GROWTH, YIELD, QUALITY AND CROSSABILITY STUDY IN

Momordica cochinchinensis Spreng.

&

Momordica dioica Roxb.

A THESIS SUBMITTED TO
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR

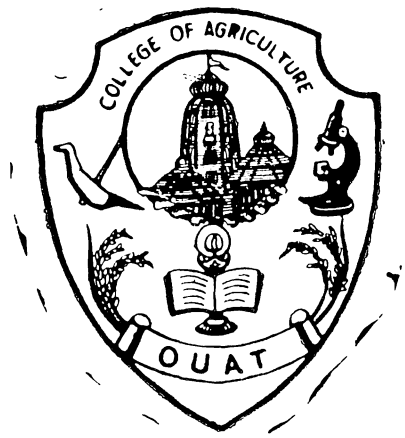
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(HORTICULTURE)

By

Chittaranjan Mohanty

Junior Fellow I. C. A. R.



DEPARTMENT OF HORTICULTURE

COLLEGE OF AGRICULTURE

BHUBANESWAR

1985

THESIS ADVISOR : T. MAHARANA

IN LOVING MEMORY
OF
MY BELOVED SISTER
SHAILABALA
(30.3.61 - 25.11.84)

GROWTH, YIELD, QUALITY AND CROSSABILITY STUDY IN *MOMORDICA COCHINCHINENSIS* SPRENG AND *MOMORDICA DIOICA* ROXB.

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This is to certify that, the thesis entitled " Growth, yield, quality and crossability study in Hemerdion cochinchinensis Spreng. and Hemerdion dioica Roxb." submitted in partial fulfilment of the requirements for the award of the DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (HORTICULTURE) of the Orissa University of Agriculture and Technology, Bhubaneswar, is a faithful record of bonafide research work carried out by Sri Chittaranjan Mohanty under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in any other form.

It is further certified that such help or source of information as has been availed during the course of investigation has been duly acknowledged by him.

17/7/96

(Trinath Maharana)

ACKNOWLEDGEMENT

I have the privilege to place my profound sense of gratitude and idebtness to Sri T. Maharana, Reader, Department of Horticulture, College of Agriculture, Bhubaneswar for his scholastic guidance, constant supervision, encouraging suggestions, constructive criticisms and painstaking efforts throughout the period of investigation and preparation of this manuscript.

I am grateful to Prof. G.C. Das, M.S.(Missouri), Head of the Department of Horticulture for providing necessary facilities without which, the work could not have been completed.

I am also grateful to Dr. N.C. Pattanaik, Prof. and Head, Department of Seed Technology for his valuable suggestions during the course of investigation.

I duly acknowledge the help of Mr. A.K. Das, Junior Agronomist, Vegetable Improvement Project and Mr. P. Mohapatra, Senior Scientist (Horticulture), Regional Research Station, Keonjhar for their help and encouragement during my preparation for I.C.A.R. Junior fellowship Examination. In this respect the role of my co-room mate Mr. B. C. Khanda is note worthy.

Words run short to express my profound sense of gratitude and indebtness to my . . . friends Santosh and Chandramani.

Special thanks to Mahendra, Bharat, Nityananda, Deo, Amarnath, Santosh, Sashi and Ananta for their help and cooperation at the cost of their study.

I am very much thankful to my departmental friends specially Manoranjan, Sunanta, Bhisir and Lingaraj and obliged to the staff members of the Department for their voluntary help at the time of need.

I sincerely acknowledge the financial assistance in the shape of Junior Research fellowship, awarded by the I.C.A.R., New Delhi during the post-graduate study.

Lastly I set down my gratitude to my parents, elder brothers (especially Bhupa Bhai) and brother-in-law (Ajaya Bhai) for their selfless sacrifice and dedication in the evolution of this personality.

Bhubaneswar
Dated the 17th July, 1986.

Chittaranjan Mohanty
(Chittaranjan Mohanty)

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ABBREVIATION

1.	Sig.	Significant.
2.	N.S.	Non-significant
3.	C.D.	Critical difference.
4.	S.E.(m)	Standard error of mean.

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CHAPTER-I
INTRODUCTION

INTRODUCTION

Cucurbitaceous plants are known to mankind since the early days of civilization. Many of them are used as important food items and specially as vegetable. Genus Momordica comprises of a small group of plants in a family of 90 genera and 700 species. This genus has nearly 23 species in Africa alone (Jeffrey 1967). The cultivated species are Momordica charantia (Bittergourd), Momordica cochinchinensis (sweet gourd), Momordica dioica (spine gourd), Momordica balsamina (balsamapple) and Momordica tuberosa. This genus is essentially a native of tropical regions of Asia with extensive distribution in India, China, South-East Asia and tropical Africa. The higher chromosome number in M. dioica (2n = 28) compared to M. charantia & M. balsamina (2n = 22) is suggested to be due to duplication rather than fragmentation. Natural polyploids (2n = 56) have been recorded in M. dioica. Interspecific hybridisation among Momordica species has been attempted by Roy et al. (1966). The crosses between M. dioica and M. charantia are unsuccessful and also between M. dioica and M. balsamina. Dutchie (1973) has given key to different species of Momordica (Table 1).

Table 1

KEY TO THE DIFFERENT SPECIES OF GENUS MOMORDICA

(J.F. Hutchie 1973)

A. Flowers monoecious :

AA. Bract of male flower attached to the middle or towards the base of the peduncle .....1. *Momordica charantia*

AAA. Bract of the male flower attached at the apex of the peduncle .....2. *Momordica balsamina*.

B. Flower dioecious :

BB. Petals yellow .....3. *Momordica dioica*.

BBB. Petals white .....4. *Momordica cochinchinensis*.

The fruits of *Momordica dioica* and *M. cochinchinensis* are considered as table delicacy. Both meat and seeds are very palatable and nutritious. These two species contain a good amount of carotenoid pigments in their ripe fruits. The most significant thing observed in *M. dioica* is that it contains exceptionally high protein (3.1%) which is considered to be highest among all cucurbitaceous fruits (Table-2).

Table 2 : Food value of five important cucurbits (per 100 gm.)

Name of the food stuff.	"Sweet gourd" Momordica cochinchinensis.	Spine gourd Momordica Moica	Bitter gourd Momordica charantia	Parval Trichosanthes dioica	Pumpkin Cucurbita moschata.
Edible portion	100	100	97	95	79
Moisture in gms.	90.4	84.1	92.0	92.0	92.6
Protein in gms.	0.6	3.1	1.6	2.0	1.4
Fat in gms.	0.1	1.0	0.2	0.3	0.1
Minerals in gms.	0.9	1.1	0.8	0.5	0.6
Carbohydrate in gms	6.4	7.7	4.2	2.2	4.6
Energy in kcal.	29	52	25	20	25
Calcium in gms.	27	33	20	30	10
Phosphorus in mg.	38	42	70	40	30
Carotene in mg	-	1620	126	153	50
Thiamine in mg.	-	0.05	0.07	0.05	0.06
Riboflavin in mg.	-	0.18	0.09	0.06	0.04
Niacin in mg	-	0.6	0.5	0.5	0.05
Iron in mg	-	4.6	1.8	1.7	0.7
Fibre in gms.	1.6	3.0	0.8	3.0	0.7

Gopalan, C; Sastri, B.V.R.; Balasubramaniam, S.C.; Nutritive value of Indian foods, ICMR; National Institute of Nutrition, Hydrabad, India, 1971.

The fruits of M. dioica are very popular in Orissa. But the crop is found in wild or semi-nesticated condition, as a result, fruits are available for a short period and sold at high price. The other species M. cochinchinensis has been brought from North-Eastern region of India and being tried for last two years. M. cochinchinensis occupies the same position as a food item in North-Eastern region as M. dioica in Orissa. There are striking differences in these two species in growth, flower biology and yield. In previous two years some of these aspects have been studied (Table 3).

In the present investigation efforts have been made to study these two crops in detail and scientifically in respect of growth, flower biology, yield, quality and crossability. The ultimate objective is to combine the useful characters of these two species for greater adaptability and domestication.

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Table 3. : Comparision of characters of 2 species of genus Momordica.

Characters	M. cochinchinensis	M. dioica.
1. Dormancy (Seed & Tuber)	Short dormancy	Long dormancy
2. Tuber	Tubers are nodular & give new plants at different points around the plant.	All the plants arise from a single tuber & from terminal points.
3. Growth habit	Vegetative growth leaf area and other characters are in higher side.	Vegetative growt and many other characters in lower side.
4. Anthesis	Morning hours	Evening hours
5. Fruiting period	Longer fruiting period.	Shorter fruiting period.
6. Fruit	Fruits are large with long stalk.	Fruits are small with short stalk
7. Seed	Flat	Round
	Seed coat semi-hard and crack easily like bitter gourd seeds.	Seed coat is har and crack with sound.
8. Pest attack	Tolerant to epilachna beetle.	Very susceptable to epilachna beetle

CHAPTER-II
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Among minor cucurbits, spine gourd and sweet gourd under genus Momordica are considered as rare table delicacy. These are found under wild and semi-domesticated condition in many parts of India. These plants creat a greater interest among scientists & field workers because of their high food value. It has not been very much popularised as a profiteering crop under field condition because of dioecism. Attempts have been made to investigate these crops thoroughly but the success has been achieved to a limited extent. In past two years some work has been done in the Department of Horticulture, O.U.A.T. to improve these two minor crops. In continuation to previous work crossability is being tried in the present investigation. This chapter contains upto date relevant literature collected on different aspects of the genus Momordica of Cucurbitaceae family comprises of 4 important cultivated species. Reviews available on all species are presented here for interpretation of results.

Distribution :

Roli (1969) suggested that bitter-gourd is a favourite in Kerala state. Distribution and

economic uses of Momordica dioica was reported in wealth of India Raw materials. Mishra and Sahoo (1963) suggested that the wild form of Momordica dioica (diploid) are cultivated in a large scale in states like Bihar, Maharastra, Rajasthan and the tetraploid form in Assam.

Taxonomy :

Chakravarty and Nora (1979) suggested that, the seed structure has a role in classification of cucurbits and a description of Momordica charantia was made by them. A comparative quantitative differences in anatomical structure of the pericarp of the Momordica charantia was studied by Matienko (1964). Hutchie (1973) described the classification of genus Momordica including the taxonomic description of Momordica dioica Roxb. A taxonomic description and classification of Momordica genus including Momordica dioica Roxb. was made by Haines (1961).

Floral Biology :

Vijay, Jalikop and Nath (1977) reported that, flowers in Momordica cochinchinensis Spreng. was borne in plants during June to November and male and female flowers require 22-24 and 19-22 days

respectively from bud initiation to full bloom stage. Anthesis for male and female flowers were at 5.30 and 6.20 A.M. respectively and continued until 7.30 A.M. Anther dehiscence started at 10.45 P.M. and completed at mid night and stigma was receptive for 18 hours before and after anthesis. Pattanaik and Pattanaik (1976) reported that flowering in Momordica cochinchinensis Sprang. Occured on node 9-28 on primary stem node 1-17 on secondary branches and node one onwards on tertiary branches. A sex ratio of 1 : 1 was recorded. The last week of August and the first week of September were the peak flowering periods of male and female plants respectively. The period from planting to flowering was about 30 days for female plants and 43 days for male plants and the period of bud initiation to flowering being 13 days in pistillate flowers. The duration of bud break to full opening was 36 minute in pistillate and 33 minutes in staminate flowers. Anthesis occured between 6.30 hours and 8 - 9 hours. Sahoo and Maharana (1994) reported that the male flowers appeared in a range of 42-70 cm height in M. dioica, 63-117 cm height in M. cochinchinensis where as female flowers produced at a height of 45 - 90cm in M. dioica and 73-125 cm in M. cochinchinensis. Development of male flowers took 17-21 days in M.dioica and 20-23 days in M. cochinchinensis. As regard to female flower M. dioica took 14-18 days and

M. cochinchinensis 13-22 days for development of flower. They also reported the time taken for full opening of flower in both the species. Male flower of M. cochinchinensis took more than 1 hours where as M. dioica took only 12-22 minutes. A similar trend was observed for female flowers. M. dioica took 7-10 minutes where as M. cochinchinensis took 2.10 to 2.20 hours.

Sex ratio and expression :

Vijay (1973) reported 48.7% female 51.3% male in seed raised plants and sex ratio for commercial planting to be 1:9 (male : female) in case of M. cochinchinensis. Sahu and Maharana (1994) reported the male and female sex ratio to be 43:32 and 57:43 in case of M. cochinchinensis and M. dioica respectively.

Biseria (1974) conducted a study on Momordica charantia and revealed that sex expression was greately increased by 1, 10 or 100 ppm Alpha-NAA by increasing female flower per plant and found male and female flower ratio to be 25.5:1 and 5:1 in untreated plants and treated plants respectively. Ghose and Bose (1972) suggested that B_9 is an effective growth retardant for sex modification in M. charantia. According to study made by Kaushik and Sharma (1975) gamma irradiation

of seeds at 100 - 500 rad. decreased the staminate flowers in M. charantia.

Seed characters :

Sahoo and Maharana (1984) studied different Momordica species and reported that individual seed weight in gm. seed coat weight in percentage, cotyledon weight in percentage and oil content of seed in percentage were found to be 0.104, 45.2, 54.3 and 24.2 respectively in case of Momordica dioica and 0.133, 40.8, 59.2 and 25.4 in case of Momordica cochinchinensis.

Dormacy of seed and Tuber :

Sahoo and Maharana (1984) studied the seed dormancy and tuber dormancy of three Momordica species and found the seed dormancy of 71 days, 26 days and 16 days in M. dioica, M. cochinchinensis and M. charantia respectively. As regards to tuber dormancy 74 days was observed in M. dioica and 28 days in M. cochinchinensis.

