit varies between seven and ten centimeter and the fruit shape is either ovate or oblong. According to them the fruits also showed variations in the spike nature and beak characters. Some are with short beaks while others have long beaks. In the same study the number of branches per plant varied between three and twelve.

Joseph and Antony (2008) did a survey through the Southern and Western Ghats of India to find out the ethanobotanocal investigations in the genus *Momordica*. They could see a lot of variations in the leaf shape, plant vigour, fruit shape, fruit size, culinary preparation, etc. They observed the fruits become smaller and more of globular in the parts of Southern Ghats whereas in Western Ghats the fruits are long and oblong.

2.3 Heritability and genetic advance

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

Chaudhari *et al*. (1991) evaluated eleven pure breeding lines of bitter-gourd (*Momordica charantia*). Information on variability, heritability and genetic advance is derived from data on 12 yield characters. High values for heritability and genetic gain were recorded for yield/plant, fruit weight and number of fruits/plant

Thakur *et al*. (1994) recorded high values for heritability and genetic gain for yield/plant, fruit weight and number of fruits/plant in bitter gourd from studies done for 12 yield characters in 11 pure breeding lines.

The nature of gene action for yield and component characters in bitter gourd was studied in a six parent full diallel cross. The presence of additive and dominant genetic system for fruit length, fruit girth and fruit weight, and dominant gene action for flesh thickness, number of fruits per hill and yield per hill were observed. High heritability for fruit girth, flesh thickness and yield per hill, and moderate estimates for fruit length, fruit weight and fruits per hill were recorded. Asymmetrical distribution of positive and negative genes was noticed for all the traits. Presence of both additive and non-additive genetic system for all the traits was indicated (Rajeswari and Natarajan, 2002).

Genetic variability, heritability and genetic advance for 10 quantitative characters in 40 bitter gourd cultivars were studied in Dharwad, Karnataka, India from August to December 2001. The genotypes showed large variation in yield and yield components at the phenotypic and genotypic levels. High heritability coupled with high genetic advance as per cent mean was observed for number of fruits per plant, fruit weight, total yield per plant, number of seeds per fruit and number of leaves at the 50% flowering stage, indicating the effects of additive gene action for these traits. Selection procedure could be effectively used for improving the bitter gourd genotypes (Kutty and Dharmatti, 2004a).

Fifteen diverse genotypes of bitter gourd were evaluated for 7 yield characters (vine length, branch number/plant, fruit length, fruit diameter, fruit number/plant, fruit weight and fruit yield/plant) and 5 genetic traits (phenotypic and genotypic coefficients of variation, heritability, genetic advance and genetic advance as percentage of mean) in Jammu and Kashmir, India during the kharif season of 2003. All characters were highly heritable, and showed high phenotypic and genotypic coefficients of variation. High genetic coefficient of variation and heritability estimates was associated with high genetic advance for branch number/plant, average fruit length, average fruit diameter, fruit number/plant and fruit yield/plant. Results showed that these characters were additive in nature and can be used for effective selection. Vine length and average fruit weight showed high heritability and low genetic advance, suggesting that these can be improved through heterosis breeding as they showed predominance of non-additive gene action (Narayan *et al*., 2006).

Fifteen diverse genotypes of bitter gourd (*M. charantia*) were evaluated in Dapoli, during rabi 2004-05 for their variability, heritability and genetic advance for 15 traits: days to 1st male flower, nodal position for first male flower, days to first female flower, nodal position for first female flower, vine length, primary branches per vine, node number per vine, days to fruit development, days to first fruit harvest, fruit number per vine, fruit length, fruit breadth, fruit weight, 100-seed weight and fruit yield per vine. Based on the nature and magnitude of genetic variability, heritability accompanied with genetic advance as percentage of mean, fruit length, vine length, fruit number per vine, days to first fruit harvest, node number per vine, primary branches per vine would offer scope for selection in breeding for high fruit yield in bitter gourd (Devmore *et al*., 2010).

2.4 Correlation and path coefficient analysis

Correlation studies on 25 diverse *Momordica charantia* forms indicated that yield/plant was positively correlated phenotypically and genotypically with length of the main stem, fruit weight, fruit length, number of fruits per plant, number of female flowers per plant and number of primary branches per plant (Ramachandran and Gopalakrishnan, 1979).

Indiresh (1982) assessed twenty-four lines of bitter gorud. High genotypic coefficients of variation were found for fruit fresh weight, yield/plant, fruit cavity length, leaf area and fruit length. Heritability estimates were high for all characters, except yield/plant and days for fruit development. Yield was positively and significantly correlated with leaf number/plant, leaf area, fruit fresh weight, length, girth and volume of fruits and vine length.

The genotypic and phenotypic correlation study of 21 bitter gourd genotypes revealed that yield was mainly contributed by number of fruits/vine, average fruit weight, fruit length and number of female flowers. The physiological attributes like vine length, primary branches and average leaf area were mutually associated and had effects on yield. Early genotypes produced higher yield and selection for such genotypes is possible in bitter gourd. The fruit weight had maximum direct bearing on yield. However, vine length, primary branches, nodes on main axis, leaf area, fruit length, number of fruits/vine and seed content indirectly contributed towards yield (Paranjape and Rajput, 1995).

In the investigations conducted at Hisar, Haryana, Path analysis indicated that fruits per plant had the highest direct contribution towards yield, followed by chlorophyll *a* content, fruit length and fruit diameter, while vine length had the highest indirect contribution towards yield, followed by internode length, average fruit weight, fruit diameter and fruit length via number of fruits per plant. Therefore, major emphasis be given on selection for more number of fruits/plant, vine length, average fruit weight, fruit length and fruit diameter which may lead to the development of high yielding cultivars of bitter gourd (Sharma and Bhutani, 2001).

Bhave *et al.* (2003) conducted correlation and path analysis for yield and quality traits using 15 F_2 lines obtained from crosses involving 6 bitter gourd (*Momordica charantia*) cultivars (Konkan Tara, Pusa Vishesh, Colong, Arka Harit, RHR 4-1 and Priya) grown in Dapoli. At the phenotypic and genotypic levels, fruit yield per vine was positively correlated with flowering duration, harvesting span, fruit length, fruit breadth, fruit rind thickness, number of fruits per vine, average fruit weight, biological yield, dry matter and harvest index, and negatively correlated with days to first flowering. Path analysis revealed that harvesting span, number of leaves per vine, fruit length, average fruit weight, number of seeds per fruit, number of fruits per vine, biological yield and keeping quality had direct positive effects on fruit yield, whereas fruit length had positive and indirect effects on fruit yield. Based on correlation and path analyses, selection for flowering duration, harvesting span, fruit length, fruit breadth, fruit rind thickness, average fruit weight, number of fruits per vine, dry fruit weight, biological yield, dry matter per vine and harvest index could improve the yield of bitter gourd.

Correlation and path coefficient studies with 40 divergent genotypes of bitter gourd (*M. charantia*) were conducted in Dharwad in 2001. Data were recorded for days to first female flower opening, node number of first female flowering, number of leaves at 50% flowering, days to first harvest, productive length of vine, number of seeds per fruit, fruit length, number of fruits per plant, total yield per plant, fruit weight, fruit fly infestation and downy mildew incidence. The number of leaves at 50% flowering stage, number of seeds per fruit, fruit length, number of fruits per plant and fruit weight were the most important traits contributing to yield per plant as they showed very high direct effects coupled with positive correlation and high indirect effects through other economic characters (Kutty and Dharmatti, 2004b).

Correlation and path coefficient analyses for 17 traits were conducted for 38 indigenous genotypes of *M. charantia* grown in New Delhi, during the spring-summer of 2004. The genotypic correlation coefficients were greater than the

phenotypic correlation coefficients. Fruit yield was most positively correlated with fruit weight, followed by number of fruits per plant, flesh thickness, number of days from fruit set to maturity, fruit index, fruit length and fruit diameter. Path coefficient analysis revealed that fruit weight had the greatest direct effect on yield, followed by number of fruits per plant and fruit length. The results indicated that fruit weight, number of fruits per plant, and node on which the first female flower appeared can be considered during selection for improved yield in *M. charantia* (Dey *et al*., 2005).

Vishal *et al.* (2007) developed 36 hybrids by using nine parents in half diallel crossing (no reciprocals) for correlation and path analyses to study the different qualitative and quantitative traits of bitter gourd fruits. Significant positive correlations were observed for fruit length with number of fruits per plant, average fruit weight and total fruit yield per vine. Days to first female flower showed highest direct contribution followed by number of fruits per plant and average fruit weight towards yield while days to first fruit harvest exhibited its highest indirect contribution via days to first female flower followed by fruit length and fruit diameter via days to first fruit harvest.

2.5 Genetic divergence and selection index

The genetic divergence among 32 genotypes of spine gourd (*Momordica dioica*) for 12 traits (vine length, number of days to flowering, node on which the first flower appeared, internode length, mature leaf size, pedicel length, petiole length, fruit weight, fruit length, fruit girth, number of fruits per plant, and yield per plant) was evaluated. The analysis of variance revealed significant variation among the genotypes for all traits. The genotypes were grouped into 7 clusters based on D^2 values. Cluster III had the highest number of genotypes (11), followed by clusters IV (9) and VI (4). The intracluster distance ranged from 30.34 (cluster I) to 371.56 (cluster III). The intercluster distance was greatest between clusters VI and VII (864.75). Genotypes included in cluster II were characterized by early flowering, and presence of the longest vines and

internodes. Cluster VI recorded the greatest number of fruits, pedicel length and yield. Cluster VII was superior with regard to the node on which the first flower appeared. Cluster III had the greatest fruit weight, fruit length and fruit girth. Yield per plant, number of fruits, fruit weight, internode length, fruit length and pedicel length accounted for 93.55% of the diversity. Thus, selection for divergent parents based on these traits is recommended (Bharathi *et al.*, 2005).

Materials and Methods

3. MATERIALS AND METHODS

The study was conducted in the vegetable research farm of the Department of Olericulture, College of Horticulture, Vellanikkara. The experiment site is located at an altitude of 23 m above M.S.L. and between 10º32" N latitude and 76º16" E longitude. The experiment was conducted during October 2011 to February 2012. The whole experiment consisted of following two parts.

3.1 Experimental materials

Thirty one accessions of spine gourd (*Momordica dioica*) collected from different parts of Kerala were used for the experiment. Among these, 15 were male accessions and remaining 16 were females. The accession number and details are given in Table no 1. The planting material used was rooted stem cuttings.

3.2 Experimental method

Three noded stem cuttings were planted in polythene bags containing two parts sand, one part red earth and one part cow dung. They were kept inside the poly house for three weeks to one month for rooting.

The experiment was laid out in randomized block design with two replications. Each replication consisted of thirty one plots. Each plot consisted of two pits at 2m x 2m spacing. There were sixty two pits per replication and two plants per pit.

The crop was raised during October 2011 to February 2012. Twenty to thirty days old rooted stem cuttings were planted to the mainfield. The crop was raised as per the Package of Practices Recommendations (KAU, 2007) for bitter gourd.