Use and quality of fruits and seeds :

Boekenoogen (1948) reported that the deep red layer of pulp surrounding the seed in fruit of Momordica cochinchinensis contain only a small quantity of carotene. Maurya (1976) reported that Momordica

cochinchinensis fruits have high protein and vitamin 'C' content and greater proportion of edible flesh than Momordica charantia. Sadhu and Chakraberty (1930) reported that the young fruits of Momordica cochinchinensis contains 2.61 percent protein, 0.65 per cent fat, 5.6 per cent carbohydrate and 1.02 per cent minerals. They also reported that the vitamin 'C' content of fruit to be of 240 mg/100 gm. of edible part.

Maharana and Maharana (1983) reported that the average number of seeds per fruit in Momordica dioica varies from 10.3 to 40.4. Sahoo and Maharana (1984) reported that the number of seeds per fruit, Vitamin 'C' content (in mg per 100 gm of edible part) and dry matter content of fruit to be 13.5, 112.6 and 14.8 in case of Momordica dioica and 27.5, 340.0 and 16.9 respectively in case of Momordica cochinchinensis. They also found the seed to fruit ratio to be 1:2.8 and 1:3.1 in M. dioica and M. cochinchinensis respectively.

Chisholm and Hopkins (1964) reported that, a variety of Momordica charantia contains 67.1 of Alpha-eleostearic acid. A study conducted by Iyer, Nagar and Kircar (1981) reveals that immature Momordica charantia seeds contain two cytokinins identified as zeatin and Riboside. They also reported that, the fleshy tissue surrounding the seeds has less growth promoting

activities than that of the seed tissues. Kedar and Chakravarty (1982) reported that powdered seed of Momordica charantia can be used for treating diabetes and can be compared with standard diabetes drug called Glibenchamide.

Chakravarty et al.(1956) studied the seeds of Cucurbitaceae family and found an oil comprising of 33.5% of Kernel or 22% of seed in Momordica dioica. He also reported 27.1% saturated acids, 9.2% oleic acid, 8.8% linoleic acids and 54.9% of conjugated trienes to be the constituent of oil.

Propagation :

Propagation of Momordica dioica through cutting method was reported by Das, Lanka, Patra and Das (1979). Sahoo and Maharana (1984) observed 23%, 50%, 80% and 73.5% of rooting of cuttings in Momordica charantia, Momordica dioica and Momordica cochinchinensis respectively.

Effect of growth substances :

A study conducted by Sankhla (1971) revealed that morphactin treated Momordica charantia plant was short and bushy with partial suppression in tendril formation. With increasing concentration,

tendril development was prevented and leaf morphology was affected. According to Ravindran (1971), Ethrel in Momordica charantia induced growth retardation and pollens sterility in the proportion of dose applied. Mangal, Pandita and Singh (1981) suggested that 4 - CPA treated plants were tall and produced female flowers earlier but yields were high with cycocel treated plants. Sadhbhi (1976) reported that single or repeated Ethephon (CEPA) treated plants exhibited retarded growth, lower number of male and female flowers and delay in their appearance.

Prasad and Tyagi (1963) reported that MH treated Momordica charantia plants exhibited increase in the proportion of female to male flowers (1 : 6.9) production. Repeated sprays at high concentration retarded growth and lowered the number of male and female flowers. According to Ghose and Bose (1970), the pistillate flower production was adversely affected by application of cycocel in high concentration to Momordica charantia.

Ghose and Bose (1982), reported increased female flowers production by GA and MH applications in Momordica charantia and cycocel at lower concentration increased male to female ratio. Prakash (1976) reported

NAA, Ethrel and Morphactin treatment increased the ratio of pistillate to staminate flowers in M. charantia where as, G.A. and ABA vernalization have got opposite effects.

Agronomic practices :

Desai and others (1966) reported increased yield of Momordica charantia for two consequitive years with nitrogen application and no significant difference in yield was observed afterwards. But phosphate increased the yield significantly for one year only and potassium reduced the yield slightly. No interaction was observed between N.P and K. Catedral, Manilyle (1978) suggested that the total fruit and seed yield of Momordica charantia (cv. Nueva Ecija) were increased by almost 50%, when spacing was reduced from 1 X 1 m to 1 X 0.5m., although 50% fruit and seed size and the number of seeds/fruit decreased. As compared with natural pollination, hand pollination increased the seeds per fruit by 17% in self pollinated (fruit and 30% in cross pollinated fruit. Cross pollination also increased the percentage of large fruit.

Crossability and crop improvement :

A natural polyploidy study by Agrawal and Roy (1976) on Momordica dioica Roxb. revealed that

the different vegetative and floral parts of naturally occuring triploid male plant were intermediate between those of diploids and natural triploids. Parija (1967) reported xenocarpy when Momordica dioica Roxb. flowers were pollinated with pollens of Luffa acutangula. The growth of ovary was stopped and it shrivelled after 15 days. Mishra and Sahu (1983) reported that the Momordica dioica is diploid with a chromosome number of 2n = 28. The flowers of tetraploid open in the morning and those of diploid at night. Triploids derived from crossing are morphologicallly intermediate between two parents. Meiosis was irregular in the triploid. The pollen fertility was 38.7% without any fruit set in triploids. Colchicine treated monoecious diploid Momordica charantia resulted in the appearance of gynoecious, andromonoecious and trimonoecious forms. Kadir and Zahoo (1965) observed colchiploidy in Momordica charantia and suggested that the colchicine treated plant produced tetraploids with a reduced fertility but with fleshy fruits. Singh, Srivastava and Prasad (1977) studied that the yield, fruit number per plant and fruit length of bitter gourd have high genetic co-efficent of variation, high estimates of heritability and expected genetic advance.

Mehetre and Thombre (1939) conducted the meiotic studied in Momordica cymbalaria and reported that aneuploidy has importance in the evolution of Momordica. Vanjari and Phadnis (1971) studied the flowering behaviour of colchicine induced autotetraploids in cucurbits. The tetraploids of Momordica charantia has fewer larger flowers and flowered later than diploids. Trivedi and Roy (1973) revealed that the colchicine induced tetraploid of Momordica charantia crossed reciprocally with diploid Momordica charantia. The number of fertile seeds derived from reciprocal crossed were low. The triploid hybrids derived from the crosses were vigorous in growth. Lal and Seth and Solanki (1976) observed in Momordica charantia for vegetative growth, floral characters and fruit yield in only successful crosses viz. Green local X White local and Green local X Bundel hand local.

Sahoo and Maharana (1984) reported interspecific crossing of genus Momordica. They noticed 8% success when M. cochinchinensis was crossed with pollen of M. dioica and 70% success in reciprocal crosses and in other crosses involving M. charantia as pollen parent or female parent no fruit set was observed. Pollens of M. dioica produced fruits in M. cochinchinensis with abnormal shape and smaller size.

Metaxenia :

Freytag (1979) reported metaxenia effect on the pod size development in common bean and found increased pod weight upto two times than normal. Xenia and Metaxenia effects in date palm have also been reported (Stancevic 1971, Osman et al. 1979, Kin et al. 1979, Shafaat and Shabana 1980, Khalifa 1980). Copra contact of coconut is increased in coconut cv. Cameroon Red dwarf by the pollinating with pollen of West Cost Tall (Bognon et al.1976). Dalta and Chauhan (1984) reported metaxenia effect on grape and strawberry and found Perlette as the best pollinzer for improving fruit size and weight in variety Foster's Seedless and Khatta Kurghan.

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CHAPTER-III
MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled " Growth, yield, quality and crossability study in Momordica cochinchinensis Spreng. and Momordica dioica Roxb.," was carried out in the department of of Horticulture of Orissa University of Agriculture and Technology during the year 1995-96 with following objectives.

(1) To study the growth, yield and quality (2) to study the flower biology (3) to test the crossability and priliminary evaluation of crosses. The materials and methods employed and used in this investigation are described below :

Meteorological information (Table 4) :

The Regional Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar is situated at 20° 15' North latitude and 85° 52' East longitude at an elevation of 25.9 meters above the mean sea level. It is situated 25 Km West of Bay of Bengal with warm and moist climate, having hot humid summer and mild winter. Hence, the locality is under moist and hot climatic group. Meteorological informations pertaining to investigation from May, 1995 to May 1996 are presented below :

Table 4 : Monthly meteorological data from May, 1985 to May, 1986 .

Months	Temperature in °C			Relative humidity in %			Rainfall in m.m.	No. of rainy days	Sun-shine hours.
	Max.	Min.	Mean	Morn.	Aft.noon	Mean			
1985									
May	37.0	22.6	31.8	79	54	66	28.3	6	9.3
June	36.1	26.4	31.2	79	59	69	147.6	17	5.8
July	31.7	25.2	28.4	91	77	84	399.7	22	3.3
August	31.3	25.4	28.3	93	78	85	402.7	27	4.2
September	31.4	25.2	28.3	92	80	86	343.0	28	4.3
October	31.3	21.7	26.5	90	68	79	220.8	13	9.3
November	30.7	17.9	24.3	94	40	62	--	--	9.1
December	29.8	15.2	22.5	89	37	63	--	--	9.2
1986									
January	27.7	15.3	21.5	87	39	63	32.0	2	8.6
February	31.2	20.2	25.2	92	43	67	27.5	3	8.7
March	35.4	27.0	28.7	90	36	63	6.6	2	9.3
April	35.9	24.8	30.3	80	59	70	55.6	5	9.3
May	35.5	25.3	30.4	86	58	72	67.7	8	8.9

(Courtesy of Meteorological Observatory, University Research Station, Bhubaneswar).

Soil and composition :

Soil samples were collected at random from garden and the mechanical and chemical analysis of the composite samples were conducted and results are presented in Table 5 (a) and (b).

Table 5 (a) Mechnical analysis of the soil.

Particulars	Percentage of composition	Method followed
1. Coarse sand	44.24	Bouyoucos Hydrometer (Buloucos, 1962)
2. Fine sand	27.05	-do-
3. Silt	11.35	-do-
4. Clay	16.96	-do-
5. Textural class	Sandy loam	

Table 5(b) : Chemical analysis of the soil :

Particulars	% of composition.	Standard method used in determination
1. Total N_2	0.075	Kjeldahl's Method (Jackson, 1962)
2. Available P.	0.00125	Bray's Method (Bray, 1948)
3. Available K.	0.00363	Morgan's Method (Jackson, 1962)
4. Organic carbon	0.6045	Walkley & Black's rapid titration method (Walkley & Black, 1934)
5. C/N ratio	10.4	—
6. p^H	6.4	Beckman's p^H meter. (Piper, 1950)

Source of planting materials :

The plant materials used in this investigation were from two sources (i) plants produced from the tubers of previous crops and (ii) plants obtained from the specific male and female plants, propagated through cuttings and planted in pots.

The plants of *D. cochinchinensis* and *D. dioica* were grown in pots for the purpose of investigation during 1934-35. These plants were planted in the field during February, 1935. After the summer showers of rain, the plants of both species sprouted by first week of May and stakings were provided and plants were maintained at a height of 1.5 mt. Each plant was dressed with 6 gm of N_2, 6 gm of P_2O_5 and 6 gm of K_2O alongwith 2 kg of FYM. The nitrogen was given in two splits, one at one month after sprouting and another at 2 months stage. Thiodan was sprayed at 15 days interval to keep the plants free from insect pests especially epilachna beetle. Altogether 50 plants were maintained under each species. Biometric and other observations were recorded from these plants. For conducting crossability test male and female plants of both species were collected from identified plant marked in the previous season. Comparable terminal cuttings were collected in 1st week of May and treated

with Seradix B_1 and planted in seed pans in sand medium. By the 1st week of June the rooted cuttings were planted in 30 cm pots containing a soil mixture of 2:1:1 of soil, sand and compost. After planting they were shaded for 3-4 days with leaves. The planting was as follows :

Table 5(c) : Planting of plant materials

Name of the species.		Number of plants for general study.	Number of plants for crossability study.
M. cochinchinensis	(Female)	70	50
	Male	25	15
M. dioica	Female	70	50
	Male	25	15

Staking was provided 15 days after planting and 20 gms of fertilizer mixture of N.P.K. in a ratio of 6:6:6 alongwith 1 kg. of FYM was applied to each pot at 3 weeks stage. Plant protection measures were taken by spraying Thiodan and Bavistin to check insects and diseases respectively.

Source of seeds :

The seeds of the both the species were collected in the previous season and these seeds were sown for

studying germination rate and sex ratio. Altogether 240 seeds were put to test in these two species.

Experimental layout :

The present investigation was conducted in pot culture and in complete Randomised Block Design. Total five replications were taken for studying the characters of crossed fruits whereas, for other characters the 't' test was followed.

Observation technique :

Time taken for germination of seed :

Time taken for germination was recorded from the begining of the germination of seeds and planting time as the intial.

Germination percentage and sex ratio :

For testing the germination and sex ratio small trenches of 20 cm width and depth and in a length of 6 m. were dug and 3 kg of FYM was spread on the top layer of soil. 120 seeds of each species were sown in the field with uniform distribution. The germination time, no. of seeds germinated were recorded after the germination and the germinated plants were staked for further growth and flowering. After flowering the

plants were counted for male and female. The percentage was expressed out of the germinated seedlings.

Leaf length and width :

To record the dimension of the leaves of two Monoecious sps., the average length and width of the 7th and 8th from the tip of the main branch at two months stage were measured in centimeters. The length was measured from the tip to base of the leaf and width was taken at 3 points, one at centre and the other two points were above and below and the average was found out.

Leaf area :

At two months of growth, 7th and 8th leaves from the tip of the main branch were taken and their area were plotted on a graph paper. Leaf area were calculated on the basis of individual leaf and the average was found out and expressed in square centimeters.

Petiole length :

The petioles length of 7th and 8th leaf from the tip of the main branch were measured and the average was expressed in centimeters.

Tendril length :

The tendrils in the 7th and 8th node from the tip of the main branches were measured and average was expressed in centimeters.

Twining direction of tendril :

The tendrils which in the stakes were observed for the twining direction i.e. clock wise or anticlockwise.

Internode length :

The length of 7th and 8th internode from the tip of stem were measured and average was calculated and expressed in centimeters.