Table 1 : Details of accessions

Sl. no	Accession number	Place of collection	Remarks
1	MD 117	Nellikkunnu forest area (Peechi)	Male
2	MD 154	Nellikkunnu forest area (Peechi)	Male
3	MD 157	Anavari forest area (Peechi)	Male
4	MD 158	Anavari forest area (Peechi)	Male
5	MD 160-1	Anavari forest area (Peechi)	Male
6	MD 161- 1	Anavari forest area (Peechi)	Male
7	MD 161-2	Anavari forest area (Peechi)	Male
8	MD 163	Anavari forest area (Peechi)	Male
9	MD 168	Anavari forest area (Peechi)	Male
10	MD 183-1	Maniyankinar colony (vaniyampara)	Male
11	MD 195-1	Olakara forest area	Male
12	MD 210	Chulannur	Male
13	MD 225	Chulannur	Male
14	MD 229	Madakkathara	Male
15	MD 230	Madakkathara	Male
16	MD 153	Nellikkunnu forest area (Peechi)	Female
17	MD 160	Anavari forest area (Peechi)	Female
18	MD 161	Anavari forest area (Peechi)	Female
19	MD 166	Anavari forest area (Peechi)	Female

Table 1 : continued

20	MD 178	Maniyankinar colony (vaniyampara)	Female
21	MD 183	Maniyankinar colony (vaniyampara)	Female
22	MD 195	Olakara forest area	Female
23	MD 207	Pazhamplalakode	Female
24	MD 215	Chelakkara	Female
25	MD 216	Chelakkara	Female
26	MD 221	Vazhakulam	Female
27	MD 222	Vazhakulam	Female
28	MD 226	Cheroor	Female
29	MD 227	Cheroor	Female
30	MD 228	Madakkathara	Female
31	MD 231	Madakkathara	Female

Plate 1 : field view

Plate 2: Production of rooted cuttings

Plate 3: Rooted cuttings

3.3 Observations recorded

Four plants per accession per replication were observed to record quantitative and qualitative characters. Descriptions were made as per the minimal descriptor list of NBPGR for bitter gourd (Srivastava *et al*., 2001) in the absence of a specific descriptor for spine gourd.

3.3.1 Morphological characters

Both quantitative as well as qualitative characters were observed.

3.3.1. 1 Qualitative parameters

a. Early plant vigour

The observation was recorded 30 days after transplanting

b. Plant growth habit

The observation was taken on fully grown plants

c. Leaf margin

The observation was taken at full foliage stage

d. Flower colour

The observation was recorded at flowering stage.

e. Fruit shape

The observation was taken at marketable stage.

f. Nature of spines

The observation was taken at vegetable harvest stage.

g. Blossom end fruit shape

The observation was taken at vegetable harvest stage.

h. Fruit skin colour

The observation was taken at marketable stage

i. Fruit bitterness

The observation was taken at marketable stage

j. Seediness

The observation was taken at marketable stage

k. Biotic stress susceptibility

The observation on pest and disease infestation was recorded throughout the crop period.

3.3.1.2 Quantitative characters

a. Vine length (m)

At the end of the crop, the length of the plant was measured from the collar region to the tip of the main vine with the help of a tape.

b. Number of branches per plant

The number of branches that arise from the main stem were counted and recorded at the end of flowering stage.

c. Days to first male and female flower opening

The number of days were counted from transplanting to first male and female flower opening in both male and female plants respectively and recorded as an average of the four plants per plot

d. Duration of the crop (days)

The number of days were counted from transplanting to end of the crop and recorded as an average of the four plants per plot in both male and female accessions.

e. Days to first harvest

The number of days were counted from transplanting to first harvest for female accessions.

f. Days to last harvest

The number of days were counted from transplanting to last harvest and recorded as an average of the four plants per plot.

g. Days from flowering to vegetable maturity

The number of days were counted from anthesis to harvest at vegetable maturity.

h. Total number of harvests

The number harvests were counted between first harvest and last harvests for female accessions and recorded as an average of the four plants per plot.

i. Fruit length (cm)

The length between the pedicel attachment and fruit apex is measured using twine and scale and recorded as an average of 10 fruits per plot.

j. Fruit girth (cm)

The maximum width of the fruit is measured using twine and scale and recorded as an average of 10 fruits per plot.

k. Average fruit weight (g)

The average weight of ten fruits per plot was recorded.

l. Number of fruits per plant

The number of fruits per plant was recorded as cumulative number of fruits from four plants and the average was calculated.

m. Yield per plant (g)

Weight of fruits harvested from all pickings was recorded and the average was calculated.

n. Shelf life in open condition (days)

The number of days the fruit can be kept at room temperature without any compromise in the quality attributes was recorde .

3.4. Statistical analysis

The mean of the values observed on four plants was taken for statistical analysis. The data on different characters were subjected to statistical analysis at the computer centre, Department of Agricultural Statistics, Kerala Agricultural University. The analysis technique suggested by Fisher (1954) was employed for estimation of various genetic parameters. Selection index was also worked out.

3.4.1. Phenotypic, genotypic and environmental variance

The variance components were estimated using the formula suggested by Burton (1952)

Phenotypic variance (Vp) = Vg + Ve

Where , Vg = Genotypic variance

Ve = Environmental variance

Genotypic variance (Vg) = $Vt - V_E / R$

Where, V_T = mean sum of squares due to treatments

V_E = mean sum of squares due to error

R = number of replication

Environmental variance (Ve) = V_E

3.4.2. Phenotypic and genotypic coefficient of variation

Phenotypic and genotypic coefficient of variation were calculated using the formula suggested by Burton and Devane (1953).

Phenotypic coefficient of variation (PCV) = (Vp ½ / X) x 100

Where, Vp = phenotypic variance

X = mean of characters under study

Genotypic coefficient of variation (GCV) = (Vg ½ / X) x 100

Where, Vg = genotypic variance

X = mean of characters under study

3.4.3. Heritability

Heritability in broad sense was estimated using the formula suggested by Burton and Devane (1953).

Heritability in broad sense H^2 = (Vg/ Vp) x 100

Where, Vp = phenotypic variance

Vg = genotypic variance

The range of heritability was categorized as suggested by Robinson *et al*., (1949) as

0 -30 per cent = low

31 – 60 per cent = moderate

61 per cent and above = high

3.4.4. Expected genetic advance

The genetic advance expected for the genotypes at five per cent selection pressure was calculated using the formula suggested by Lush (1949) and Johnson *et al*., (1955) with the value of the constant K as 2.06 as given by Allard (1960).

Expectd genetic advance (GA) = $(Vg / Vp^{½}) \times 2.06$

Where, Vp = phenotypic variance

Vg = genotypic variance

3.4.5. Genetic gain

Genetic advance (GA) calculated by the above method was used for the estimation of genetic gain

Genetic gain (GG) = (GA / X) x 100

Where, GA = Genetic advance

X = mean of characters under study

Genetic gain was classified according to Johnson *et al*., (1955) as follows

1 – 10 per cent = low

11- 20 per cent = medium

21 per cent and above = high

3.4.6. Genotypic and phenotypic correlation coefficients

Genotypic and phenotypic correlation coefficients were worked out to study the extend of association between the characters. The different covariance was calculated by the method suggested by Fisher (1954).

Phenotypic covariance between characters 1 and 2

COVp 12 = COVg 12 + COVe 12

Where, COVg 12 = genotypic covariance between character 1 and 2

COVe 12 = environmental covariance between character 1 and 2

Genotypic covariance between characters 1 and 2

$$COVg\ 12 = (Mt\ 12 - Me\ 12) / R$$

Where, Mt 12 = treatment mean sum of product of characters 1 and 2

Me 12 = error mean sum of product of characters 1 and 2

R = number of replication

The phenotypic and genotypic correlation coefficients among the various characters were worked out in all possible combinations according to the formula suggested by Johnson *et al*., (1955).

Phenotypic correlation coefficient between two characters 1 and 2

$$Rp\ 12 = COVp\ 12 / (Vp\ 1 \,.\, Vp\ 2) \times 1/2$$

Where, Vp 1 = phenotypic variance of character 1

Vp 2 = phenotypic variance of character 2

Genotypic correlation coefficient between two characters 1 and 2

$$Rg\ 12 = COVg\ 12 / (Vg\ 1 \,.\, Vg\ 2) \times ½$$

Where, Vg 1 = genotypic variance of character 1

Vg 2 = genotypic variance of character 2

3.4.7. Path coefficient analysis

In the path coefficient analysis the correlation between a particular cause and the effect is partitioned into direct and indirect effects of the various causal factors on the effect factor. The principle and techniques suggested by Wright

(1921) and Li (1955) for the analysis using the formula given by Dewey and Lu (1959)

0.00-0.09	- negligible
0.10 – 0.1	- low
0.20- 0.29	- moderate
0.30 – 1.00	– high
More than 1.00	– very high

3.4.8 Selection index

Discriminant function analysis developed by Fisher (1954) and first applied by Smith (1936) for plant improvement was used for formulating selection index.

3.4. Organoleptic evaluation

The observations on organoleptic qualities were recorded using marketable fruits. The organoleptic scores for following sensory attributes were recorded over a five point hedonic scale (Amerine *et al*., 1965) by a panel of ten evaluators.

Appearance

Colour

Texture

Flavor

Taste

Result

4. RESULT

The results obtained from the present investigation are presented under the following heads

4.1 Genetic cataloguing of spine gourd

4.2 Assessment of genetic variability and identification of promising genotypes

4.3 Organoleptic evaluation

4.1 Genetic cataloguing of spine gourd

Evaluation of qualitative characters of both male and female accessions were done acoording to the Minimal Descriptor of Agri – horticultural crops by NBPGR (Srivastava, *et. al.*, 2001)

4.1.1 Genetic cataloguing of male accessions of spine gourd.

Fifteen male accessions of *M. dioica* were evaluated for the different qualitative characters. The major morphological characters studied in male accessions were early plant vigour, plant growth habit, leaf margin, flower colour and susceptibility to major biotic stress (Table 2). Among the male accessions, early plant vigour was very good for five accessions while six accessions showed good vigour. Only four accessions showed poor vigour. Plant growth habit varied between medium viny and short viny. Half of the accessions showed multifid leaf margin while the remaining half were trifid. Flower colour for all the accessions was yellow. Major biotic stress observed in male plants were the damage caused by red pumkin beetle and fusarium wilt. Most of the accessions recorded low susceptibility to fusarium wilt except MD 158, MD 163, MD 168 and MD 195 – 1 which showed medium susceptibility. In the case of red pumkin beetle also most of the accessions recorded low susceptibility except MD 160 – 1, MD 161 – 1 and MD183 -1 which showed medium susceptibility.

Table 2 : Qualitative characters of male accessions

Accessions	Early plant vigour	Plant growth habit	Leaf margin	Flower colour	Biotic stress susceptibility	
					Fusarium wilt	Red pumkin
MD 117	Very good	Short viny	Trifid	Yellow	Low	Low
MD 154	Very good	Medium viny	Multifid	Yellow	Low	Low
MD 157	Poor	Short viny	Multifid	Yellow	Low	Low
MD 158	Good	Short viny	Multifid	Yellow	Medium	Low
MD 160-1	Poor	Short viny	Multifid	Yellow	Low	Medium
MD 161-1	Good	Medium viny	Multifid	Yellow	Low	Medium
MD 161-2	Good	Medium viny	Multifid	Yellow	Low	Low
MD 163	Good	Medium viny	Trifid	Yellow	Medium	Low
MD 168	good	Medium viny	Multifid	Yellow	Medium	Low
MD 183-1	Poor	Short viny	Trifid	Yellow	Low	Medium
MD 195-1	Good	Short viny	Trifid	Yellow	Medium	Low
MD 210	Poor	Short viny	Trifid	yellow	Low	Low
MD 225	Very god	Medium viny	Multifid	Yellow	Low	Low
MD 229	Very good	Medium viny	Trifid	Yellow	Low	Low
MD 230	Very good	Short viny	Trifid	Yellow	Low	Low

Plate 4: Male twig with buds

Plate 5: Male flower

Plate 6: Female flower

Plate 7: Leaf shape and leaf margin variability

MD 158

MD 154

MD 229

MD 161 – 2

Plate 8: Male accessions

4.1.2 Genetic cataloguing of female accessions of spine gourd

There were sixteen female accessions for the study. Apart from the above mentioned morphological characters for male accessions, fruit characters were also recorded for female accessions like fruit shape, nature of spines, blossom end fruit shape, fruit skin colour, fruit bitterness and seediness (Table 3).