Dry matter content of leaf :

The weight of 10 fresh leaves from two Momordica species were recorded accurately by a chemical balance and kept in the oven till a constant weight was obtained. Then the dry matter content of leaf was assessed and expressed in percentage.

Leaf shape group :

The shape of the leaf was expressed as lobed or slightly lobed or non lobed and entire or denticulated by visual observation.

Flowering height :

The flowering height was recorded at the appearance of first flower in the leaf axil of two

Momordica spp. both in male and female plants.

Time taken for development of flower :

The period between flower bud intiation (observed by magnifying glass) to the opening of flower was recorded in days for male and female flowers separately. Observations were recorded from 5 plants of each species selected randomly from the population.

Time of anthesis :

Anthesis time was studied by observation the earliest time of opening of male and female flowers in two Momordica spp. and the range was recorded.

Time taken for opening of flower :

The period between starting of small rupture at the tip of the petal to complete opening of flowers was observed in male and female flowers of the two species. The range was found out and expressed in hours and minutes.

Withering of petals :

The withering time of petals for both male and female flowers were observed and data were recorded for general information.

Flower characters :

The flower characters like shape, length, width, colour etc. of bracts, caly and corolla were observed from a group of 10 flowers separately from each spp. The average data was found and expressed in centimeters.

Monthly flower production :

Flower production per day was observed in 5 plants each for male and female of two species and average was calculated separately.

Pollen viability through fruit set :

The male flowers from two species were collected just after the time of anthesis and were kept in a moist petridish chambers separately. After 24 hours the pollens were dusted in freshly opened female flowers of respective species which were bagged before opening with butter paper bags to prevent natural pollination and again bagged after dusting. Pollen viability was recorded from the fruit set observiour ovary swelling after 5 days of pollination.

Time taken for pollen germination :

The pollens from two species were allowed to germinate separately in 3% sucrose solution and

average time was recorded from 10 repeated observations.

Pollen viability and germination :

Freshly collected pollens from two species were kept in wet petridish and were allowed to germinate in cavity slide containing 3% sucrose solution at 6 hrs intervals. The germination of pollen tube was observed in pollen grains microscopically. The percentage of viable pollens were calculated for each species after staining in acetocarmine stain.

Methods of pollination :

Fruit set was observed by three methods such as open pollination, hand pollination and bagging. Observations were taken in the month of September. In open pollination the flowers were selected and observations were recorded for fruit set. In hand pollination the female flower were bagged 24 hours before the opening of flowers and were hand pollinated with freshly opened male flowers and again bagged to check further natural pollination. In case of bagging flowers were bagged 24 hours before opening. The fruit set was recorded through visual observation of every swelling and it was expressed in percentage.

Days taken for fruit development :

The period between pollination to complete maturity of fruit was observed and the average days required for fruit development was recorded in 10 fruits of two species.

Weight of individual fruit :

Ten fruits were taken randomly from each species and the average weight of a fruit was calculated seperately.

Yield :

The fresh weight of number of fruits harvest at intervals per plant were added to get the approximate yield plant and expressed in kilograms.

Length of fruit :

Ten fruits were selected randomly and the average length of fruit was found out separately for each species and expressed in centimeters.

Diameter of fruit :

The fruits selected for length measurement were also measured for their diameter and the average diameter of fruits were expressed in centimeters.

Rind thickness :

The average of rind thickness of fruits were found out and expressed in centimeters.

Number of seeds per fruit :

Total number of seeds collected from ten fruits and average was found out to know the number of seeds per fruit.

Seed to fruit ratio :

Ten well matured fruits were collected from each Myrsticon species and the weight of these fruits were recorded accurately. The weight of seed extracted from those fruits were also recorded separately for each species and expressed in grams. Then seed to fruit ratio was found out.

Drymatter content of fruit :

The individual fresh weight of ten fruits were recorded by a chemical balance and cut in to small pieces. Then it was dried in oven till a constant weight was obtained. Then the dry matter content of each species was calculated and expressed in percentages.

Vitamin 'C' content of fruit :

Ten grames of edible part were ground and volume made upto 100 ml. 2 ml of 2% freshly prepared starch solution as indicator was added to 5 cc of sample taken in a 50 ml conical flask and titrated against 0.01 N potassium iodide (KI) solutions taken in a burettee. The end point was marked by a bluish black colouration which persisted for 15 seconds only. Vitamin 'C' content was determined on the basis of KI utilised in titration and the value was expressed at the rate of 1 ml of 0.01 N KI=88 mg. of vitamin.

Seed characters :

Ten seeds each were collected from two Momordica species and dried uniformly. The seed weight was taken and after then the cotyledon and seed coat were separated and their weight was taken and expressed in grams and the cotyledon and seed coat weight was expressed in percentage of seed.

Oil content of seed :

Two grams of dried crushed seed was placed in a thimble and transferred into the soxhlet extractor. One and half cyphones of petroleum ether was added to the apparatus and then the condenser was fitted and made

air tight. The heating was continued and adjusted to condense the petroleum ether and fall drop wise from the condenser. After 6 hours the flask containing petroleum ether was removed, evaporated and placed inside the oven at 105°C for 1 hour. Then the fat content was determined as per Chopra and Kanwa (1976).

Moisture loss from fruits :

Ten fresh fruits of each species were weighted and kept under room temperature and weight of the fruit was taken everyday upto 7 days to assess the moisture loss from the fruits

Storage quality of fruits :

Twenty fruits each of M. cochinchinensis and dioica were kept under observation. Number of fruits were discarded due to ripening upto 7 days and recorded

Length of pedicel/fruit stalk :

Ten fruits were harvested from each species with their stalk intact and the length of the pedicel was found out and the average was expressed in centimeters.

Extent of fruit set in different months :

The extent of fruit set in different months were recorded by considering the fruit bud initiation,

development, opening and fruit set in ten consecutive nodes.

Percentage of success due to crossing in different months:

In every month starting from July to December 20 crossing were made for each species and the percentage of success was calculated. Hand pollination was made for this.

Percentage of male flower opening in different months :

From selected 5 male plants 10 nodes were taken for observation leaving 3 buds on the terminal position. The number of flowers developed and opened in these nodes were taken into account and expressed in percentage.

Interspecific crossing :

The male and female flowers were bagged 24 hours before the expected period of opening of flower. The pollens were collected from the freshly opened male flowers or male flowers stored in moist petridish chamber and dusted in the stagmatic surface and again bagged for another 2-3 days. All possible crossing between two species were made.

Statistical analysis of data :

Complet Randomise Block Design was employed for growth, yield, quality and crossability study in the present investigation to analyse the data. Mean, standard error, analysis of variance and critical difference were calculated for different characters. The percentage value do not follow the normal distribution, therefore they were transformed to their angular values. Significant test for "F" values were found out from "F" table and the value of 't' from the table. The formula for standard error, difference and critical difference was given below :

Standard Error of difference

$$= \sqrt{\frac{2\,VR}{r}}$$

VR = Variance due to error.

r = replication.

Critical difference = S.E. difference X t (0.05) at error d.f.

CHAPTER-IV
RESULTS

RESULTS

The results of the present investigation entitled "Growth, yield, quality and crossability study in Momordica cochinchinensis Spreng and Momordica dioica Roxb." has been presented in Table 6 to 27 and figures 1 to 5. The analysis of variance has been shown in Appendix I to iii. The experimental findings are presented as follows.

Germination test (Table 6) :

The percentage of germination and days required for germination were tested for the two Momordica species and observed that the germination percentage in M. dioica was poor (60.8%) as compared to M. cochinchinensis (70%). The days required for germination was less in M. cochinchinensis (10-12 days) compared to M. dioica (12-16 days).

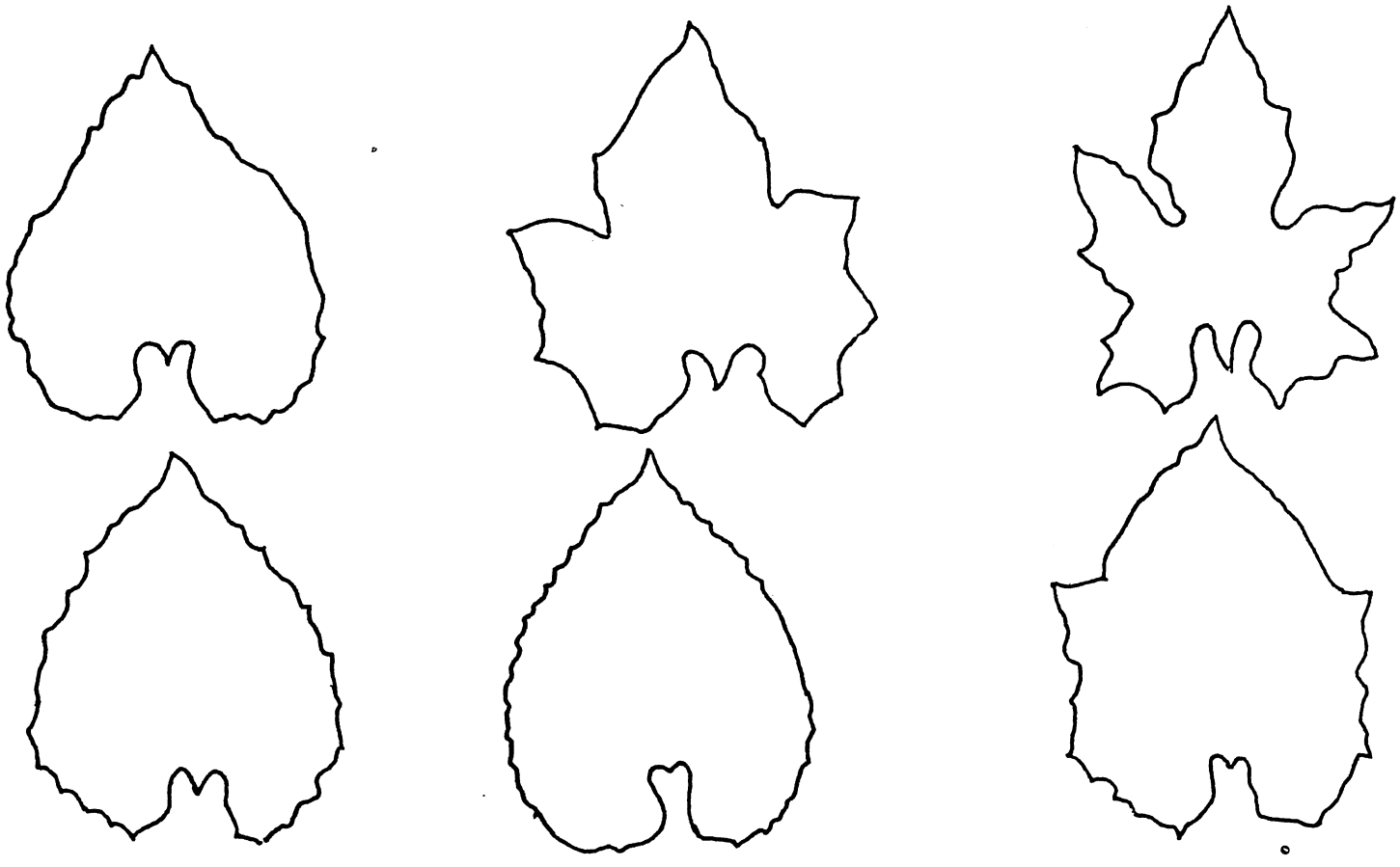
Table 6 : Percentage of germination and days required for germination of seeds.

Momordica spp.	Total no. of seeds sown	No. of seeds germinated.	Percentage of germination.	Days required for germination.
M. cochinchinensis	120	84	70	10 - 12
M. dioica	120	73	60.8	12 - 16

Fig. 1: LEAF SHAPE GROUPS OF MOMORDICA SPECIES

M dioica

M. cochinchi-
-nensis



Leaf characters (Table 7) :

The length of leaf was higher in Momordica cochinchinensis as compared to M. dioica. However due to variation in leaf, the range in M. cochinchinensis was in between 7.6 - 10.0 cms. (mean 8.3 cms) and that of M. dioica 5.1 - 9.7 cm. mean (7.4 cms). As regard to the width the range was 7.0 - 9.5 cms. and 7.3 -9.2 cms. with an average of 8.2 cm and 6.0 cm in M. cochinchinensis and M. dioica respectively. Similarly with respect to actual leaf area the ranges were 40.0 - 78.6 sq.cms and 18.5 - 70.0 sq.cms. with an average of 54.5 sq.cms and 44 sq.cms in M. cochinchinensis and M. dioica respectively. The length of petiol was longer in M. cochinchinensis with an average of 4.5 cms as compared to 2.5 cm in M. dioica. The length of the tendril was found to be higher in case of M. cochinchinensis (21 cms) as compared to M. dioica (14.0 cms). The length of internode was higher in M. cochinchinensis 7.5 cms against 4.8 cms in M. dioica. M. cochinchinensis showed higher amount of dry matter content (21%) as compared to M. dioica (10%). in leaves. The shape of the leaf (Fig. 1) was non-lobed or slightly lobed in case of M. cochinchinensis and lobed, slightly lobed and non-lobed in case of M. dioica (plate 1).

A female plant of M. cochinchinensis with flowers and small fruits.

Table 7 : Leaf characters.

	Leaf			Length of petiole (cms)	Length of tendril (cms)	Length of internode (cms)	Dry matter content (%)
	Length (cms)	Width (cms)	Area (sq.cms)				
Momordica cochinchinensis							
Range	7.6-10.0	7.0-9.5	40.0-78.6	3.0-6.0	15.5-28.5	5.5-10.5	17-22
Average	8.3	8.2	54.5	4.5	21	7.5	21.0
Momordica dioica							
Range	5.1- 9.7	3.8-9.2	13.5-70.0	1.5-5.5	11.0-18.5	1.5-9.9	16.5-21.5
Average	7.4	6.0	44	2.5	14.0	4.8	19.0

Flowering height and sex ratio (Table 8) :

The male flowers appeared in a height range of 65 - 118 cms in M. cochinchinensis and 43 - 70 cms in M. dioica whereas female flowers produced at a height of 75 - 122 cms M. cochinchinensis and 43 -92 cms. in M. dioica. The plant population grown out of seed exhibited a sexratio of 47 : 53 male to female in case of M. cochinchinensis and 56 : 44 in case of M. dioica.