Early plant vigour was very good for half of the accessions while the remaining half was good. Five female accessions recorded long viny plant growth habit. For the remaining accessions plant growth habit varied between short viny and medium viny. Leaf margin was trifid for most of the accessions. Only three accessions showed entire serrate leaf margin. The flower colour was yellow for all accessions. Fruit shape was globular for eight accessions. For the remaining eight fruit shape varied among oblong, tapering and elliptical. Nature of spines varied among dense, dense soft, dense sharp, sparse sharp and sparse. For ten accessions blossom end fruit shape was acute. Fruit skin colour varied from light green, green to dark green. For all accessions evaluated, the fruit bitterness was mild. Medium seediness (35 – 44 seeds) was observed in ten accessions while the other six accessions showed high seediness (more than 45 seeds per fruits). Eleven accessions exhibited low susceptibility to *Fusarium* wilt while the other 4 showed medium susceptibility. Susceptibility to red pumkin beetle was low in ten accessions while it was medium in the other six accessions. All the accessions showed medium susceptibility to fruit fly infestation.

Table 3 : Qualitative characters of female accessions

Accessions	Early plant	Plant growth	Leaf margin	Flower colour	Fruit shape	Nature of	Blossom end
MD 153	Very good	Medium viny	Trifid	Yellow	Globular	Sparse	Obtuse
MD 160	Very good	Medium viny	Trifid	Yellow	Globular	Dense	Acute
MD 161	Very good	Medium viny	Trifid	Yellow	Globular	Dense, sharpe	Obtuse
MD 166	Good	Short viny	Trifid	Yellow	Globular	Dense, sharp	Obtuse
MD 178	Very good	Long viny	Trifid	Yellow	Globular	Dense, soft	Obtuse
MD 183	Very good	Medium viny	Trifid	Yellow	Globular	Dense	Acute
MD 195	Good	Medium viny	Entire serrate	Yellow	Elliptical	Dense, soft	Obtuse
MD 207	Good	Long viny	Entire serrate	Yellow	Globular	Dense, soft	Acute
MD 215	Very good	Long viny	Trifid	Yellow	Oblong	Sparse, sharp	Acute
MD 216	Good	Long viny	Entire serrate	Yellow	Tapering	Dense, sharp	Acute
MD 221	Good	Short viny	Multifid	Yellow	Tapering	Dense	Acute
MD 222	Good	Long viny	Multifid	Yellow	Globular	Dense, sharp	Acute
MD 226	Very good	Medium viny	Trifid	Yellow	Globular	Sparse, sharp	Obtuse
MD 227	Very good	Medium viny	Trifid	Yellow	Tapering	Dense	Acute
MD 228	Good	Medium viny	Entire serrate	Yellow	Oblong	Dense	Acute
MD 231	Good	Long viny	Trifid	Yellow	Oblong	Sparse, sharp	Acute

Table 3 : continued

Accessions	Fruit skin colour	Fruit bitterness	Seediness	Botic stress susceptibility		
				Fusarium wilt	Red pumkin beetle	Fruit fly
MD 153	Dark Green	Mild	Medium	Medium	Low	Medium
MD 160	Light green	Mild	Medium	Low	Medium	Medium
MD 161	Dark green	Mild	Medium	Low	Low	Medium
MD 166	Light green	Mild	Medium	Low	Low	Medium
MD 178	Light green	Mild	Medium	Medium	Low	Medium
MD 183	Green	Mild	Medium	Low	Medium	Medium
MD 195	Green	Mild	High	Low	Medium	Medium
MD 207	Light green	Mild	Medium	Medium	Low	Medium
MD 215	Dark green	Mild	High	Low	Low	Medium
MD 216	Green	Mild	Medium	Low	Medium	Medium
MD 221	Light green	Mild	High	Low	Low	Medium
MD 222	Dark green	Mild	High	Low	Low	Medium
MD 226	Light green	Mild	High	Low	Low	Medium
MD 227	Light green	Mild	High	Medium	Low	Medium
MD 228	Dark green	Mild	Medium	Medium	Low	Medium
MD 231	Green	Mild	Medium	Low	Medium	Medium

Plate 9: Variability in fruit shape and blossom end shape

4.2 Assessment of genetic variability and identification of promising genotypes

4.2.1. Evaluation of quantitative characters of male accessions

All the fifteen male accessions of *M. dioica* were evaluated for four quantitative characters *viz.* vine length, number of branches per plant, days to first flower opening and total duration of the crop and the data are presented in Table 4.

a. Vine length

There was no significant difference in the vine length of male accessions. Among the fifteen accessions the maximum vine length was observed in the accession MD 117 (1.12m). The shortest vine length was recorded for MD 168 and it was 0.52m.

b. Number of branches per plant

There was significant difference among all the fifteen accessions for number of branches per plant. Number of branches per plant varied between 7.00 and 12.75. Maximum number of branches was recorded for the accession MD 230 and the lowest value was recorded for the accession MD 183-1.

c. Days to first flowering

Days to first flowering also recorded significant difference among the accessions. Days to first flowering ranged between 43.75 and 57.00. The accession MD 225 and MD 229 were the earliest to flower (43.75 days) closely followed by MD 230 and MD 117 and MD 161-1 which were at par. MD 183-1 recorded the maximum number of days for first flowering.

d. Duration of the crop

Significant difference was observed among the accessions for duration of the crop. The longest duration of 121 days was recorded for the accession MD 160-1 which was on par with MD 229 and MD 230 (119.5 and 119.75 days respectively). The shortest duration of 109 days was recorded for the accession MD 161-2.

Table 4: Quantitative characters of male accessions

Accessions	Vine	Number of	Days to first	Duration of the crop
MD 117	1.12[a]	11.00[abc]	44.50[fg]	118.50[ab]
MD 154	1.03[a]	8.50[cdef]	47.50[cdef]	116.00[abcdef]
MD 157	0.75[a]	8.00[def]	50.00[bcd]	111.00[cdef]
MD 158	0.96[a]	11.00[abc]	46.50[defg]	114.00[abcdef]
MD 160-1	0.76[a]	8.50[cdef]	52.50[b]	121.00[a]
MD 161-1	1.06[a]	11.00[abc]	44.50[fg]	111.75[bcdef]
MD 162-2	0.95[a]	10.00[bcde]	46.50[efg]	109.00[f]
MD 163	0.95[a]	7.50[ef]	50.50[bc]	116.50[abcde]
MD 168	0.52[b]	10.75[abc]	50.00[bcd]	117.00[abcd]
MD 183-1	0.84[a]	7.00[f]	57.00[a]	109.50[ef]
MD 195-1	0.98[a]	10.50[abcd]	47.25[cdefg]	113. 75[abcdef]
MD 210	0.95[a]	8.00[def]	49.00[efg]	110.00[def]
MD 225	1.01[a]	10.50[abcd]	43.75[g]	117.75[abc]
MD 229	1.11[a]	11.50[ab]	43.75[g]	119.50[a]
MD 230	1.09[a]	12.50[a]	44.25[fg]	119.75[a]

4.2.2 Evaluation of quantitative characters of female accessions.

Sixteen female accessions were evaluated for sixteen quantitative characters. Apart from the four quantitative characters for male accessions fruit characters were also included for female accessions. The characters studied were vine length, number of branches per plant, days to first flower opening, days to first harvest, days to last harvest, days from flowering to vegetable maturity, total number of harvests, fruit length, fruit girth, average fruit weight, number of fruits per plant, yield per plant, duration of the crop and shelf life in open condition. The data are presented in Table 5.

a. Vine length

In the female accessions also there was no significant difference in vine length. The highest vine length of 1.20m was recorded in the accession MD 166. The shortest vine length was recorded for MD 221 and it was 0.57m.

b. Number of branches per plant

Number of branches per plant also did not show any significant difference between female accessions except for MD 183. The accession MD 183 recorded 6.25 for number of branches per plant which was significantly lower. All other accessions were at par. However the highest value of 12.25 was recorded for two accessions, MD 166 and MD 222.

c. Days to first flower opening

There was significant difference among the accessions for days to first flower opening. It varied between 51.25 and 61.75. The first accession to open the flower was MD 231 (51.25days) and the last one to open the flower was MD183 (61.75days).

d. Days to first harvest

Significant difference was observed among the sixteen accessions for days to first harvest. The accession MD 161 recorded the highest value (90.75 days) and it is on par with the accession MD 227 (90.25 days). The lowest value of 88.50 days was recorded for the accession MD 228.

e. Days to last harvest

There was significant difference among the accessions for days to last harvest. The range for days to last harvest was from 91.75 to 118.00. The accession MD 161 was the last harvested accession (118.00 days) which was on par with MD 178 (117.00 days) . The lowest value of (91.75days) was recorded for the accession MD 221.

f. Days from flowering to vegetable maturity

There was significant difference among the sixteen accessions for days from flowering to vegetable maturity. The highest duration from flowering to vegetable maturity was recorded for the accession MD 178 (9.50 days). The lowest value recorded was five days for the accessions MD 215, MD216, MD 221 and MD 228.

g. Total number of harvests

Total number of harvests also recorded significant variation among the accessions. Total number of harvests varied between 2.75 and 6.00. The highest value of 6.00 was recorded for the accession MD 227. The lowest value of 2.75 was recorded by four accessions MD 153, MD 160, MD 183 and MD 222 which were on par with MD 166 (3.25), MD 215 , MD 216 and MD 231 (3.00).

h. Fruit length

There was significant difference for fruit length among the sixteen accessions. The maximum fruit length was recorded by the accession MD 221 (11.30 cm). The minimum fruit length of 4.70 cm was recorded for the accession MD 161.

i. Fruit girth

Significant difference was observed for fruit girth among sixteen accessions. The fruit girth varied between 4.41 cm and 7.23 cm. The maximum fruit girth of 7.23 cm was recorded by the accession MD 231 and minimum fruit girth was recorded by the accession MD 161 (4.41 cm).

j. Average fruit weight

There was significant difference among the sixteen accessions for average fruit weight. The range for average fruit weight was from 5.14g to 7.83g. The accession MD 231 recorded the maximum fruit weight (7.83g). Minimum fruit weight was recorded for the accession MD 178 (5.14g).

k. Number of fruits per plant

Number of fruits per plant recorded significant difference between the accessions. The maximum number of fruits per plant was recorded for the accession MD227 (18.25). The accessions MD 260 and MD 231 recorded minimum number of fruits per plant (12.50).

l. Yield per plant

There was significant difference among the sixteen accessions for yield per plant. The maximum yield was recorded for the accession MD 227 (110.06g) closely

followed by MD 207 and MD 226 which were at par. The accession MD 183 recorded the minimum yield per plant (90.83g).

m. Duration of the crop

Duration of the crop also showed significant difference among the accessions. The longest duration of 122.00 days was recorded for the accession MD 161 which was on par with the accession MD 178 (121.50 days). The shortest duration of the crop was recorded for the accession MD 215 (99.50 days).

n. Shelf life in open condition

Shelf life in open condition ranged between two and three days.