Table 8 : Flowering height and sex ratio.

	Flowering height (cm)		Male and Female sex ratio	
	Male flower	Female flower	Male	Female
1. Momordica cochinchinensis	65 - 118	75-122	47 :	53
2. Momordica dioica	43 - 70	43- 92	56 :	44

Flower development (Table 9) :

Male flowers took 19-24 days from bud initiation to flowering in M. cochinchinensis and 18-21 days in M. dioica. As regards to female flowers, in general less days was taken for bud development than male flower. M. cochinchinensis took 18-22 days and M. dioica 14-17 days.

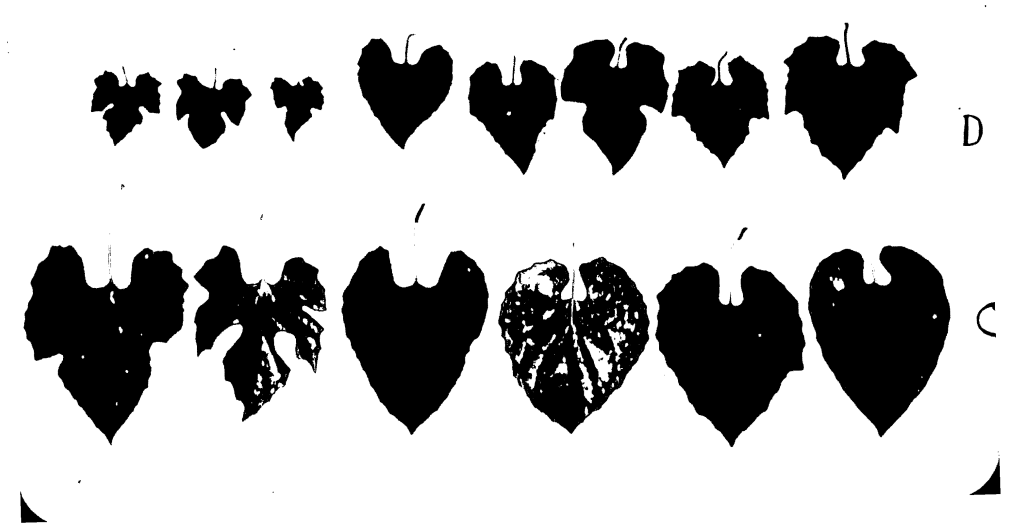
Time taken for full opening of flowers in both male and female in two species were studied. Female flowers took less time as compared to male flowers. Male flowers of M. cochinchinensis took 2.30 to 3.30 hours compared to 20-25 minutes in M. dioica. Similarly female flower in M. cochinchinensis took 2.0 to 2.15 hours against 3.12 minutes in M. dioica. The time of anthesis was recorded both for male and female flowers. The anthesis time of male flower was slightly earlier than female flower. M. cochinchinensis opened during early morning hours and M. dioica in afternoon. In both the species of Momordica petals withered in a short period. M. cochinchinensis withered in evening hours where as M. dioica wither in morning hours.

Floral characters (Table 10) :

The floral characters were recorded in both male and female flowers of two species. The length of bract was higher in M. cochinchinensis (2.2 cm) than M. dioica (1.7 cm) but the width of bract was higher in M. dioica (2.0 cms) as compared to M. cochinchinensis (1.4 cms). As regard to calyx length and width it was more in M. cochinchinensis having 1.3 cms and 1.4 cms. respectively against 1.5 cms and 1.07 cms. in M. dioica. Similar trends were observed for corolla length and width.

Table 9 : Flower development, anthesis, withering of petals and time taken for blooming.

	Days required for flower bud development		Time taken for full opening of a flower (in Min/hrs.)		Time of anthesis		Withering time of petals	
	Male	Female	Male	Female	Male	Female	Male	Female
H. cochinchinensis	19-24	13-22	2.30 to 2.50 hrs.	2.0 to 2.15 hrs.	4.15 to 6.30 A.M.	4.40 to 6.30 AM	4.30 to 8.15 PM	3.45 to 7.45 PM
H. dioica	13-21	14-17	20-25 min.	3.12 min.	4.30 to 5.40 PM	4.30 to 5.45 PM	4.30 to 7.30 PM	4.7.30 AM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flower length and opening diameter of flowers were higher in M. cochinchinensis with 4.6 cms and 6.3 cms respectively compared to M. dioica with 3.5 cms and 3.6 cms.

Pollinological study (Table 11) :

The pollen size recorded in M. cochinchinensis was found to 46.62 microns and in M. dioica 26.6 microns. The pollen viability tested on the basis of germinability in 3% sucrose solution revealed that pollen viability was upto 30 hours after anthesis in M. cochinchinensis where as 24 hours in M. dioica and the two species took more or less 2.0 to 2.10 hours for germination. Pollen viability at the time of anthesis was observed to be 100% in two species. Pollens were round in shape. Pollen viability was studied through (i) pollen tube germination and (ii) fruit set suggest that, freshly collected pollens show 100% viability but after-wards, when they were observed at 6 hours interval, the pollen germination decreased in these two species. Pollen viability study through fruit set revealed that freshly collected when pollinated with their respective female flowers showed 100% fruit set and after-wards the fruit set gradually decreased.

Table 10 : Flower characters.

	Bract		Calyx		Corolla		Flower length cms.	Opening diameter of flower(cms)
	Length cms.	Width cms.	Length cms.	Width cms.	Length cms	Width cms		
Memecylon caeruleopaniculatum								
Range	1.5-2.7	1.3-1.9	1.5-2.8	1-1.5	3.0-6.2	1.5-3.5	4.0-6.8	5.6-9.0
Average	2.2	1.4	1.8	1.4	4.6	2.6	4.6	6.3
Memecylon sicica								
Range	1.2-2.2	1.5-2.6	1.3-1.7	0.9-1.4	2.0-3.7	1.2-1.8	3.0-4.1	3.1-4.5
Average	1.7	2.0	1.5	1.07	3.2	1.4	3.5	3.6

Table 11 : Pollen size, pollen viability and pollen tube germination in *Ipomoea cochinchinensis* and *Ipomoea dioica*.

	Pollen size in microns.	Period of pollen viability in hrs.	Time taken for pollen tube germination in (min/hrs)
Ipomoea cochinchinensis	46.62	30	1.55 - 2.30 (2.00)
Ipomoea dioica	26.6	24	1.35 - 2.35 (2.10)

Monthly flower production (Table 12) :

Data recorded on flower production in two species revealed that in case of *I. dioica* flowers were produced in all months except January, February, March, and April. Flowering started onwards and reached a peak period during August and September and then declined upto December. In case of *I. cochinchinensis* flowers were not observed in January, February and March and started after that and reached peak in August and September and then declined.

Methods of pollination (Table 13) :

Three methods of pollination i.e. open pollination, hand pollination and bagging to test the

Fig.2 FLOWER PRODUCTION / DAY IN DIFFERENT MONTHS

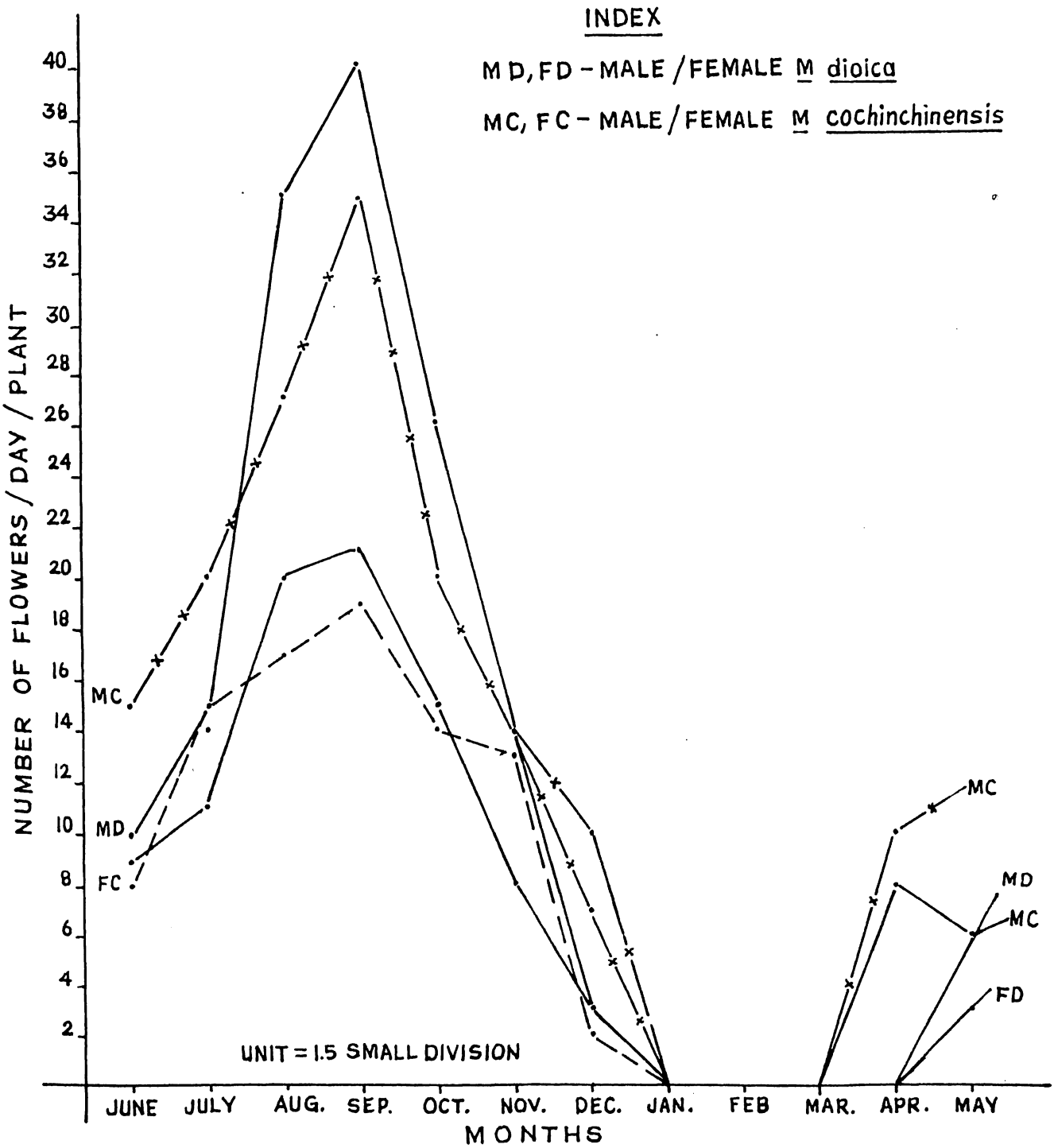


Table 12 : Flower production/plant/day as influenced by different months.

	Sex of flower	June	July	August.	Septem-ber	Octob-er.	Novem-ber	Decem-ber	Janu-ary	Feb-ruary	March	April	May
Momordica cochin-chinensis	Male	15	20	27	35	20	14	10	-	-	-	10	12
	Female	8	15	17	19	14	13	2	-	-	-	8	6
Momordica dioica	Male	10	14	35	40	26	14	7	-	-	-	-	6
	Female	9	11	20	21	15	8	3	-	-	-	-	3

extent of fruit set was tested for during September. Data revealed that no fruit set was observed in case of bagging in two species where as in case open pollination the fruit set was more in *M. dioica* compared to *M. cochinchinensis*. But in general the percentage is lower as compared to hand pollination in both the species. In case of hand pollination the extent of fruit set was 94.98% and 93.98% in *M. cochinchinensis* and *M. dioica* respectively.

Table 13 : Effect of different methods of pollination on fruit set.

	% of fruit set with open pollination.	% of fruit set with hand pollination.	% of fruit set with bagging.
Momordica cochinchinensis	47.2	94.98	nil
Momordica dioica	80.98	93.98	nil

Extent of fruit set (Table 14) :

The fruit set per ten nodes was observed during fruiting months. It was highest in month of September and lowest in May and June in *M. cochinchinensis*. Where as in *M. dioica* it was highest during August, and September and lowest in May and June. Average

fruit set during a year was higher in M. cochinchinensis as compared to M. dioica.

Table 14 : Extent of fruit set in different months (in consecutive ten nodes and open pollination).

	July	August	Sept-ember	Octob-er	April	May	June
Momordica cochin-chinensis.	30	50	70	60	30	20	20
Momordica dioica.	50	70	70	50	—	10	10

Yield characters (Table 15) :

Average number of fruits per plant was found to be 58 in M. cochinchinensis and 175 in M. dioica. This has been observed in plants with limited staking. Significant difference was observed for individual fruit weight. Fruits of M. cochinchinensis was nearly eight times than that of M. dioica. The variety of M. dioica under study was a small fruited one. The total average yield in five plants recorded upto 3.51 kg. in case of M. cochinchinensis and upto 1.23 kg. in M. dioica.

Table 15 : Number of fruits per plant, individual fruits weight and total yield/plant in *M. cochinchinensis* and *M. dioica*.

	Number of fruits per plant (Average of 5 plants)	Individual weight of fruit.	Total yield/plant (kg).
Momordica cochinchinensis	53	54.96	3.51
M. dioica	175	6.64	1.23
't' test		Sig. **	

Fruit characters (Table 16) :

The average length of pedical in *M. cochinchinensis* was found to be 11.94 cms compared to 1.78 cms. in *M. dioica*. Length of fruits differed significantly and the average length in case of *M. cochinchinensis* was 9.02 cms. whereas in *M. dioica* it was 2.56 cms. Diameter of the fruit showed significant difference and the average was 4.02 cms). in *M. cochinchinensis* as compared to *M. dioica* (2.20 cms). The average rind thickness was found to be 0.30 cm and 0.296 cms in *M. cochinchinensis* and *M. dioica* respectively. *M. cochinchinensis* took on an average more time (38.8 days) to mature than *M. dioica* (31.2 days).