Table 5 : Quantitative characters of female accessions

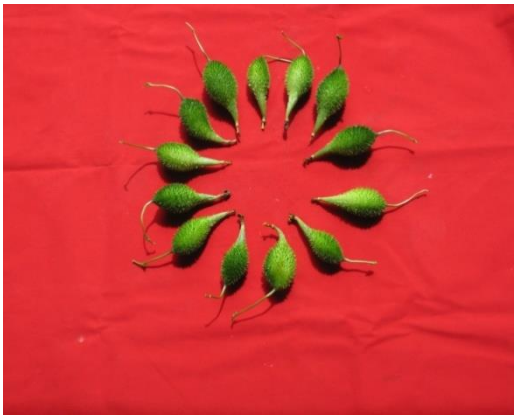
Accessions	Vine length	No of branches	Days to first flowering	Days to first harvest	Days to last harvest	Days from flowering to
MD 153	1.15^{a}	9.75 ^{a}	55.35 ^{cde}	84.50^{abc}	107.25 ^{bcd}	6.00^{e}
MD 160	1.03^{a}	9.25 ^{a}	55.00 ^{cde}	77.00^{bcde}	100.00^{cdef}	9.00^{b}
MD 161	1.17^{a}	11.75 ^{a}	55.00 ^{cd}	90.75^{a}	118.00 ^{a}	6.00^{e}
MD 166	1.20^{a}	12.25 ^{a}	53.50 ^{de}	74.50^{cde}	100.25^{bcdef}	7.00^{d}
MD 178	1.17^{a}	11.50 ^{a}	54.90 ^{cde}	85.00^{abc}	117.00^{a}	9.50^{a}
MD 183	0.92^{a}	6.25^{b}	61.75 ^{a}	80.75^{abcd}	108.75 ^{abc}	7.00^{d}
MD 195	1.05^{a}	10.00 ^{a}	58.25 ^{abc}	77.50^{bcde}	100.75^{bcdef}	6.00^{e}
MD 207	1.04^{a}	11.75 ^{a}	55.25 ^{cde}	76.25^{cde}	107.00 ^{bcd}	6.00^{e}
MD 215	1.18^{a}	11.75 ^{a}	54.25 ^{cde}	73.00^{de}	96.50^{ef}	5.00^{f}
MD 216	1.13^{a}	11.75 ^{a}	59.50 ^{ab}	77.50^{bcde}	104.50^{bcde}	5.00^{f}
MD 221	0.57^{a}	12.00 ^{a}	52.75 ^{de}	69.50^{e}	91.75^{f}	5.00^{f}
MD 222	1.17^{a}	12.25 ^{a}	57.75 ^{bc}	75.75^{cde}	99.25^{cdef}	8.00^{c}
MD 226	1.14^{a}	10.25 ^{a}	55.25 ^{cde}	87.25^{ab}	105.00 ^{bcde}	7.00^{d}
MD 227	1.08^{a}	11.75 ^{a}	55.05 ^{cde}	90.25^{a}	105.50 ^{bcde}	7.00^{d}
MD 228	1.10^{a}	11.25 ^{a}	54.50 ^{cde}	88.50^{a}	110.00 ^{ab}	5.00^{f}
MD 231	1.16^{a}	10.50 ^{a}	51.25 ^{e}	72.00^{de}	99.25^{def}	6.00^{e}

Table 5 : continued

Accessions	Total no of harvests	Fruit length (cm)	Fruit girth (cm)	Avg. fruit wt. (g)	No of fruits per plant	Yield per plant (g)
MD153	2.75 ^{f}	5.46 ^{g}	5.07^{hi}	5.83^{fgh}	16.25^{abc}	95.70^{efg}
MD160	2.75 ^{f}	5.42 ^{g}	6.11^{cd}	6.62^{cd}	12.50^{d}	95.97^{efg}
MD161	5.00^{abcd}	4.70 ^{h}	4.41^{j}	7.16^{b}	14.00^{bcd}	102.14^{bcde}
MD166	3.25 ^{f}	7.02 ^{cd}	5.97^{de}	6.34^{cde}	15.25^{bc}	96.03^{efg}
MD178	3.50^{ef}	5.52 ^{g}	6.15^{c}	5.14^{i}	16.00^{abc}	99.12^{cdef}
MD183	2.75 ^{f}	5.51 ^{g}	6.58^{b}	6.78^{bc}	13.25^{cd}	90.83^{g}
MD195	4.50 ^{cde}	5.22 ^{g}	4.93^{i}	5.51^{hi}	16.00^{abc}	103.43^{bcd}
MD207	5.25^{abc}	6.17 ^{f}	6.13^{cd}	5.85^{fgh}	17.00^{ab}	105.50^{abc}
MD215	3.00 ^{f}	5.22 ^{g}	5.16^{h}	5.59^{h}	16.00^{abc}	98.86^{def}
MD216	3.00 ^{f}	6.39 ^{ef}	5.78^{fg}	5.61^{gh}	15.50^{bc}	95.45^{fg}
MD221	4.75^{bcd}	11.30 ^{a}	5.13^{h}	6.37^{cde}	15.25^{bc}	103.36^{bcd}
MD222	2.75 ^{f}	6.66 ^{de}	5.84^{ef}	6.07^{efg}	15.50^{bc}	96.06^{efg}
MD226	5.75 ^{ab}	5.43 ^{g}	4.93^{i}	5.68^{gh}	17.50^{ab}	105.91^{ab}
MD227	6.00^{a}	10.87 ^{b}	5.70^{fg}	5.95^{efgh}	18.25^{a}	110.06^{a}
MD228	4.00 ^{def}	6.52^{ef}	5.66^{g}	6.17^{def}	15.50^{bc}	98.56^{def}
MD231	3.00 ^{f}	7.22 ^{c}	7.23^{a}	7.83^{a}	12.50^{d}	100.08^{bcdef}

Table 5 : continued

Accessions	Duration of the crop (days)	Shelf life in open condition
MD 153	116.50^{abc}	3.00
MD 160	110.00^{bcde}	3.00
MD 161	122.00^{a}	2.00
MD 166	107.50^{cdef}	3.00
MD 178	121.50^{a}	3.00
MD 183	116.00^{abc}	2.00
MD 195	104.00^{ef}	2.00
MD 207	115.50^{abc}	2.00
MD 215	99.50^{f}	2.00
MD 216	115.00^{abcd}	3.00
MD 221	104.50^{ef}	3.00
MD 222	104.00^{ef}	3.00
MD 226	110.50^{bcde}	3.00
MD 227	112.50^{abcde}	2.00
MD 228	118.50^{ab}	2.00
MD 231	105.00^{def}	3.00



MD 227 plant and fruits

MD 226 plant and fruits

Plate 10 : Better performing female accessions


MD 207 plant and fruits


MD 231 plant and fruits


MD 161 plant and fruits

Plate 10 : continued

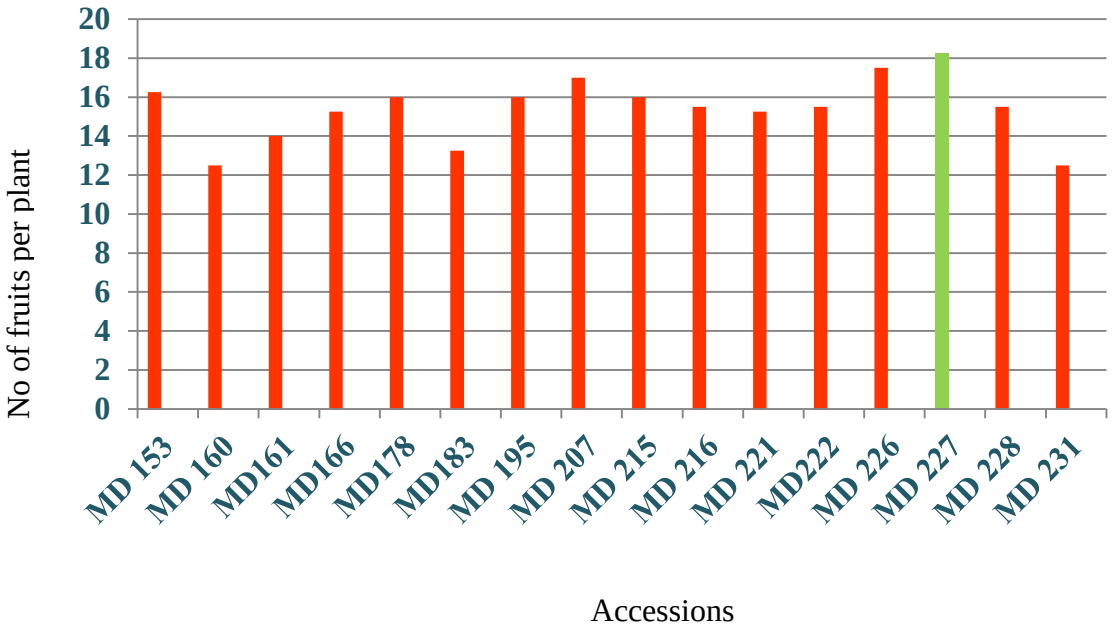


Figure 1: Number of fruits per plant in 16 accessions of spine gourd

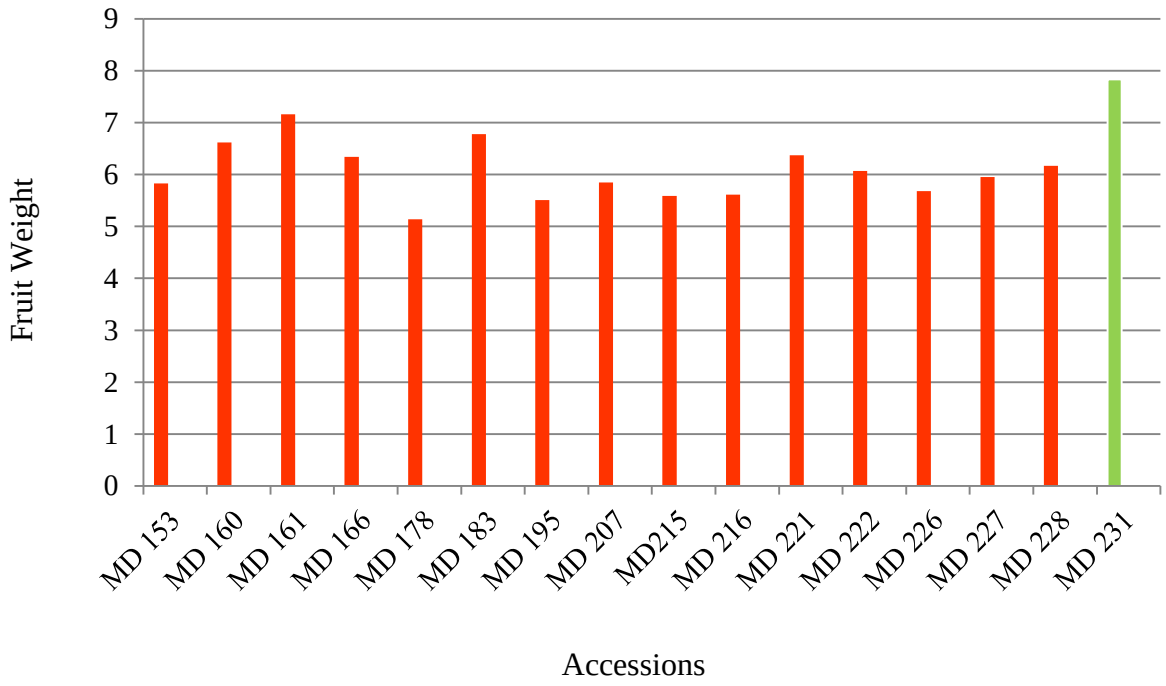


Figure 2: Fruit weight in 16 accessions of spine gourd

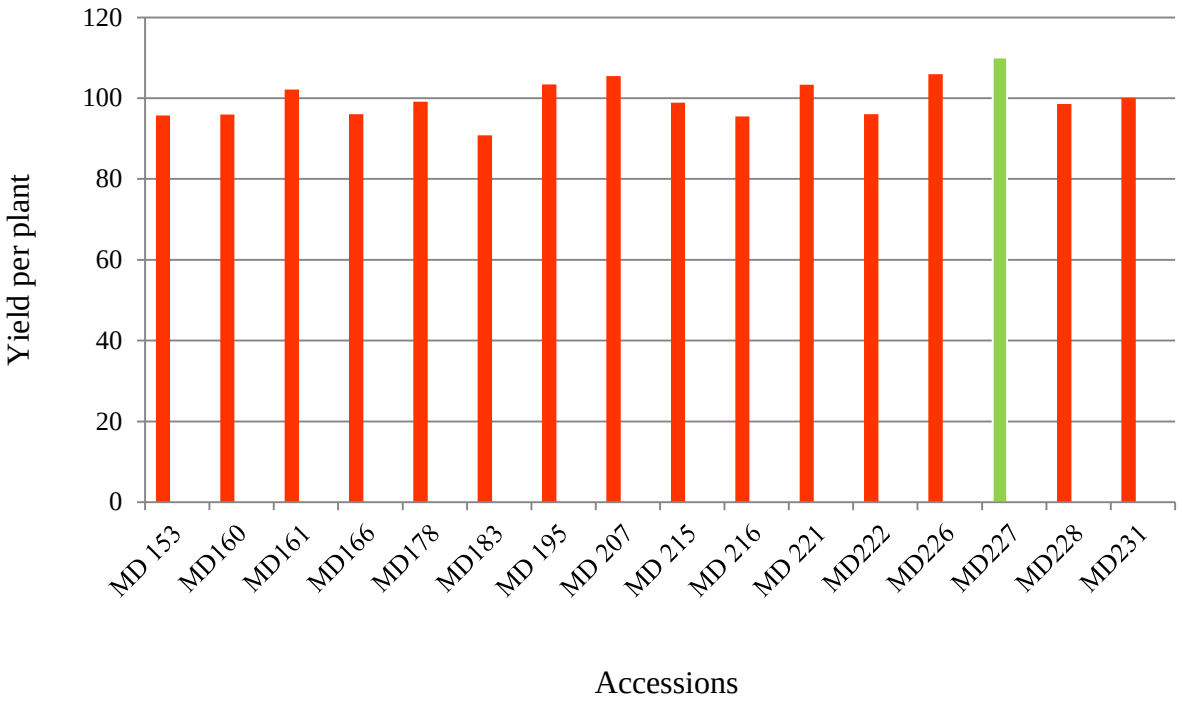


Figure 3: Yield per plant in 16 accessions of spine gourd

4.2.3 Genotypic coefficient of variation, Phenotypic coefficient of variation, heritability, genetic advance and genetic gain

Genetic parameters like genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance and genetic gain were estimated for 14 quantitative characters and presented in Table 6

a. Genotypic coefficient of variation

Days from flowering to vegetable maturity (21.10), total number of harvests (28.48) and fruit length (29.09) showed high genotypic coefficient of variation (21 per cent and above). Medium genotypic coefficient of variation (11 – 20 per cent) was recorded for number of branches per plant (11.39), fruit girth (12.53) number of fruits per plant (18.27) and shelf life in open condition (19.99). Other characters gave low genotypic coefficient of variation (0 – 10 per cent).

b. Phenotypic coefficient of variation

High phenotypic coefficient of variation (21 per cent and above) was observed for characters like days from flowering to vegetable maturity (21.28), total number of harvests (31.42), fruit length (29.25) and number of fruits per plant (27.17), whereas some other characters like vine length (18.16), number of branches per plant (16.62), fruit girth (12.60), average fruit weight (11.36) and shelf life in open condition (19.99) gave medium phenotypic coefficient of variation (11 – 20 per cent). Other characters resulted in low phenotypic coefficient of variation (0 – 10 per cent).

c. Heritability

The magnitude of heritability is the most important aspect of genetic constitution of breeding material, which has close bearing on the response to selection (Panse, 1957). Heritability is a measure of efficiency of selection system in separating genotypes and indicates the effectiveness with which selection of

Table 6 : Range, Mean, Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV), Heritability, Genetic advance and Genetic gain of different characters

Characters	Range	Mean	GCV	PCV	Heritability (%)	Genetic advance	Genetic gain (%)
Vine length	0.570 – 1.197	1.081	8.86	18.16	23.8	0.10	9.25
Number of branches per plant	6.250 – 12.250	10.875	11.39	16.62	46.9	1.75	16.09
Days to first flowering	51.250 – 61.750	55.612	4.12	5.14	64.3	3.78	6.79
Days to first harvest	69.500 – 90.750	80.001	7.53	9.42	63.8	9.91	12.38
Days to last harvest	91.750 – 118.00	104.344	6.20	7.31	72.0	11.31	10.83
Days from flowering to vegetable maturity	5.00 – 9.500	6.531	21.10	21.28	98.4	2.82	43.17
Total number of harvests	2.750 – 6.00	3.875	28.48	31.42	82.2	2.06	53.16
Fruit length	5.220 – 11.300	6.545	29.09	29.25	98.9	3.90	59.58
Fruit girth	4.410 – 7.230	5.674	12.53	12.60	98.9	1.46	25.73
Average fruit weight	5.140 – 7.830	6.156	10.90	11.36	92.1	1.33	21.60
Number of fruits per plant	12.500 – 18.250	15.390	18.27	27.17	45.2	3.89	25.30
Yield per plant	90.835 – 110.063	99.819	4.58	5.33	73.9	8.09	8.10
Duration of the crop	99.500 – 122.00	111.406	5.49	6.72	66.7	10.28	9.22
Shelf life in open condition	2.0 – 3.0	2.563	19.99	19.99	1.000	1.06	41.35

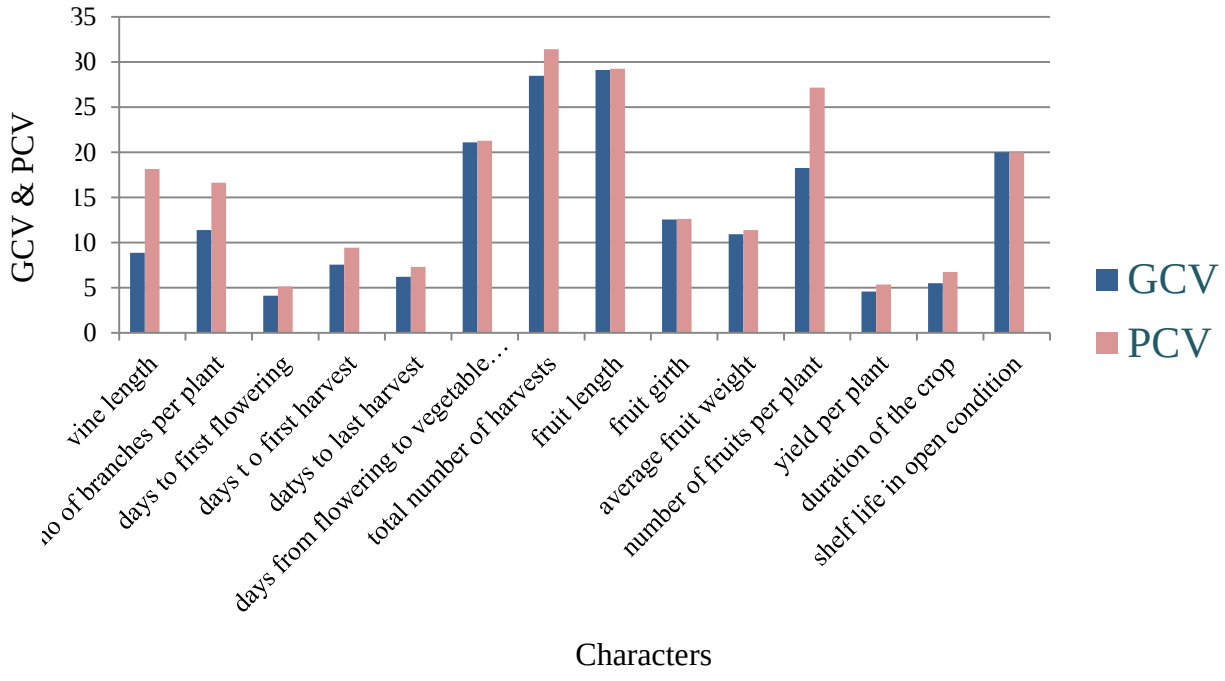


Figure 4 : Variation of GCV and PCV for yield and its components

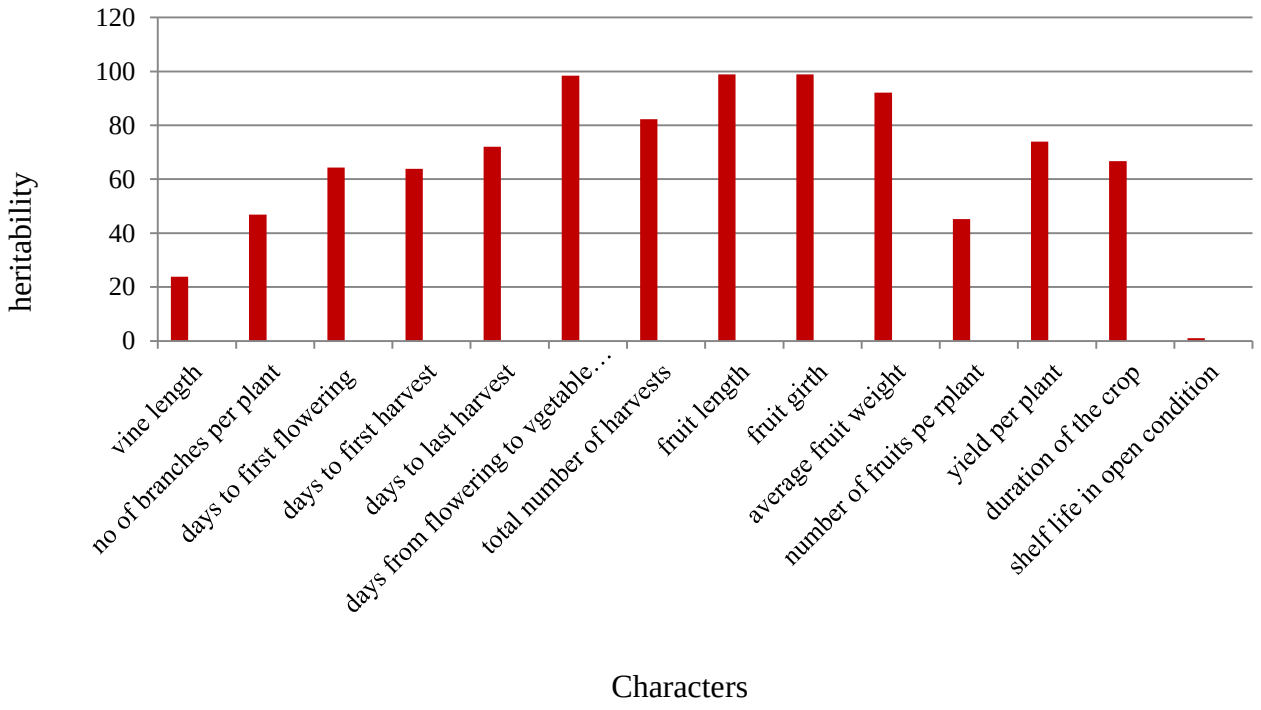


Figure 5: Variation of heritability for yield and its components

genotypes could be done. Allard (1960) suggested that gain from selection for a particular character depends largely on the heritability of the character.

In the present study most of the quantitative characters like days to first flowering (64.3 %), days to first harvest (63.8 %), days to last harvest (72.0 %), days from flowering to vegetable maturity (98.4 %), total number of harvests (82.2 %), fruit length (98.9 %), fruit girth (98.9 %), average fruit weight (92.1 %), yield per plant (73.9 %) and duration of the crop (66.7 %) recorded high heritability (61 per cent and above). Two characters *viz*. number of branches per plant and number of fruits per plant showed moderate heritability (31 – 60 per cent). Low heritability was observed only for vine length and shelf life in open condition (0 – 30 per cent).

d. Genetic advance

Maximum genetic advance was recorded for the character days to last harvest (11.31). The minimum genetic advance was observed for the character vine length (0.10).

e. Genetic gain

The highest magnitude of genetic gain was recorded for the character fruit length (59.58%) and the lowest magnitude of genetic gain was recorded for the character days to first flowering (6.79%). High magnitude of genetic gain (21 per cent and above) was recorded for the characters like days from flowering to vegetable maturity (43.17%), total number of harvest (53.16%),fruit length (59.58%), fruit girth (25.73%), average fruit weight (21.60%), number of fruits per plant (25.30%) and shelf life in open condition (41.38%). Medium genetic gain (11 – 20 per cent) was recorded for number of branches per plant (16.09%) and days to first harvest (12.38%). All other characters showed low genetic gain (0 – 10 per cent).