Fig.5: FRUIT TYPES IN *Momordica dioica* (ACCORDING TO THEIR SHAPE)

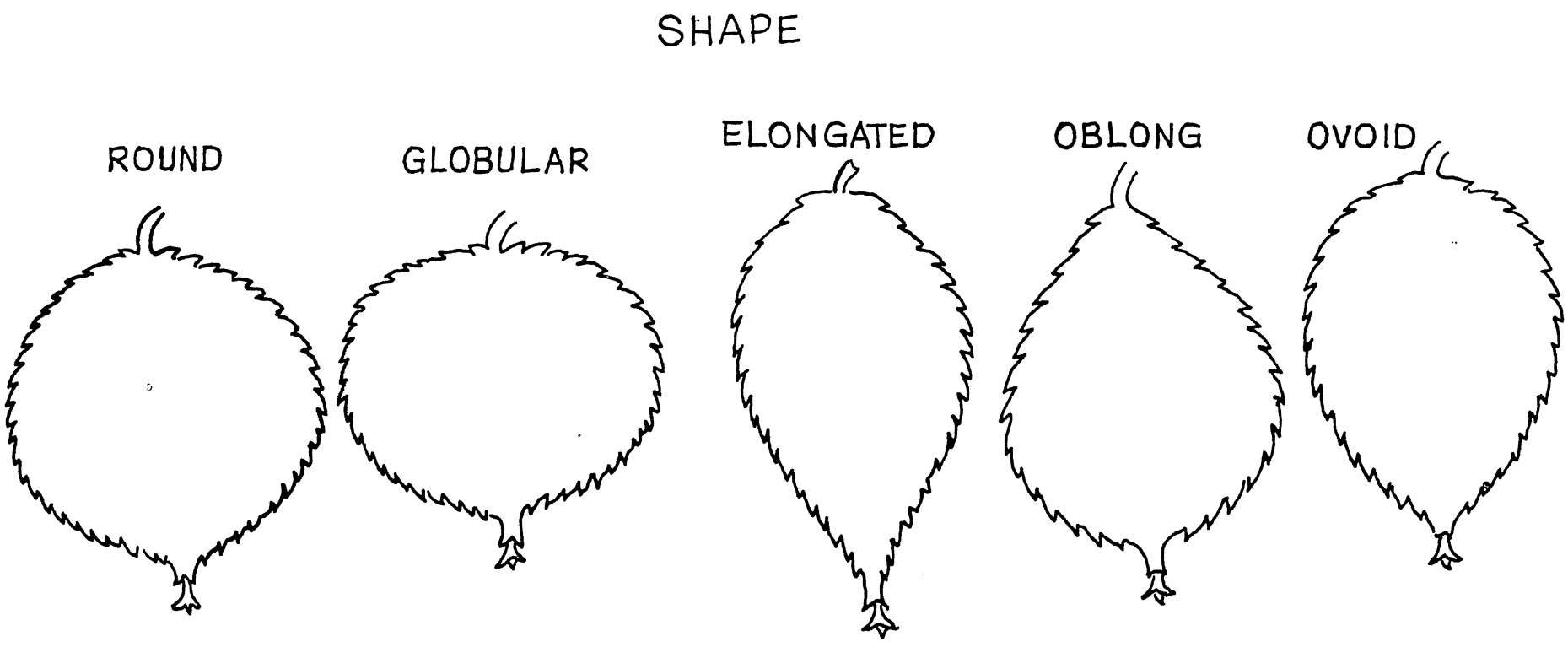
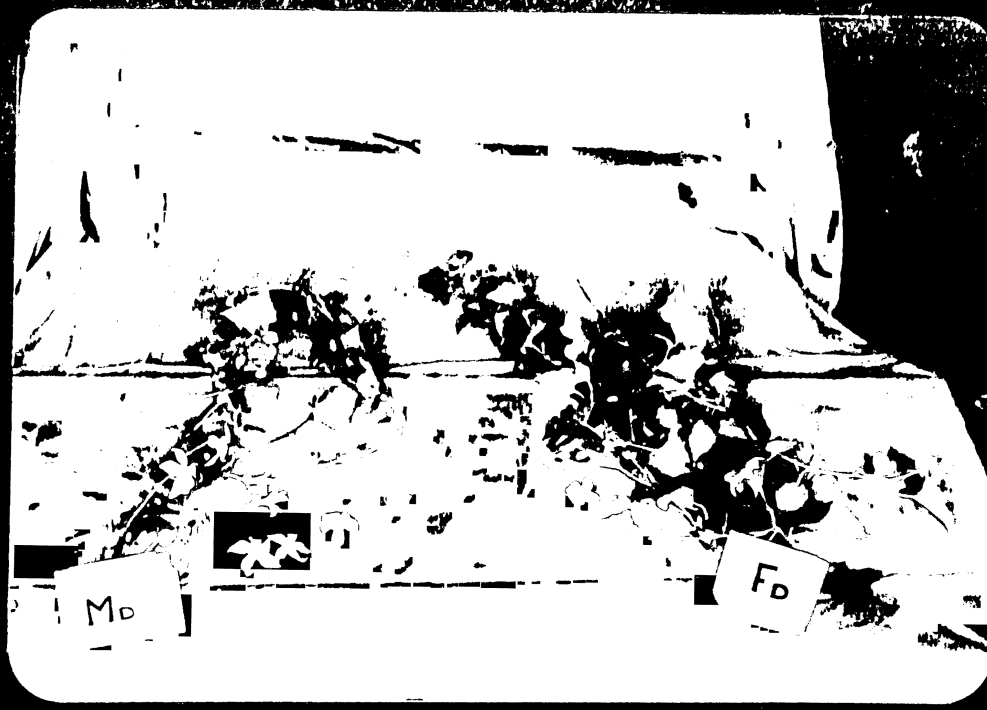


Table 16 : Length of pedicel, fruit length, fruit diameter, rind thickness and days taken for fruit maturity.

	Length of pedicel(cms)	Length of fruit (cms)	Diameter of fruit (cms)	Rind thickness (cms)	Day required for fruit maturity
Momordica cochinchinensis.	54.96	9.02	4.02	0.60	31-40 (38.8)
Momordica dioica	6.64	2.56	2.20	0.296	26-32 (31.2)
't' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**

Seed characters and fruit quality (Table 17):

Average number of seeds per fruit was 41.8 and 19.2 in M. cochinchinensis and M. dioica respectively. The average number of perfect seeds per fruit was 37.6 in M. cochinchinensis and 4.8 in M. dioica. The number of rudimentary seeds per fruit was more in M. dioica (13.4) as compared to M. cochinchinensis (4.2). The vitamin 'C' content of fruit was found to be higher in M. cochinchinensis (241.86 mgs.) as compared to M. dioica(116.49 mgs). The dry matter content of fruit in M. cochinchinensis (16.88% was found to be significantly higher as compared to M.dioica (15.02%). The seed to fruit ratio in case of M. cochinchinensis was found to be 1:3.1 as compared to M. dioica 1:2.8.



Male flower(MD) and female flower and fruits(FD) in M. dioica .

Table 17 : Number of seeds, vitamin 'C' content, dry matter and seed to fruit ratio in fruits

	No. of seeds per fruit			Vitamin 'C' in fruits in 100 gms edible part.	Dry matter (%)	Seed to fruit ratio.
	Perfect seeds	Rudimentary seeds	Total			
Momordica cochinchinensis.	37.6	4.2	41.8	241.36	16.35	1:3.1
M.dioica	15.3	13.4	19.2	116.43	15.02	1:2.8
't' test.	** Sig.	** Sig.	** Sig.	** Sig.	* Sig.	N.S.

Storage quality of fruits (Table 18):

Storage quality of fruits of both species were studied. M. cochinchinensis fruits could be kept safely for 3 days but M. dioica fruits only 2 days. After that the fruit started ripening. The process of ripening was found to be gradual in case of M. cochinchinensis were as sudden in case of M. dioica.

Table 18 : Storage quality of fruits.

	No. of fruits kept under observation	No. of fruits removed due to ripening and rotting (nos.)						
		1	2	3	4	5	6	7
Momordica cochinchinensis.	20	0	0	0	3	5	5	7
M.dioica	20	0	0	2	3	8	7	-

Moisture loss during storage (Table 19) :

Moisture loss from the fruits of both species were studied and it was found that the extent of moisture loss in a week was 37% and 45% in *M. cochinchinensis* and *M. dioica* respectively. The loss of moisture progress in a slower rate in *M. cochinchinensis* than *M. dioica*.

Table 19 : Percentage of Moisture loss (in cumulative) in fruits

	No. of fruits observed.	Percentage of moisture loss						
		1	2	3	4	5	6	7
				(Days)				
Momordica cochinchinensis	20	11	17	22	28	32	35	37
M. dioica	20	10	18	25	30	35	41	45

Seed quality (Table 20) :

Weight of hundred seeds showed significant difference and it was 21.40 gms. in *M. cochinchinensis* and 5.65 gms in *M. dioica*. Reverse trend was observed for seed cost weight and it was more in *M. dioica* (45.36%) as compared to *M. cochinchinensis* (34.17%). Significant difference was observed in cotyledon percentage in two species. The cotyledon percentage was maximum in *M. cochinchinensis* (65.83%) compared to *M. dioica* (54.64%). Both the species contained good amount of oil and it was 24% in *M. cochinchinensis* and 25.2% *M. dioica*.

Table 20 : Seed weight, cotyledon percentage, seed coat percentage and oil content of seed in M. cochinchinensis and M. dioica.

	Hundred seed weight (in gms)	Cotyledon weight (in %)	Seed coat weight (in %)	Oil content of seed (in %)
Momordica cochinchinensis	21.402	65.83	34.170	34
M. dioica.	5.65	54.64	45.36	25.2
't' test	** Sig.	** Sig.	** Sig.	** Sig.

INTERSPECIFIC HYBRIDIZATION :

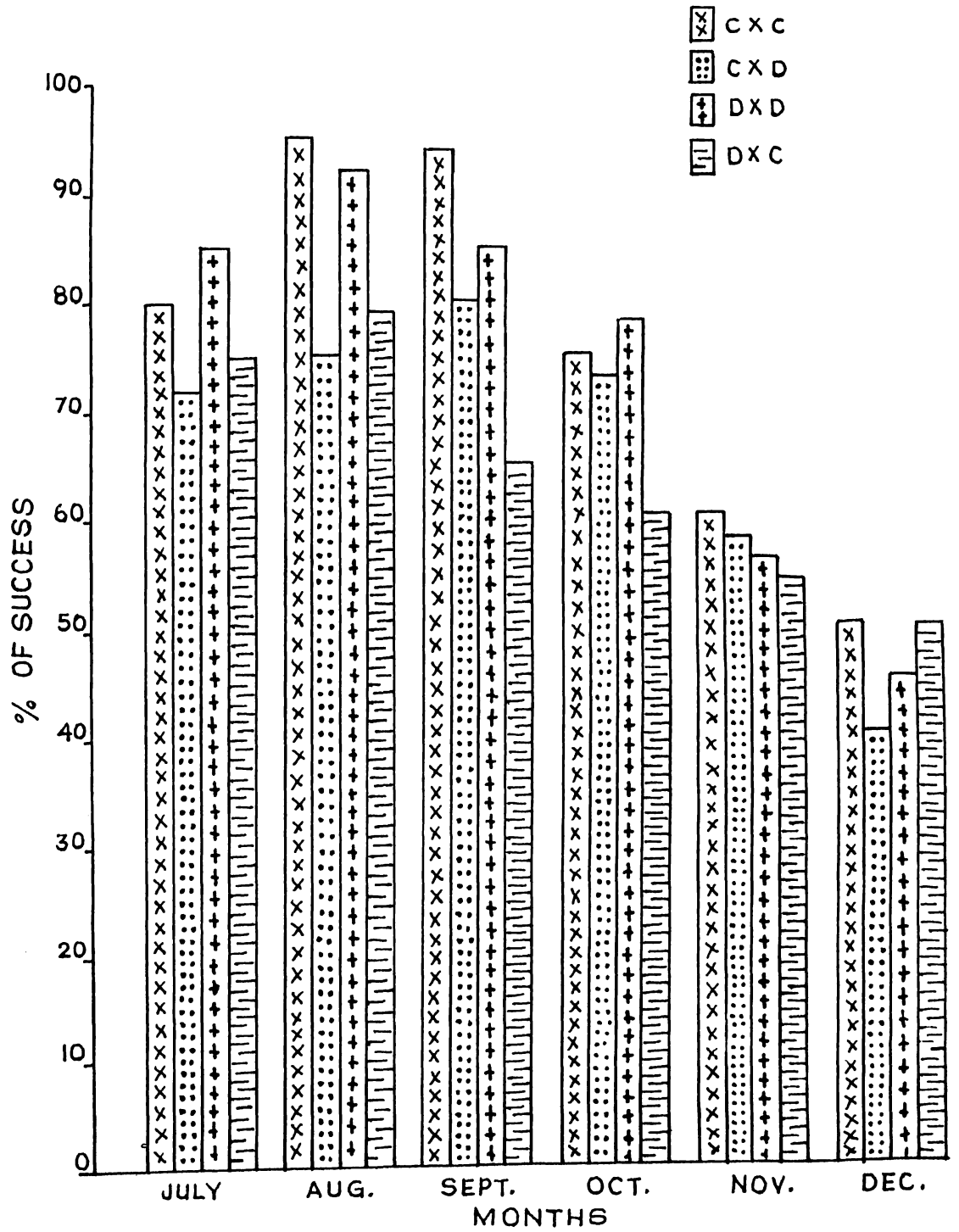
Percentage of success (Table 21) :

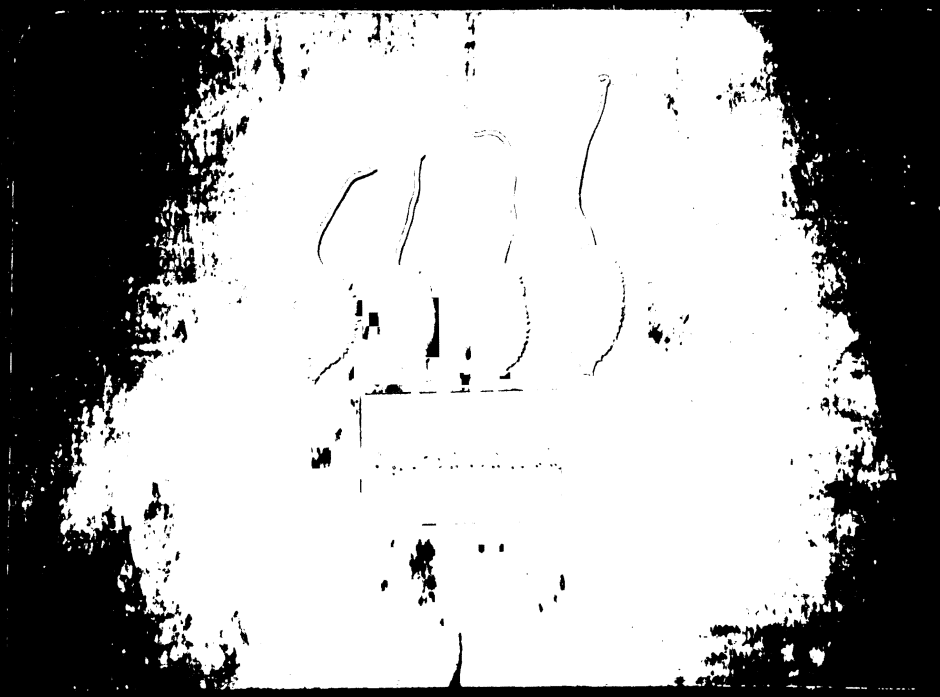
Percentage of fruit set was observed in interspecific crossing. Crossing within the species revealed 90-94% success with normal fruit and seed development. But the fruit set was decreased in inter-specific crosses. Fruit set upto 80% was noticed in C X D crossess whereas 75% in D X C crossess. Percentage of success differed from months to month.

Fruit characters (in different crosses)(Table 22):

Significant difference was observed for weight of the fruit in different crosses. Fruit size was reduced

Fig. 3 PERCENTAGE OF SUCCESS IN CROSSING IN DIFFERENT MONTHS





Normal development of fruits in M. cochinchinensis.

to the extent of 60% in M. cochinchinensis (21.27 gm) when crossed with pollen of M. dioica (C X D) compared to M. cochinchinensis 54.96 gm (C X C). Similarly fruit size was increased in M. dioica (9.0 gms) when crossed by the pollen of M. cochinchinensis (D X C) compared to M. dioica 6.64 gms (D X D) but not significantly. Significant difference was observed for diameter of fruits. Fruit diameter was reduced in cross C X D (3.33 cms) as compared to C X C (4.02 cms). Reverse trend was observed in reciprocal cross D X C (2.637 cms) compared to D X D (2.20 cms). Length of fruit also expressed a similar trend like that of weight of fruit and diameter of fruit and the lengths were 9.02 cms. 7.14 cms, 8.80 cms, and 4.82 cms in C X C, C X D, D X D and D X C respectively. Significant difference was noticed for rind thickness of fruit in intraspecific crosses. But it was decreased in cross C X D (0.46 cms) as compared to C X C (0.60 cms). However, it was in a increasing trend in D X C (0.30 cms) as compared to D X D (0.206 cms) crosses. There was significant difference in maturity period of fruits between two species. Intraspecific crossed fruit of M. cochinchinensis (C X C) took 38.8 days to mature as compared to M. dioica (D X D) 31.2 days. However, earlier maturity was observed in C X D crossed as compared to C X C and C X D and other combinations were not significant.

Table 22 : Fruit weight, fruit length, fruit diameter, rind thickness and days taken for fruit development in different crosses.

Crosses	Weight of individual fruit (in gms)	Length of fruit (in cms)	Diameter of fruits (in cms.)	Rind thickness of fruit (in cms)	Days required for fruit development	
					Average	Range
C X C	54.96	9.02	4.02	0.60	38.8	40-41
C X D	21.27	7.14	3.38	0.46	33.6	28-35
D X D	6.64	2.56	2.20	0.29	31.2	26-32
D X C	0.00	4.52	2.68	3.0	32.4	28-33
'F' test	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.	
S.E.(m) ±	2.79	0.41	0.09	0.17	1.38	
C.D.(0.05)	6.09	0.89	0.21	0.33	3.02	

Seed characters and fruit quality (Table 23 & 24) :

Significant difference for seed number per fruit was observed in two species. However the number seed per fruit was decreased to the extent of 3% in C X D cross as compared to C X C. No difference was observed in D X D and D X C crosses for similar trend was observed for number of perfect seed per fruit. The number of seeds in C X C were 37.6 as compared to 5.8 in D X D. But number of perfect seeds reduced to the extent of 75% 9.6 seeds) in C X D cross as compared to C X C cross (37.6 seeds). All other cross combination did not show any significence difference. No significant difference was observed for seed to fruit ratio between two species as well as in different cross combinations and the ratios were 1:3.1, 1:3.0, 1:2.8 and 1:2.9 in C. X C, C X D, D X D and D X C respectively.

Table 23 : Number of seeds/fruits, number of perfect seeds, number of under developed seeds/fruit and seed to fruit ratio in different crosses.

Crosses	Total number of seed per fruit.	Number of perfect seeds.	Number of under developed seeds	Seed to fruit ratio
C X C	41.8	37.6	4.2	1:3.1
C X D	14.6	9.6	5.0	1:3.0
D X D	19.2	5.8	13.4	1:2.8
D X C	19.2	11.2	8.0	1:2.9
'F' test	Sig.**	Sig.**	Sig.**	N.S.**
C.D.(n) t	1.56	3.31	1.23	—
C.D.(0.05)	3.40	8.36	2.30	—

Weight of 100 seeds showed significant difference between intra as well as interspecific crosses. Seed weight was reduced from 21.40 gms (C X C) to 13.36 gms. in (C X D) cross. Similar seed weight was increased from 5.56 gms. in (D X D) to 8.15 in (D X C). No significant difference was observed for seed coat weight except between interspecific crosses. The seed coat percentages were 34.17, 46.36, 45.36 and 46.62 in C X C, C X D, D X D and D X C cross combinations respectively. Cotyledon percentage (%) showed similar trend like seed coat percentage (%) and they were 65.83, 53.64, 54.64 and 53.48 percentage in cross combinations of C X C, C X D, D X D and D X C respectively.

Table 24 Weight of hundred seeds, seed coat weight, cotyledon weight of seeds in different crosses.

Crosses	Weight of hundred seeds (gms)	Seed coat weight (percentage)	Cotyledon weight (percentage)
C XC	21.40	34.17	65.83
C X D	13.36	46.36	53.64
D X D	5.65	45.36	54.64
D X C	8.15	46.52	53.48
'F' test	Sig.**	Sig.*	Sig.**
S.E.(m) ±	0.22	1.01	1.01
C.D.(0.05)	0.48	2.20	2.20

M. cochinchinensis fruits fully developed (C x C), Tetraxenia effect (C x D).

Table 25 : F_1 (C X D) plant ch-racters.

	Leaf			Length of petiole (cms)	Length of tendril (cms)	Length of internode (cms)
	Length (cms)	Width (cms)	Area (sq. cms)			
Hermaphrodite (female)	8.4	8.2	55	4.5	22	7.6
M. dioica (male)	7.4	5.0	45.0	2.5	15	4.7
F_1(C X D)						
(Male)	7.8	6.8	48.2	3.2	8.5	5.6
(female)	7.0	6.8	43.0	3.3	18.0	5.8

Fig.4. IDENTIFICATION OF MALE AND FEMALE TUBERS

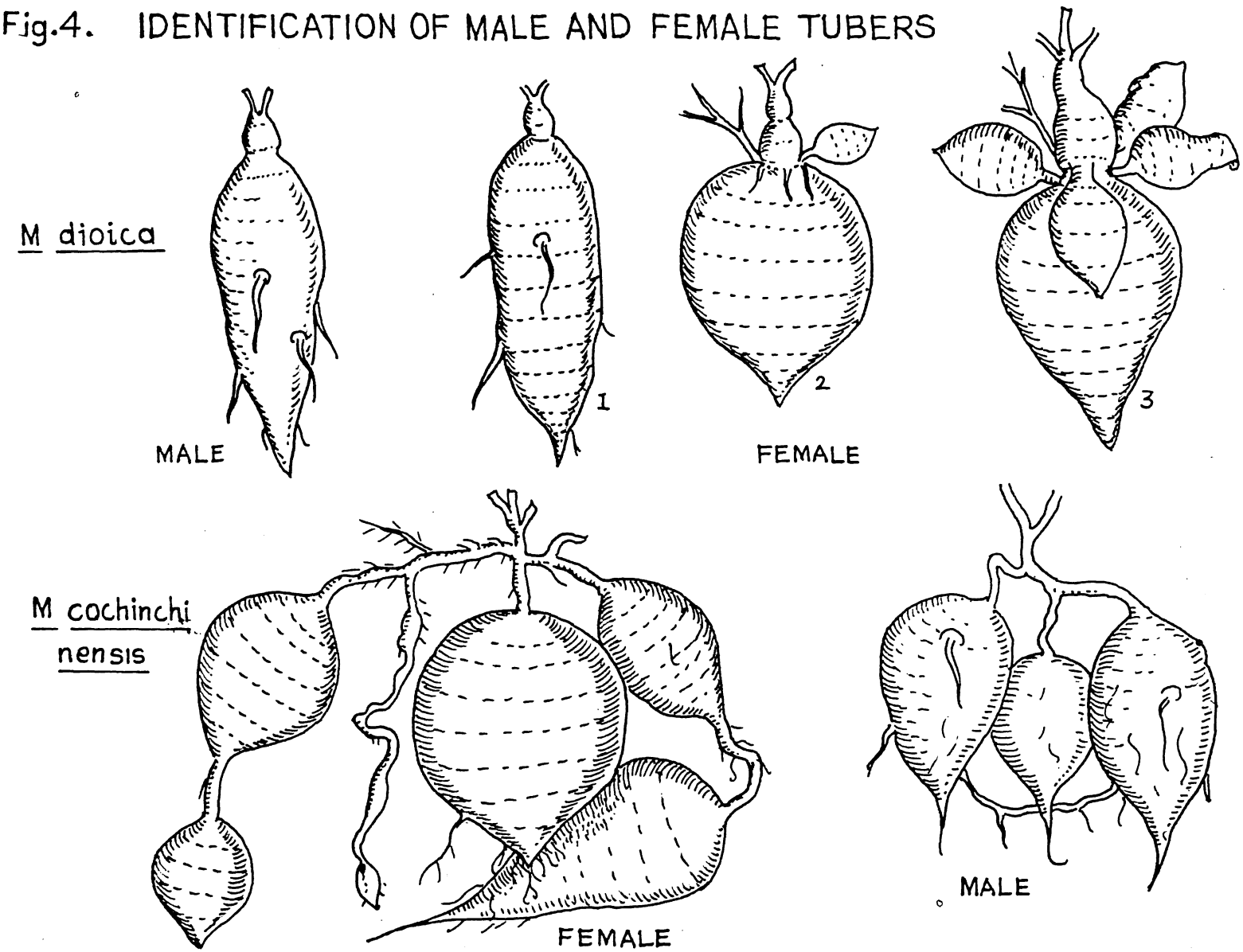


Table 26 (a) : F_1 (C X D) Flower characters.

	Tract		Calyx		Corolla		Flower length	Opening diameter.	Pollensize (microns)	Pollen fertility (%)
	Length (cms)	Width (cms)	Length (cms)	Width (cms)	Length (cms)	Width (cms)				
Nerodia cochinchinensis (male)	2.2	1.4	1.8	1.4	1.6	2.5	.46	6.3	46.62	100
Nemordica dioica (male)	1.7	2.0	1.5	1.07	3.2	1.4	2.5	3.6	26.6	100
F_1(C X D) (male)	1.9	1.3	1.6	1.2	4.0	2.3	4.0	5.0	33.3	13

Table 26 (b) : F_1 (C X D) Flower characters :

	Flowering height (cms)	Days required for bud development	Time taken for full opening of flower (min/hors)	Time of anthesses	Withering of petals
Hemsadesmus cochinchinensis (female)	91.5	20	2.0 hrs.	4.40 to 6.30 AM	3.45 to 7.45 PM
H. indicus (male)	56.5	15.5	10 min.	4.30 to 5.40 PM	4.00 to 7.30 AM
F_1(C X D) (male)	67.0	16.5	1.15 hrs.	2.45 AM to 4.00 AM	2.00 to 4.30 PM

Study of F_1 character :

Few F_1 seedlings of C X D process were grown and male phase appeared. Characters relating to growth, leaf, petiole, tendril and internode length were observed (Table 25). All the above characters were found to be intermediary in nature confirming inheritance of characters from both the parents. Since the female plants have not come to flowering only male flowers were compared with parent plants for bract, calyx, corolla, flower length and opening diameter (Table 26(a). Flowering height (67 cms) and days taken for bud development (16.5) were observed and found to be more close to Momordica dioica where as the time taken for full opening of flowers (1.15 hours) and time of anthesis (2.45&4.00 AM) although were of intermediary in nature but close to M. cochinchinensis (2 hours and 4.40- 6.30 AM respectively). Pollen fertility was observed and found to be only 18% in the month of May as compared to their parents (upto 100%) (Table 26(a). Similar observation were found in the case of pollen size i.e. 46.62 microns in M. cochinchinensis, 26.6 in M. dioica and 33.3 in F_1 (C X D).

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Table 27 : The inheritance of several characters in C X D cross.