4.2.4. Correlation

Correlation provides the information about the nature and the extend of relationship of yield and its component characters and is essential for the simultaneous improvement of yield components, and in turn yield. The genotypic correlation provides a reliable measure of genetic association between the characters and helps to differentiate the vital association useful in breeding from non-vital ones (Falconer, 1981). Selection for yield alone need not be effective or rather not possible since there may not be any gene or genes for yield alone, and it is a consequence of multiplicative interaction of several component characters (Singh, 1983). The genotypic and phenotypic correlations between different pairs of characters were estimated and presented in Table 7.

In the present study it was observed that yield had got significant and positive genotypic correlation with number of branches per plant (0.516), total number of harvests (1.000) and fruit length (0.481). On the other hand, yield showed significant and negative genotypic correlation with number of fruits per plant (-0.518).

Vine length expressed significant and positive genotypic correlation with days to last harvest (0.685) while significant and negative genotypic correlation was expressed with fruit length (-0.875).

The characters having highly significant and positive genotypic correlation with days to first harvest were days to last harvest (0.933), total number of harvests (0.537) and duration of the crop (0.838). Days to first flowering was significant and has got negative genotypic correlation with number of branches per plant (-0.485).

Duration of the crop had got positive and significant genotypic correlation with days to first harvest (0.838) and days to last harvest (0.984). Number of fruits

Table 7 : Phenotypic (lower diagonal) and genotypic (upper diagonal) correlation coefficients between yield and its components.

Char	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	1.00**	0.301	0.107	0.506	0.685**	0.379	-0.393	-0.875**	0.070	-0.240	0.119	-0.446	0.060	0.011
X2	0.140	1.00**	-	-0.220	-0.235	-0.269	0.393	0.445	-0.321	0.297	-0.949**	0.516*	-0.247	0.171
X3	-0.040	-0.515	1.00**	0.166	0.251	0.089	-0.230	-0.404	-0.049	-0.307	0.234	-0.448	0.262	-0.299
X4	0.297	-0.028	0.170	1.00**	0.933**	0.180	0.537*	-0.198	-0.390	-0.166	-0.059	0.247	0.838**	-0.367
X5	0.286	-0.054	0.279	0.724*	1.00**	0.270	0.195	-0.489*	-0.111	0.129	0.197	-0.013	0.984**	-0.324
X6	0.171	-0.146	0.080	0.166	0.249	1.00**	-0.183	-0.190	0.324	-0.097	0.811**	-0.168	0.197	0.351
X7	-0.139	0.229	-0.163	0.363	0.175	-0.146	1.00**	0.378	-	-0.171	-0.439	1.000**	0.143	-0.398
X8	-0.484	0.291	-0.304	-0.171	-0.407	-0.180	0.358	1.00**	0.102	0.107	-0.082	0.481*	-0.282	0.104
X9	0.052	-0.236	-0.026	-0.318	-0.116	0.319	-0.417	0.100	1.00**	0.366	0.653**	-0.376	-0.033	0.210
X10	-0.069	-0.210	-0.226	-0.134	-0.085	-0.090	-0.137	0.097	0.361	1.00**	0.177	-0.195	-0.051	0.016
X11	-0.120	-0.310	0.178	-0.016	0.172	0.563	-0.216	-0.035	0.460	0.078	1.00**	-0.318	0.207	0.152
X12	0.007	0.381	-0.372	0.266	-0.010	-0.126	0.831*	0.404	-0.317	-0.139	-0.287	1.00**	-0.135	-0.304
X13	0.205	-0.089	0.205	0.668*	0.876*	0.165	0.172	-0.237	-0.028	-0.030	0.233	-0.019	1.00**	-0.174
X14	0.005	0.117	-0.240	-0.293	-0.275	0.348	-0.361	0.103	0.209	0.016	0.102	-0.261	-0.142	1.00**

X1-vine length, X2- number of branches per plant, X3- days to first flowering, X4- days to first harvest, X5- days to last harvest, X6- days from flowering to vegetable maturity, X7- total number of harvests, X8- fruit length, X9- fruit girth, X10- average fruit weight,X11- number of fruits per plant, X12- yield per plant, X13- duration of the crop, X14- shelf life in open condition.

*- significant

per plant had got positive and significant genotypic correlation with days from flowering to vegetable maturity (0.811.) and fruit girth (0.653). But the number of fruits per plant showed significant and negative genotypic correlation with number of branches per plant (-0.949).

Fruit length was found to have significant and negative genotypic correlation with vine length (-0.875) and days to last harvest (-0.489). Similarly, fruit girth had got significant and negative genotypic correlation with total number of harvests (-0.465).

Total number of harvests showed significant and positive genotypic correlation with days to first harvest (0.537). Days to last harvest expressed significant and positive genotypic correlation with vine length (0.685) and days to first harvest (0.933).

Yield had got positive phenotypic correlation to number of branches per plant, days to first harvest, total number of harvests and fruit length. Yield was significantly and positively correlated to total number of harvests (0.831).

Days to first harvest expressed significant and positive phenotypic correlation with days to last harvest (0.724) and duration of the crop (0.668).

Days to last harvest was significant and has got positive phenotypic correlation with days to first harvest (0.724) and duration of the crop (0.876).

Days from flowering to vegetable maturity had highly significant and positive phenotypic correlation with duration of the crop (0.876) which can be attributed to the larger effect of environment**.**

4.2.5 PATH COEFFICIENT ANALYSIS

The direct and indirect contribution of component characters and yield can be found out by partitioning the correlation between yield and component characters into direct and indirect effects. The result of path coefficient analysis of sixteen female accessions of *Momordica dioca* Roxb. for different characters is furnished in Table 8 and Table 9.

In path coefficient analysis the highest positive direct genotypic effect on yield was exhibited by total number of harvests (0.931), followed by fruit girth (0.370), days to first harvest (0.362), days from flowering to vegetable maturity (0.352) and duration of the crop (0.304).

Direct effect of vine length on yield was negative (-0.141) and its correlation with yield was also negative (-0.446).

Number of branches per plant showed very low positive direct effect on yield (0.053) which is negligible.

Days to first flowering also showed direct negative effect on yield (-0.351) and its genotypic correlation with yield was also negative (-0.448).

Days to first harvest showed high positive direct effect on fruit yield (0.362). Its genotypic correlation with yield was also found to be positive (0.247).

Days to last harvest exhibited maximum direct negative effect on yield (-0.946) and its genotypic correlation with yield was also found to be negative (-0.013). This may be due to the negative indirect effects of vine length, days to first flowering and number of fruits per plant.

Table 8 : Phenotypic path coefficient analysis of the various characters on the yield of spine gourd.

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X13	X14	rp
X1	**0.130**	0.008	0.007	0.040	-0.037	0.012	-0.102	-0.048	0.003	0.005	0.008	-0.019	0.000	0.007
X2	0.018	**0.059**	0.096	-0.004	0.007	-0.010	0.169	0.029	-0.015	0.016	0.020	0.008	-0.011	0.381
X3	-0.005	-0.030	**-0.187**	0.023	-0.036	0.005	-0.120	-0.030	-0.002	0.017	-0.011	-0.019	0.023	-0.372
X4	0.039	-0.002	-0.032	**0.136**	-0.093	0.011	0.268	-0.017	-0.020	0.010	0.001	-0.062	0.028	0.266
X5	0.037	-0.003	-0.052	0.098	**-0.129**	0.017	0.129	-0.040	-0.007	0.006	-0.011	-0.082	0.026	-0.010
X6	0.022	-0.009	-0.015	0.023	-0.032	**0.068**	-0.108	-0.018	0.020	0.007	-0.036	-0.015	-0.033	-0.126
X7	-0.018	0.013	0.030	0.049	-0.023	-0.010	**0.737**	0.035	-0.026	0.010	0.014	-0.016	0.034	0.831
X8	-0.063	0.017	0.057	-0.023	0.052	-0.012	0.264	**0.099**	0.006	-0.007	0.002	0.022	-0.010	0.404
X9	0.007	-0.014	0.005	-0.043	0.015	0.022	-0.308	0.010	**0.063**	-0.027	-0.029	0.003	-0.020	-0.317
X10	-0.009	-0.012	0.042	-0.018	0.011	-0.006	-0.101	0.010	0.023	**-0.074**	-0.005	0.003	-0.001	-0.139
X11	-0.016	-0.018	-0.033	-0.002	-0.022	0.038	-0.159	-0.003	0.029	-0.006	**-0.063**	-0.022	-0.010	-0.287
X13	0.027	-0.005	-0.038	0.091	-0.113	0.011	0.127	-0.023	-0.002	0.002	-0.015	**-0.093**	0.014	-0.135
X14	0.001	0.007	0.045	-0.040	0.035	0.024	-0.266	0.010	0.013	-0.001	-0.006	0.013	**-0.095**	-0.304

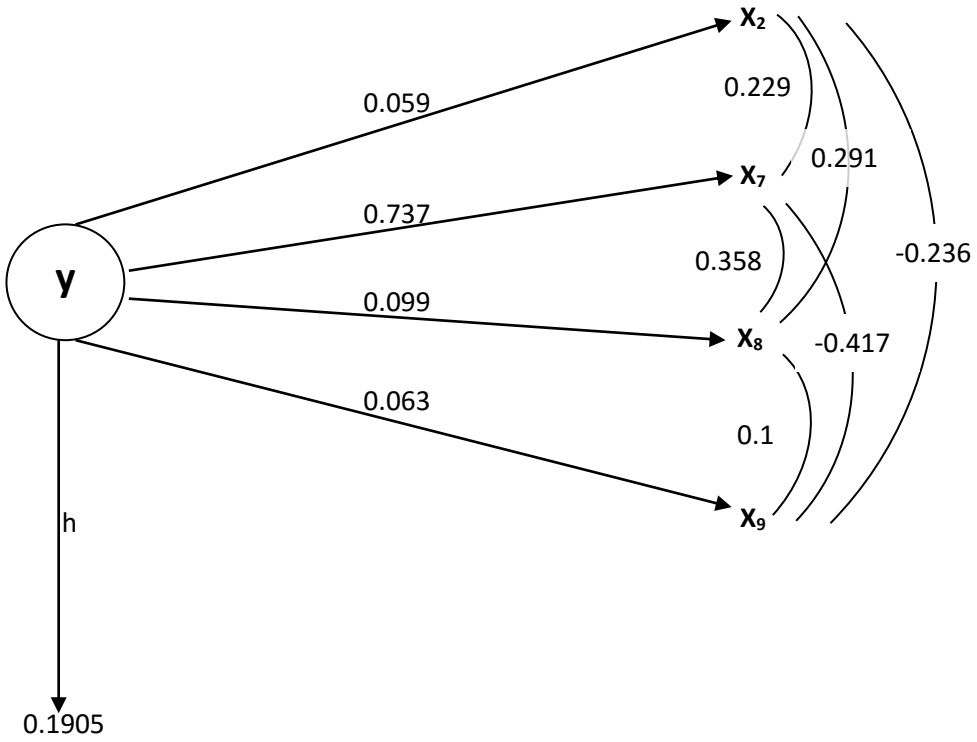
X1-vine length, X2- number of branches per plant, X3- days to first flowering, X4- days to first harvest, X5- days to last harvest, X6- days from flowering to vegetable maturity, X7- total number of harvests, X8- fruit length, X9- fruit girth, X10- average fruit weight,X11- number of fruits per plant, X13- duration of the crop, X14- shelf life in open condition.