Characters observed in F_1(C X D) plants.	Dominance/recessive
1. Plant growth	Dominant and more close to *U. cochinchinensis*.
2./ Leaf shape	Dominant and more close to *U. cochinchinensis*.
3. Flowering height	Intermediate
4. Anthesis	Dominant and more close to *U. cochinchinensis*.
5. Flower colour	Yellow dominant and more close to *U. dioica*.
6. Pollen size	Intermediate
7. Pollen fertility	Partially fertile

CHAPTER-V
DISCUSSION

DISCUSSION

The results of the present investigation titled "Growth, yield, quality and crossability study in *Momordica cochinchinensis* Spreng and *Momordica dioica* Roxb". presented in the preceding chapter revealed some useful information on various aspects of plant growth, yield, quality, Xenia and metaxenia in crossed fruits as well as some characters of F_1 male plant and female plants. The results are discussed below.

Seeds of cucurbits exhibit greater variation in respect of germination. Germination is 2-4 days earlier in *M. cochinchinensis* as compared to *M. dioica*. The germination of seeds is nearly 16% higher in *M. cochinchinensis* as compared to *M. dioica*. The seed of *M. cochinchinensis* are flat whereas in *M. dioica* it is round and harder than the former. The dormancy of seeds has been reported in *Momordica* species (Sahoo and Maharana, 1994). The dormancy is upto 26 days in *M. cochinchinensis* and 71 days in *M. dioica*. Dormancy for a long period in seeds may be considered as a disadvantage as they can not be used immediately for a second crop. Seeds *M. cochinchinensis* are germinated quickly as seeds are flat having a fissure which imbibes water quickly and hastens germination. But in seeds of *M. dioica* both internal and external dormancy are observed. Dormancy due to

chemical inhibitors has been observed in water melon. The inhibitor is present in red fluid of fruit.

In seed propagated dioecious plants, study of sex ratio is very important. The male to female ratio in M. cochinchinensis is 47 : 53 whereas the trend is reverse in M. dioica (56 : 44). Hence seminal method of propagation in these two species are not desired unless a sex linked character is found out. Attempts may be made to cross distinct male and female plant types (for leaf shape) so that male and female plants can be identified in early stage. Identification of male and female plants in early stage would greatly help for developing a better farming system in these crops.

Propagation of these two species are made through tuber planting. The tubers are categorised in three groups such as round, globular and elongated (Fig. 4). M. cochinchinensis mostly produce nodular spindle shaped tubers whereas M. dioica produces globular, elongated tubers. Some people try to determine sex in tuber groups. It is very difficult to identify the male and female through tuber without the presence of floral parts. In M. dioica female tubers are round or globular in shape with few rudimentary side tubers and with a number of circular rings around the tuber surface whereas in male plants the tubers are mostly

elongated in shape without any side tubers. However, this is not considered as a authentic scientific method for sex determination of tubers. This may be correct upto 60-70%. D. dioica tubers develop as a single one from the proximal end of mother plants D. cochinchinensis tubers develop number of tuberous roots.

As regard to leaf length, D. dioica produces smaller leaves as compared to D. cochinchinensis. A similar pattern is observed for leaf width although a wide variation has been observed for leaf area, the pattern is more or less similar. The leaves of D. cochinchinensis are non-lobed or rarely lobed whereas D. dioica is having leaves of mixed shape i.e. lobed, non-lobed and semilobed (Fig. 1). Petiole length is also is the similar pattern and petioles of D. cochinchinensis are significantly longer than D. dioica. The tendril which help the plant to climb on stakes is longer in D. cochinchinensis as compared to D. dioica and always attach to the thinner stakes either coiling in a clockwise or anticlockwise direction (Green, 1904, Sensarma, 1955). Longer internodes are found in D. cochinchinensis as compared to D. dioica and dry matter content of leaf is higher in D. cochinchinensis (21%) as compared to D. dioica (19%). Leaf area is nearly 28% higher in D. cochinchinensis as compared to D. dioica. The leaf area is considered as the most important yield

attributing character being site of photosynthesis. The number of leaves present in cucurbit plants are positively related to percentage of fruit set which has been confirmed in water melon (Cunningham 1940). All the increased leaf characters in *L. cochinchinensis* help the plant to put forth a vigorous vegetative growth, increased fruit weight and total yield per plant.

During the course of investigation some biometric observations relating to plant height, sex ratio, flower development, anthesis and physical characters of flower have been recorded and presented in Table 8, 9 and 10. These two species are dioecious so the characters have been observed in both male and female plants. In both the species male phase is found earlier than the female phase. *L. dioica* flowers at a lower height (43-81cm) compared to *L. cochinchinensis* (70-120 cms)(Pattanaik and Pattnaik 1976). All the cucurbits have a herbaceous stem which maintain a short juvenile stage after which reproductive stage appears in phases later both the phases follow simultaneously. However flowering height varies from season to season. In rainy season flowers appear at a higher height as compared to winter and summer when they appear at a lesser height.

In cucurbits development of flower bud takes place in the order of sepal, petal, stamen and pistil

and some work has been done in this respect (Judson 1929, 1935, 1949, Kirkwood 1905).

The bracts, calyx and corolla are present in close succession with peduncle attached to the stem (Dutchie 1973). Lot of variation exists in different genus as well as in species. Data collected on the size of bracts, calyx, corolla, flower length and opening diameter in these two species reveals some interesting results. The length of bract is longer in M. cochinchinensis compared to M. dioica, but as regard to width the trend is reverse. The bract covers the male flower till the petals develop colour and protrude outside for blooming. The length and width of calyx is smaller in M. dioica (1.6 cms and 1.07 cm) as compared to M. cochinchinensis (1.8 cms and 1.4 cms). A similar trend is observed for corolla length, flower length and opening diameter of flower as in case of length and width of calyx (Table 10). The flowers of M. cochinchinensis are white with black spot in side near the base but flowers of M. dioica are golden yellow in colour.

In dioecious as well as monoecious plants development of flower bud, anthesis time and duration of flowering are very important. Data collected on these aspects reveals that female flowers take less

number of days for complete development than male flowers and very spectacularly the male flower of M. cochinchinensis take longer days (19-24 days) for complete development of flower bud and female flowers of M. dioica take minimum period (14-19 days). However most flowers attain a full developmental stage within a period of 3 weeks. But the study made by Vijay, Jakilop and Nath (1977) in M. cochinchinensis reveals that the male and female flowers take 22 - 24 days and 19 - 24 days respectively from bud intiation to complete bloomings of the flowers.

Interesting results have been obtained for time taken for full opening of flower (Table - 9). In M. cochinchinensis anthesis is in early morning hours whereas in M. dioica it is in early evening hours (Sahoo and Maharana 1984). The opening time is very short in male and female flowers of M. dioica i.e. upto 25 minutes in male and 12 minutes in female. But in M. cochinchinensis it is upto 2.5 hours and 2.15 hours respectively.

The duration of opening of flower is an important factor for increasing the yield by providing a considerable more time for pollination. Petals drop within 12 hours after anthesis. M. dioica flowers wither early in the days whereas M. cochinchinensis in the

afternoon. Natural crossing between these two species is not possible since withering time of one species coincides with the anthesis time of other and the petals curve inwardly and cover the stigmatic surface at the fading time.

Data on flower production/day in different months suggests that flowering in M. cochinchinensis starts from April and reaches to peak during September and then gradually declines and completely ceases in January, February, March. In case of M. dioica flowering starts from May to reach peak in September and completely stop from January to April (Fig. 2)

As regard to pollen size, period of viability and pollen germination a considerable amount of variation are observed. Some work has been done in this respect by Mean and Robinson (1950) in some cucurbits. The dehisence of pollen is immediately after opening of the flower. The pollen size is larger in M. cochinchinensis (46-62) microns) as compared to M. dioica (26.6 microns). The viability of pollen is retained upto 30 hours in M. cochinchinensis and 24 hours in M. dioica. Similar results have been reported by Sahoo and Maharana (1994). The acetocarmine test reveals that all the pollen of both the species are fertile (upto 100%) in the growing

season. The pollen grains of M. dioica are golden yellow in colour while it is orange yellow in M. cochinchinensis. No variation in observed for pollen tube germination. In these two species it is mostly 2 hours in 3% sucrose solution.

Fruit set study (Table 13) was carried out through open pollination, hand pollination and bagging and the data reveals that no fruit set is observed in bagging. In cucurbitaceae family parthenocarpic fruit development is hardly observed. However it is reported in cucumber (Mitch et al. 1962) and also observed in Coccinia indica. Xenocarpy in M. dioica with Luffa, Lagenaria and M. charantia pollens has been reported (Parija 1967, Nakin singh 1978). Parthenocarpy in M. dioica reported by Singh (1978) following natural and hand pollination with pollens of Lagenaria laucantha M. charantia and L laucantha + M. charantia. Hand pollination in both the species resulted in higher fruit set compared to open pollination.

Fruit characters studied in different Momordica species (Bailey 1949) reveals that fruits may be found globular, elongated, oblong, ovoid in shape with soft, hard, longer short spines. The fruits take nearly 31-40 days to mature in M. cochinchinensis

compared to M. dioica (26-32 days) but the edible stage attain within 13 and 14 days respectively in Momordica cochinchinensis and Momordica dioica. As regard to length of fruit stalk, fruit length, diameter, weight of fruit and rind thickness M. cochinchinensis showed significantly higher values as compared to M. dioica (Table 16).

The fruits of genus Momordica contain good amount of protein, carbohydrate and appreciable amount of fat (Table 2). Khanna and Jain (1979) reported the economic importance of M. charantia. Beekenoogen (1940) reported the carotene content of M. cochinchinensis Maurya (1976) & Mahoo and Maharana (1984) reported the protein and vitamin 'C' content of M. cochinchinensis and M. dioica. As regard to vitamin 'C' content M. cochinchinensis contain 241.83mg/100 gm of edible portion compared to 116.43 mg. in M. dioica.

In the present investigation it is observed that the total dry matter content of fruit is higher than many of the cucurbits. In M. cochinchinensis dry matter content is higher (16.29%) as compared to M. dioica (15.02%). Attempt may be made to increase the dry matter content in M. dioica through crossing with M. cochinchinensis.

The oil content analysed in the whole seed (with testa) reveals a very interesting result. Chakravarty

et al. (1966) reported that M. dioica contains oil comprising 33.5% of Kernel or 22% of seed. The oil content is appreciable very high in M. dioica (25.2%) compared to M. cochinchinensis (24%).

As regard to the number of seeds per fruit and seed to fruit ratio it is observed that number of seeds are more in M. cochinchinensis (37.6) compared to M. dioica (15.3). But the seed to fruit ratio showed a reverse trend, i.e. 1:3.1 in M. cochinchinensis and 1:2.3 in M. dioica. Desirable maturity stage of M. dioica should be found out so that it develops optimum amount of seed to give a good taste.

The seeds of cucurbits vary in size, shape and colour and the presence of scar at hilum. The structure of cucurbit seeds has been studied by Yasuda (1903) Barber (1900 and Singh 1953). Data on hundred seed weight, seed coat and cotyledon weight reveals interesting results. Significant differences are observed for all these characters in these two species (Table 20).

In some cucurbits like summer squash, Tinda, bitter gourd, pickling cucumber and long melon, fruit reach optimum edible stage within a week or little later and in many other cucurbits edible stage attain within 20 days. In the early days of plant domestication man

most have selected many cucurbits because of their early harvesting character. In the present study the fruit attains edible stage in 13 day and 14 days in M. cochinchinensis and M. dioica respectively but ripening of fruit takes 33.8 days and 31.2 day in M. cochinchinensis and M. dioica respectively.

M. cochinchinensis plants in an average produce 30 fruits as observed by Sadhu and Chakravarty (1980) but in this investigation average fruit number per plant has been observed upto 58. In case of M. dioica number of fruits produced per plant(175) is nearly 2.5 times that of M. cochinchinensis and the average yield/ plant being 3.51 kg and 1.23 kg. respectively in M. cochinchinensis and M. dioica (Table 15). The average fruit weight observed to be 54.96 gm and 6.64 gm respectively in M. cochinchinensis and M. dioica. In an average 2 kg. fruits/plant in M. dioica and 4 kg. in M. cochinchinensis may be considered as economic yield.

Importance of these crops as a minor oil seed crop may be considered. The oils obtained by crushing the seeds found to be colourless odourless and semidrying in nature. High protein and fat content in seeds give a better test to M. dioica and M. cochinchinensis. Over mature and ripened fruits are more tastier because of

this reason. If 16 tonnes of yield of fruits can be obtained from one hectare which can produce nearly 30% seeds and these seeds can yield 25% oil which will be nearly 1200 kg. of oil yield from one hectare of land. The economics of these crops as a minor oil seed crop may be worked out. Bitterness is absent in the fruits of these two species. Another member of this genus M. charantia more of cucurbitacin. This substance imparts bitterness in some cucurbits.

Mendelian variation interspecific hybridization and polyploidy are considered the process of evolution in plant kingdom. In the present investigation attempts have been made for interspecific crossing in Momordica species i.e. M. cochinchinensis and M. dioica. These two are dioecious plants. It is likely that large number of genetic differences likely to appear in chromosome organisation leading to bewildering complexity in seggregating generations. There may be also disharmonious combination in F_1 hybrids in interspecific hybridisation. The useful characters in F_1 hybrids are well preserved as in vegetative propegated plants. There has been tremendous development in roses, grapes, strawberry and many other vegetatively propagated plants through interspecific hybridisation. Both the species of Momordica understudy are easily propagated through cuttings(Maharana and Maharana 1983),(Sahoo and Maharana 1984). The chromosome number in these two species (2n=28).