Table 9 : Genotypic path coefficient analysis of the various characters on the yield of spine gourd.

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X13	X14	rg
X1	**-0.141**	0.016	-0.037	0.183	-0.648	0.133	-0.366	0.358	0.026	0.050	-0.035	0.018	-0.003	-0.446
X2	-0.042	**0.053**	0.170	0.080	0.222	-0.094	0.366	-0.182	-0.119	0.062	0.282	-0.075	-0.047	0.516*
X3	-0.015	-0.026	**-0.351**	0.060	-0.238	0.031	-0.214	0.165	-0.018	0.064	-0.070	0.080	0.082	-0.448
X4	-0.070	-0.012	-0.058	**0.362**	-0.882	0.063	0.500	0.081	-0.144	0.035	0.017	0.255	0.101	0.247
X5	-0.097	-0.012	-0.088	0.338	**-0.946**	0.095	0.181	0.200	-0.041	0.027	-0.058	0.299	0.089	-0.013
X6	-0.053	-0.014	-0.031	0.063	-0.255	**0.352**	-0.170	0.078	0.120	0.020	-0.241	0.060	-0.097	-0.168
X7	0.055	0.021	0.081	0.194	-0.184	-0.064	**0.931**	-0.154	-0.172	0.036	0.130	0.043	0.110	1.000**
X8	0.123	0.024	0.142	-0.072	0.463	-0.067	0.352	**-0.409**	0.038	-0.022	0.024	-0.086	-0.029	0.481*
X9	-0.010	-0.017	0.017	-0.141	0.105	0.114	-0.433	-0.042	**0.370**	0.077	-0.194	-0.010	-0.058	-0.376
X10	0.034	-0.016	0.108	-0.060	0.122	-0.034	-0.159	-0.044	0.136	**-0.209**	-0.053	-0.015	-0.004	-0.195
X11	-0.017	-0.050	-0.082	-0.021	-0.186	0.285	-0.409	0.033	0.242	-0.037	**-0.297**	0.063	-0.042	-0.318
X13	-0.008	-0.013	-0.092	0.304	-0.931	0.069	0.133	0.115	-0.012	0.011	-0.062	**0.304**	0.048	-0.019
X14	-0.002	0.009	0.105	-0.133	0.306	0.124	-0.371	-0.042	0.078	-0.003	-0.045	-0.053	**-0.276**	-0.261

X1-vine length, X2- number of branches per plant, X3- days to first flowering, X4- days to first harvest, X5- days to last harvest, X6- days from flowering to vegetable maturity, X7- total number of harvests, X8- fruit length, X9- fruit girth, X10- average fruit weight,X11- number of fruits per plant, X13- duration of the crop, X14- shelf life in open condition

Figure 6 : Path diagram



X_2: No. of branches/plant

X_7: Total no. of harvests

X_8: Fruit length

X_9: Fruit girth

Number of days from flowering to vegetable maturity also showed high and direct positive effect on yield (0.352). But its correlation with yield was found to be negative (-0.168). This may be due to the indirect negative effects of days to last harvest (-0.255) and number of fruits per plant (-0.241).

Total number of harvests also showed high positive direct effect on yield (0.931) and also its correlation with yield was significant, positive and high (1.00).

Direct effect of fruit length on yield was negative (-0.409) while fruit girth showed positive effect (0.370). Correlation of fruit length with yield was found to be positive and significant (0.481). This may be due to the high indirect effects of days to last harvest (0.463) and days to first flowering (0.142). Fruit girth showed negative correlation with yield through indirect effects of total number of harvests (-0.433).

Average fruit weight on yield was found to be negative (-0.209) and correlation with yield was also negative (-0.195).

Number of fruits per plant exhibited negative effect on yield (-0.297) through the indirect effects of total number of harvests (-0.409). Genotypic correlation was also negative and significant (-0.5180

Duration of the crop exhibited high positive effect on yield (0.304) through the high positive and indirect effects of days to first harvest (0.304). Its correlation with yield recorded negligible negative effect (-0.019) which may be due to the indirect negative effects of days to last harvest (-0.931).

Shelf life of fruits in open condition showed moderate negative effect on yield (-0.276) and its correlation with yield was also found to be negative (-0.261).

The characters like vine length, number of branches per plant, days to first harvest, days from flowering to vegetable maturity, total number of harvests, fruit length and fruit girth exhibited direct and positive phenotypic effect on yield. In path coefficient analysis the highest positive direct phenotypic effect on yield was exhibited by total number of harvests (0.737) and its phenotypic correlation was also posistive (0.831).

4.2.6 Selection index

Selection index refers to a linear coefficient of characters associated with the dependent variable (Nadarajan and Gunasekaran, 2005). Based on reliable and effective characters, a selection index can help to select suitable genotypes from a mass population (Table 10).

Characters considered for estimation of selection indices were selected based on their phenotypic and genotypic correlations, direct and indirect effects on yield, variability and heritability. Estimation of selection indices involving the characters vine length, number of branches per plant, days to first harvest, total number of harvest, fruit length, fruit girth and number fruits per plant was conducted to identify the superior genotypes.

Based on the selection indices, the accession MD 226 (53.34) was found to be the most superior one followed by the accession MD 227, MD 221 and MD 207. MD 227 was the highest yielding accession with an average fruit yield of 110.06g per plant.

Table 10 : Estimation of selection index spine gourd

Sl. No.	Accession number	Selection index	Rank according to yield	Rank according to selection index
1	MD 226	53.34	2	1
2	MD 227	19.55	1	2
3	MD 221	17.04	5	3
4	MD 207	15.89	3	4
5	MD 195	13.27	4	5
6	MD 228	12.82	10	6
7	MD 231	10.25	7	7
8	MD 178	9.30	8	8
9	MD 216	9.11	14	9
10	MD 166	8.85	12	10
11	MD 222	8.33	11	11
12	MD 183	8.21	16	12
13	MD 215	8.02	9	13
14	MD 160	7.72	13	14
15	MD 153	7.24	15	15
16	MD 161	-6.63	6	16

4.3 Organoleptic evaluation

Five qualities *viz.* appearance, colour, texture, flavor and taste of cooked fruits were assessed in organoleptic evaluation for the sixteen female accessions and is presented in Table 11.

4.3.1 Appearance

The accession MD 161 was more appealing in appearance with a score of 4.00 out of five. The lowest score of 2.25 was recorded for the accession MD 216.

4.3.2 Colour

The score for colour varied between 2.5 and 4. The highest score of 4 was recorded for two accessions, MD 161 and MD 231. The lowest score of 2.5 was recorded for the accession MD 216.

4.3.3 Texture

For texture the highest score recorded was 4.25 for the accession MD 161. The lowest score recoded was 2.5 for the accessions MD 160, MD 216 and MD 222.

4.3.4 Flavour

For flavour the highest score of 4 was recorded for two accessions, MD 161 and MD 178. The lowest score of 2.5 was recorded for the accessions MD 160 and MD 222.

4.3.5 Taste

The accession MD 178 recorded the highest value of 4.6 for taste while the lowest value of 2.25 was recorded for the accession MD 160.

4.3.6 Total

From the total scores obtained for different accessions it could be concluded that MD 161 with the over all score of 20 out of 25 was the most accepted accession. It could also be observed that the least accepted accession was MD 160 with the total score of 12.25 out of 25 .

Table 11: Organoleptic evaluation of spine gourd accessions

Accessions	Characters					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Total**
MD 153	2.8	3.8	3	2.8	3	15.4
MD 160	2.75	3	2.5	2.5	2.25	12.25
MD 161	4	4	4.25	4	3.75	20
MD 166	3	3	3.25	3	2.75	15
MD 178	3.6	3.2	3.8	4	4.6	19.2
MD 183	3	3	3	2.75	2.75	14.5
MD 195	3.6	3.2	2.5	3.8	2.75	15.4
MD 207	3	3.75	3	3.5	3.5	16.75
MD 215	3.75	3.75	4	3.25	3.75	18.5
MD 216	2.25	2.5	2.5	3.6	2.5	13.75
MD 221	3	2.8	2.75	3	3	17.2
MD 222	3.75	3.5	2.5	2.5	2.75	15
MD 226	2.8	4	3	3.75	3.5	15.4
MD 227	3.2	3.4	4	3.2	3.6	17.4
MD 228	2.75	3	3.25	4	3.25	16.25
MD 231	3.4	4	2.8	2.8	3	16

Maximum score : 5

Discussion

5. DISCUSSION

Spine gourd is a perennial and distinctly dioecious crop. In this study there were fifteen male accessions and sixteen female accessions. Very little attempt has been paid for the improvement of this crop. For genetic amelioration of crop plants, the assessment of available genetic variability is a pre- requisite. Large genetic variability in the initial material ensures chances of obtaining desired genotypes.

The present study was planned to estimate variability, heritability, genetic gain, correlation and analysis of association pattern among them. The results are discussed hereunder.

5.1 Genetic cataloguing in spine gourd

Gentic cataloguing of male and female accessions was done separately. From the study it was observed that the plant growth habit included long vining, medium vining and short vining plants. Leaf margin was either trifid or multifid. Flower colour was yellow. Fruit shape ranged from globular, oblong, elliptical or tapering with dense or sparse spines on fruits. The blossom end shape of fruit was either acute or obtuse and fruit skin colour was either dark green, green or light green. Fruits of all accessions expressed mild bitterness. Seediness was either medium or high.

5.2 Variability

Information on variability helps the plant breeder for effective selection of characters for crop improvement. For the male accessions qualitative characters and quantitative characters were recorded up to flowering. There was good variation among the qualitative characters of male accessions. Different accessions recorded very good, good and poor early plant vigour. There was no long viny plants among the male accessions grown for the experiment. This may be due to the raising of crop during the period from October to February. In its natural habitat in the forest and semi forest areas plants sprout from tubers with

the onset of monsoon and during this period they have more vegetative growth. Most of the accessions recorded multifid leaves. The flower colour was uniquely yellow for all accessions. Most of the accessions showed low susceptibility to *Fusarium* wilt and red pumkin beetle while others exhibited medium susceptibility.

Among the quantitative characters of male accessions, the difference in vine length was not significant. In the other characters *viz*., number of branches per plant, days to first flowering and duration of the crop significant variability was present. The accession MD 230 with maximum number of branches per plant also recorded a significantly high duration of the crop.

In the case of female accessions observations were recorded till the end of the crop. A good variability was observed in the qualitative characters pertaining to both plant and fruit.

In the present study, significant differences were observed among the female accessions for characters such as vine length, number of branches per plant, days to first flowering, days to first harvest, days to last harvest, days from flowering to vegetable maturity, total number of harvests, fruit length, fruit girth, average fruit weight, number of fruits per plant, yield per plant and duration of the crop. The accession MD 161 recorded high values for vine length, number of branches per plant, days to first harvest, days to last harvest and duration of the crop. The existence of considerable variation indicates enough scope for crop improvement.

The estimates of genotypic and phenotypic coefficients of variation were high for the characters days from flowering to vegetable maturity, total number of harvests and fruit length suggesting influence of environment and genotype on these characters. This variability can offer scope for selection in breeding for high fruit yield as suggested by Panchbhai *et al.* (2006) in spine gourd.

For all characters, PCV was higher than GCV indicating the high influence of environment on these characters. The medium GCV and PCV values recorded for number of branches per plant, fruit girth and average fruit weight can also be used to make an effective selection. This was also reported by Bharathi *et al.* (2006).

5.3 Heritability

Heritability is a good index of the transmission of characters from parents to offspring (Singh and Narayanan, 2009). The estimates of heritability help the breeder in selection of elite genotypes from diverse genetic population. High heritability of a character indicates low influence of the environment and low heritability indicates that the character can be highly influenced by the environment. If the effect of environment is high, genetic improvement through selection will be difficult due to masking effects of environment on genotypes. Presence of additive gene effect is indicated by high genetic advance and genetic gain.

In the present study high heritability was observed for the characters, days to first flowering, days to first harvest, days to last harvest, days from flowering to vegetable maturity, total number of harvests, fruit length, fruit girth, average fruit weight, yield per plant and duration of the crop. Most of the characters are having high heritability. This indicated that these characters were least influenced by the environment. This was also reported by Johnson *et al*, (1955) and Bharathi *et al.* (2005).

The value of genetic advance indicates the expected genetic progress for a particular trait under a suitable selection system. The genetic gain that could be expected by selection for a character provides the estimates of genetic advance and expressed as per cent of mean. In the present study high genetic gain was recorded for the characters days from flowering to vegetable maturity, total number of harvests, fruit length, fruit girth, average fruit weight, number of fruits

per plant and shelf life in open condition. This was also reported by Chaudhari *et al.* (1991) in bitter gourd.

Heritability with genetic gain is of more precise in predicting the effect of selection than the former alone. The estimates of heritability were high and coupled with high genetic gain for days from flowering to vegetable maturity (98.4%, 43.17%), total number of harvests (82.2%, 53.16%), fruit length (98.9% 59.58%), fruit girth (98.9%, 25.73%) and average fruit weight (92.2%, 21.60%). High heritability coupled with high genetic gain indicates prevalent role of additive gene effect. High heritability coupled with high genetic advance was recorded for fruit weight, fruit volume and number of fruits per plant in spine gourd by Bharathi *et al*. (2006). The high heritability coupled with high genetic gain is also supported by the studies in bitter gourd by Chaudhari *et al*. (1991), Kutty and Dharmatti (2004a), Devmore *et al*, (2010) and Dey *et al.* (2009).

According to Burton (1952), GCV along with heritability estimates would give a better idea about the efficiency of selection as the latter measures the proportion of the variability of a character that is transmitted to the progeny. High GCV and PCV values coupled with high heritability and genetic gain were recorded for the characters like total number of harvests, fruit length and fruit girth. This was in accordance with the findings of Dey *et al.* (2009) and Devmore *et al.* (2010) in bitter gourd.

High heritability along with low GCV and PCV values were recorded in characters like days to first flowering, days to first harvest, days to last harvest, yield per plant and duration of the crop which implied that these characters are less effective in selection since they are controlled by non additive genes.

5.4 Correlation

Yield is a complex character contributed by many mutually related components. Hence information on the magnitude of relationship of individual yield components to the final yield and relationship among themselves would play

a vital role for the identification of characters which would influence the economic traits (Nadarajan and Gunasekaran, 2005). Simultaneous increase of yield and its component characters is possible only with a thorough knowledge of the direction of the interaction of these component traits with yield.

In the present investigation, yield was significant and has got positive correlation with total number of harvests (rg=1.00, rp= 0.831). This indicates the importance of this trait in determining the yield since it has a direct inherent effect on yield.

The genotypic correlation coefficient of vine length, number of branches per plant, days to first harvest, total number of harvests, fruit length and duration of the crop were higher than the phenotypic correlation coefficient. This indicates the direct influence of these characters with yield. The low phenotypic correlation coefficient indicates the less effect of environment on yield. This was also supported by the reports of Paranjape and Rajput, (1995) in bitter gourd.

5.5 Path coefficient analysis

Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficients into the measure of direct and indirect effects. It measures the direct and indirect contribution of various independed characters on a dependent character (Singh and Narayanan, 2009).

In the present study on partitioning of the coefficients into direct and indirect effects, it was observed that maximum positive direct effect on yield was exhibited by total number of harvests (0.931) followed by fruit girth, days to first harvest, days from flowering to vegetable maturity, duration of the crop and number of branches per plant. This reveals the direct relationship between these characters and yield. Hence these characters can be considered for selection in yield improvement programmes.

Even though number of days from flowering to vegetable maturity, fruit girth and duration of the crop showed high and direct positive effect on yield,

their correlation with yield was found to be negative. In such situation, direct selection for the trait should be practised to reduce the undesirable indirect effects.

5.6 Selection index

Selection index helps to select the best suitable genotypes from germplasm based on minimum number of reliable and effective characters.

In this study selection index was worked out using the characters vine length, number of branches per plant, total number of harvests, fruit length, fruit girth and number of fruits per plant since they were observed to have the maximum efficiency compared to direct selection based on yield alone.

Ranking based on the selection index showed MD 226 as the most superior one followed by MD 227 and MD 221. The superiority of these genotypes can be considered as stable and reliable since the selection index value was calculated considering other yield contributing factors.

The accession MD 227 was found to be the best performer with an average yield of 110.06g followed by MD 226 and MD 207 with average yield of 105.91g and 105.50g respectively.

Thus the study revealed the accessions MD 227, MD 226 and MD 207 as the most promising ones with respect to yield and other important economic characters.

5.7 Organoleptic evaluation

In the organoleptic evaluation MD161with total score of 20 was found to be the most accepted one. In the qualitative and quantitative characters also MD 161 was found to have reasonably good performance. So MD 161 can be suggested as a promising accession from the point of view of its organoleptic acceptance.

Summary

6. SUMMARY

The present study on "Performance evaluation and variability studies in spine gourd (*Momordica dioica Roxb*.)" was carried out in the Deprtment of Olericulture, College of Horticulture, Vellanikkara, during October 2011 – February 2012.

The programme envisaged catalouging of available germplasm, assessment of genetic variability, assessment of association of different traits with yield including the direct and indirect effects of traits on yield and formulation of a selection index to identify superior genotypes. The experiment was laid out in RBD with two replications and the experimental material consisted of 31 (15 male and 16 female) accessions collected from different parts of Kerala and Western Ghats.

The salient findings of the study are summarized below:

- Thirty one genotypes were catalouged based on the descriptor for bitter gourd (*Momordica charantia*) in the absence of specific descriptor for spine gourd (*Momordica dioica Roxb*.).
- The accessions showed significant differences for the characters studied *viz.* early plant vigour, plant growth habit, leaf margin, biotic stress susceptibility, number of branches per plant, days to flowering and duration of the crop for male accessions and early plant vigour, plant growth habit, leaf margin, biotic stress susceptibility, fruit shape, nature of spines, blossom end fruit shape, fruit skin colour, seediness, biotic stress susceptibility, number of branches per plant, days to flowering, days to first harvest, days to last harvest, days from flowering to vegetable maturity, total number of harvests, fruit length, fruit girth, average fruit weight, number of fruits per plant, yield per plant and duration of the crop for female accessions.

- The accession MD 227 was found to be the best performer with an average yield of 110.063g per plant followed by MD 226 and MD 207 with average yield of 105.917 and 105.500 g per plant respectively.
- Total number of harvests was highest for the accession MD 227 (6.00) while the duration of the crop was the highest for the accession MD 161(118 days).
- The genotypic coefficient of variation was the highest for fruit length (29.09) and phenotypic coefficient was the highest for total number of harvests (31.42).
- The heritability estimate was the highest (98.9) for fruit length and fruit girth.
- Correlation studies revealed that yield had got significant and positive genotypic association with number of branches per pant, total number of harvests and fruit length.
- Results of path coefficient analysis revealed that the highest positive direct effect on yield was exhibited by total number of harvests, followed by fruit girth , days to first harvest , days from flowering to vegetable maturity, duration of the crop and number of branches per plant.
- A selection index was formulated using the characters vine length, number of branches per plant, days to first harvest, total number of harvests, fruit length, fruit girth and number fruits per plant. Based on the selection indices, the accession MD 226 (53.3412) was found to be the most superior one followed by the accession MD 227, MD 221 and MD 207. MD 227 was the highest yielding accession with an average yield of 110.063g per plant.
- From the organoleptic evaluation the accession MD 161 with a total score of 20 was the most accepted one followed by MD 160 with total score of 12.25 out of 25.

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Annexures

Appendix 1. Meteorological data (mean monthly during 2011).

Source: College of Horticulture , Vellanikkara.

Month and year	**Temperature (^{o}C)**		**Mean relative humidity (%)**	**Ranfall (mm)**	**Sun shine hours (hrs)**
	Maximum	**Minimum**			
August 2011	32.0	20.4	96	713.8	68.7
September 2011	32.0	22.3	94	435.2	131.9
October 2011	33.8	22.0	91	193.0	190.4
November 2011	32.8	18.4	79	240.0	188.9
December 2011	33.6	17.4	75	2.4	226.6
January 2012	34.3	17.3	75	0.0	294.0
February 2012	37.1	18.9	75	0.0	265.4

Appendix 2. Analysis of varience in 15 male accessions of spine gourd

Source of variation	df	Mean squares			
1	2	3	4	5	6
		Vine length (m)	Number of branches per plant	Days to first flower opening	Duration of the crop
Replication	1	0.021	0.133	0.300	4.033
Treatment	14	0.053	5.380	28.012	32.321
Error	14	0.026	1.151	2.121	8.962

Appendix 2. Analysis of varience in 16 female accessions of spine gourd

Source of variation	df	Mean squares													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Vine len	Number of	Days to	Days to	Days to	Days fro	Total nu	Fruit len	Fruit girt	Average fruit	Number	Yield per plant	Duration of the crops	Shelf life in open
Replication	1	0.027	0.500	0.211	2.00	6.125	0.013	0.013	0.023	0.006	0.198	3.781	0.622	2.531	0.000
Treatment	15	0.716	4.800	13.418	93.117	100.031	3.831	2.700	7.290	1.016	0.939	8.031	49.127	93.415	0.525
Error	15	0.441	1.733	2.917	20.583	16.275	0.031	0.265	0.039	0.006	0.039	3.031	7.380	18.665	0.000

PERFORMANCE EVALUATION AND VARIABILITY STUDIES IN SPINE GOURD (*Momordica dioica* Roxb.)

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The experiment entitled "Performance evaluation and variability studies in spine gourd (*Momordica dioica Roxb*.)" was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara, during October 2011 – February 2012. The major objective of the study was to identify superior spine gourd genotypes with high yield. The other objectives were to genetically catalogue the germplasm and to assess genetic variability, heritability, genetic gain and correlation of different traits with yield. Thirty one accessions of spine gourd collected from different parts of Kerala were grown in randomized block design with two replications.

Cataloguing of germplasm exhibited significant differences for all characters studied *viz*., early plant vigour, plant growth habit, leaf margin and flower colour in both male and female accessions, and also fruit shape, nature of spines, blossom end fruit shape, fruit skin colour, fruit bitterness and seediness in female accessions. The quantitative characters studied were vine length, number of branches per plant, days to first flower opening and duration of the crop in both male and female accessions, and also days to first harvest, days to last harvest, days from flowering to vegetable maturity, total number of harvests, fruit length, fruit girth, average fruit weight, number of fruits per plant, yield per plant, duration of the crop and shelf life in open condition in female accessions. Among these all the characters showed significant difference between the accessions except vine length.

From the experiment it could be concluded that the highest yielding accession was MD 227 with an average yield of 110.06 g per plant. The same accession recorded the highest value for total number of fruits per plant (18.25) and total number of harvests (6.0).

High genotypic and phenotypic coefficient of variation was observed for days from flowering to vegetable maturity, total number of harvests and fruit length.

Yield exhibited genotypic correlation with number of branches per plant, total number of harvests, fruit length and number of fruits per plant.

In path coefficient analysis the highest positive direct effect on yield was exhibited by total number of harvests followed by fruit girth.

Based on the selection indices, the accession MD 226 was found to be the most superior one followed by the accession MD 227, MD221 and MD 207.

In the organoleptic evaluation the accession MD 161 with the total score of 20 out of 25 was the most accepted one.