So there is good chance for success in interspecific crossing and hybridisation. Earlier attempts have been made with some success (Roy et al. 1966, Trivedi and Roy 1972, Sahoo and Maharana 1984). But the most important problem is dioecy in these two plants. Although dioecy is not common in cultivated plants, it is observed in few cucurbitaceous plants like Trichosanthes dioica, Coccinia indica, M. dioica and M. cochinchinensis. The male plants of these species produce no fruit and their main function is to produce pollen. For this reason together with the fact quality of fruit is influenced by metaxenia. Because of this pollination in performed by hand so that the number of male plants can be kept to a minimum. This is practised in many species like date palm where selected pollen parent is used for pollination. As out lined by Whitaker and Bohn (1950) breeding of cucurbitacae plants are more advantageous because of simple method of culture, easy maturity, relatively large flowers, intermediate growth habits, distribution of flower over a long period, easy storage of fruits and plenty of seeds. So far very little work has been done on Momordica species as they are less used food items and majority of them are not yet fully domesticated. The diploid chromosome number of these two species of Momordica is (2n = 28). Mirza (1984)

has claimed that some tetraploids are grown in Assam. Kadir and Mohamed (1965) has reported that tetraploid can be obtained with 0.2% colchicine treatment. Triploids of M. dioica has been reported by Agrawal and Roy(1976). M. cymbalaria consists of 4 small, 3 medium and one large chromosome in haploid (n = 8) condition (Mehtra and Thombre 1960). Trivedi and Roy (1973) Kadir and Zahoo (1966) have reported tetraploid with colchicine treatment in M. charantia. The crop improvement has been made in a greater extent in M. charantia as compared to M. dioica and M. cochinchinensis.

Interspecific crosses in cucurbits have been commenced with (Erwin 1917) and since then there has been sustained interest in these subjects for nearly 70 years. Attempts have been made to improve quality, resistance to disease and insect pests and adaptability to varied climatic conditions. Hall and York (1960) has also worked in interspecific crosses in Cucurbits. Whitaker and Bohn (1950) has obtained sterile F_1 hybrids between Cucurbita moschata and Cucurbita maxima. Subsequent development has been made by Veilung (1965) for developing embryo culture technique as an aid in interspecific hybridization due to poor endosperm development.

The interspecific hybridization programme in this study is aimed to develop tolerance against epilachna beetle, powdery mildew, leaf spot, soft fruit rot disease, spiny characters of fruit from hairy type to about pyramidal ones to check rooting during transit, shortening dormancy in tuber and seeds of M. dioica and to produce off season crop. The desirable characters of M. cochinchinensis are a loose scandent growth, larger fruits with longer fruiting period, tolerance to epilachna beetle, long fruit stalk and better keeping quality and the desirable characters in M. dioica are high protein content, better taste with more fruits/plant. But the disadvantages in M. dioica are many like compact growth, highly susceptible to epilachna beetle, long dormancy, short fruiting season, poor storage quality etc. An intermediary type is aimed to develop combining some desirable characters of both the species for Orissa condition.

Interspecific crossing is possible in months starting from July to December (Table 21). In inter-specific crossing there has been 10% decrease in percentage of fruit set as compared to intraspecific crossing. Decrease in percentage of success has been recorded in different interspecific crosses of Cucurbita maxa and C. maxima(Costantin 1930, Erwin and Haber 1939).

In all possible crosses of M. cochinchinensis and M. dioica variations are observed for fruit characters like weight length, diameter, rind thickness as well as days taken for maturity of fruit (Table-22). In all cases positive metaxenia effect has been observed in D X C crosses while negative metaxenia effect in C X D crosses. There has been a decrease of 62.29% fruit weight in C X D crosses and increase of 35.54% in D X C crosses as compared to their intraspecific crossing. Similarly there has been decrease in length, diameter, and rind thickness in C X D crosses as compared to C X C crosses and increase in D X C crosses as compared to D X D crosses. The increase is nearly 30% of the decrease. As regard to the seed characters similar trend has been observed. There has been decrease in number of seeds in C X D cross upto 65% but no increase in total number of seeds in D X C crosses are observed. However, the number of perfect seeds are greatly reduced in C X D crosses and comparatively increased in D X C crosses as compared to respective intraspecific cross. Very little difference is observed for rudimentary seeds per fruits in C X C and C X D crosses whereas the rudimentary seeds are decreased to nearly 80% in D X C crosses as compared to D X D cross.

Pollens of M. dioica has reduced the development of both embyo and endosperm, in C X D cross but

there has been spectacular increase in endosperm and embryo characters with the use of M. cochinchinensis pollens in D X C cross. The pollen source (xenia and metaxenia) controls the development of embryo and endosperm. The retardation of growth in embryo and endosperm in C X D crosses can be attributed to partial failure in fertilization due to the fact that the style of maternal species is much longer than the style of pollen parent. Pollen tubes are not trevers the great length between stigma and ovary therefore failed to effect fertilization. Other reasons may be the inadequate pollen germination on the stigmatic surface of M. cochinchinensis. The temperature and humidity in the evening and morning hours differ. Hence when pollens of M. dioica are used after 12 hours on th stigma of M. cochinchinensis might have resulted in poor vigour and germination.

Germination of pollen on stigmatic surface secretes some pectin digestive enzyme which triggers hormone production. This condition afterwards control the development of ovary and endosperm. There has been a decrease of nearly 40% weight of seeds in C X D cross due to the pollens of M. dioica whereas there has been 60% increase in D X C crosses. The xenia effect is clearly observed here. Effects of xenia and metaxenia has been observed in many plant species like date,

apple, pear, cherry, corn coconut by several workers as mentioned earlier.

Germination in F_1 seeds is observed. Nearly 25% of seeds of C X D crosses germinated. All total 12 F_1 seedling of C X D cross were grown. Male phase appeared earlier and 2 seedlings produced flowers. Female flowers have not been yet appeared but 2 plants are observed to be female and small female flowers buds are appearing. *H. dioica* seeds normally germinate during the onset of monsoon due to long dormancy but D X C seeds did not germinate in the first lot but in second lot started germinating. Two seedling have been transplanted.

The leaf characters like length, width, area are observed in F_1 (C X D) plants (Table 25). The characters are mostly intermediary type and more or less no difference was observed between male and female plants for these characters. Similar intermediate characters have been observed for length of petioles length of tendril and internode length. The male flowers in C X D crosses are found to be intermediate type in all respect like bract, calyx corolla, flower length and opening diameter (Table 26 (a). In F_1 of C X D crosses flowering height have been greatly reduced as compared to C X C

and are of intermediate type F_1 (C X D) male flowers took lesser days (16.5 days) than C X C (20 days). Interesting result has been obtained for time taken for flower opening and anthesis time. F_1 (C X D) male plants took 1 hour 15 minutes as compared to 2 hours and 10 minutes respectively in C X C and D X D crosses. The time of anthesis is also 1-2 hour earlier than M. cochinchinensis but nearly 8-10 hours later than M. dioica. So these characters have been more influenced by of M. cochinchinensis. The flower colour in F_1 (C X) is more close to M. dioica (pale yellow). Pollen size is found to be intermediate in character (fertile upto 18% in the month of May) and high degree of sterility in pollen has been observed as against upto 100% in both the species at the time of anthesis.

It is pertinent to discuss some economic aspects of these two Momordica species. M. cochinchinensis is a large climbing vine as compared to M. dioica. The spacing for M. cochinchinensis should be 12 meter but for M. dioica one meter. On this basis there would be a population 10,000 plants/ha in M. dioica and 2,500 plants in M. cochinchinensis. If 10 percent plants are maintained female, the female population

per hectare will be 9000 and 2,250 respectively for M. dioica and M. cochinchinensis. The approximate yield in M. dioica at the rate of 2 kg/plant would be 18 tonnes/ha. and 9 tonnes/ha for M. cochinchinensis. Therefore the urgent need is to develop a intermediate type by improving M. dioica for maintaining sizeable population with larger fruits for higher yield.

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CHAPTER-VI
SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present investigation entitled "Growth, yield, quality and crossability study in *Momordica cochinchinensis* Spreng. and *Momordica dioica* Roxb. was carried out in the Department of Horticulture, O.U.A.T. at Bhubaneswar, to study the flower biology of two *Momordica* species, assessment of some important food value and oil content in seed, collect information regarding yield and quality of fruits, crossability test in these two species and finally to study the performance of F_1 seedlings.

In continuation of the previous season work plants of *M. cochinchinensis* and *M. dioica* were grown. Germination percentage and sex ratio in seeds were tested. Various characters were studied like floral biology, yield, quality, crossability studies in these two species. Weeding and plant protection measures were taken when required by spraying Thiodan 35 EC @ 0.05% for epilachna beetle and Bavistin for leaf blight. Seeds collected from the crossed fruits were grown for studying F_1 population. The following results were obtained.

1. Seed germination was found to be low in *M. dioica*. *M. cochinchinensis* seeds germinated earlier than *M. dioica*.

2. Dry matter content of leaf was higher in *M. cochinchinensis*.

3. Leaf length, width area and internode length were higher in M. cochinchinensis.

4. The leaves of M. dioica were lobed, non-lobed, slightly lobed whereas in M. cochinchinensis it was non-lobed or slightly lobed

5. Male and female flowers appeared at a lower height in M. dioica compared to M. cochinchinensis.

6. Sex ratio of male to female was higher in M. dioica.

7. Flowering was earlier in M. dioica.

8. Time of anthesis in M. cochinchinensis was in dawn hours against dusk hours in M. dioica and in F_1 male (C X D) plant it was in late night.

9. M. cochinchinensis flowers took longer time for opening compared to M. dioica.

10. Petals wither mostly within 12 hours of anthesis in both the species but it is within 9 hours in F_1(C X D) male plant.

11. Length of bracteole maximum in M. cochinchinensis and width is maximum in M. dioica.

12. The length and width of calyx was maximum in L. cochinchinensis.

13. Length and width of corolla was also higher in L. cochinchinensis.

14. Flowers were larger in L. cochinchinensis.

15. Monthly female flower production was mostly well distributed in a high range during July, August, September and October in both the species. Flowering started in the month of April in L. cochinchinensis and from May in L. dioica.

16. Larger pollen was observed in L. cochinchinensis.

17. Hand pollination ensured highest amount of fruit set. No parthenocarpic fruit development was observed in both the species.

18. L. dioica takes 26-30 days for maturity of fruits whereas L. cochinchinensis takes 31 - 40 days.

19. Individual fruit weight, fruit length and fruit diameter were higher in L. cochinchinensis.

20. Vitamin 'C' content was higher in *M. cochinchinensis*.

21. Seeds are flat in *M. cochinchinensis* whereas round in *M. dioica*.

22. Higher oil content was observed in seeds of *M. dioica*.

23. Storage quality of fruits was better in *M. cochinchinensis*.

24. Both the species cross freely between themselves but the success was more in C X D cross.

25. Individual fruit weight, length, diameter, rind thickness and days taken for maturity decreased in C X D crosses whereas increase was observed in D X C crosses.

26. Total number of seeds/fruit decreased in C X D crosses.

27. Number of perfect seeds/fruit increased in D X C crosses.

28. Seed to fruit ratio decreased in C X D crosses but increased in the case of D X C crosses.

29. Weight of hundred seeds decreased in C X D crosses and increased in D X C crosses.

30. F_1(C X D) plants are found to be intermediary with respect to length of leaf, petiole, tendril and internode.

31. Flowering height and days taken for flower development were intermediary and more close to M. dioica.

32. Anthesis time and time taken for full opening of flower were more close to M. cochinchinensis.

33. Flower colour in M. cochinchinensis and M. dioica were white and golden yellow respectively but F_1 (C X D) flowers were pale yellow in colour confirming intermediary type.

Interspecific crossing was possible between M. cochinchinensis and M. dioica in either way and met with success. Positive xenia and metaxenia effects have been observed in D X C crosses while negative effects in C X D crosses. Improvement of these two crops through interspecific hybridisation can be carried out after proper evaluation of F_1 generations. M. cochinchinensis

has been studied for the last three years and the performance is upto the mark for which it may be popularised for the time being. Attempts should be made to improve M. dioica whose fruits are more tastier but smaller, with M. cochinchinensis for improving tolerance to epilachna beetle, size of fruits with pyramidal solid spines and longer keeping quality and fruiting period.

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BIBLIOGRAPHY

BIBLIOGRAPHY

Agrawal, P.K. & Roy, R.P. (1976). Natural polyploids in cucurbitaceae I. Cytological study in Triploid Momordica dioica Roxb. Cariologia 29 (1) 7-13.

Bailey, L.H. (1949). Three discussion in cucurbitaceae, Manual of cultivated plants, Macmillan, N.Y. 851 pp.

Barber K.C. (1909). Comparative histology of fruits and seeds of certain species of cucurbitaceae. Bot. Gaz. 47 : 263-310.

Bauyoucous, G.I. (1962). Hydrometer method for making particle size analysis of soil. Agron. Jour. 54 : 464 - 465.

Misaria, A.K. (1974). The effect of foliar spray of Alpha-napthalene-acetic acid on the sex expression in Momordica charantia L. Science and Culture 40(2) 78-80.

Boelsmoogen, H.A. (1940). The carotene content of fruits of Momordica cochinchinensis Sprang. Philipp. Journal of Sci. 71 : 299-300.

Bose T.K. and Ghosh H.P. (1976). Effect of photoperiod on growth and sex expression in some cucurbits, Indian Journal of Agric. Sci. (1975 publ. in 1977) 45 (10) 481-485.

Castetter, E.F. (1930). Species crosses in the genus Cucurbita. Amer. J. Bot. 17 : 41-67.

Catedral, L.C. & Manicsic, N.C. (1976). The effect of spacing and artificial pollination on seed yield and other characters of Ampalaya (M. charantia L.) Philip. J. of Crop Sci. 1 (4) 190-191.

Chakravarty, H.L. & Hore, D.K. (1970). Role of seed structure in cucurbit classification, Indian J. of Botany 2 (4) 323-329.

Chisholm, M.J. & Hobbins, C.Y. (1964). Fatty acid composition of some cucurbitaceae seed oils, Canad. J. Biochem. 45 : 1931-3.

Cunningham, G.H. (1940). Fruit setting of watermelon Proc. Amer. Soc. Hort. Sci. 37,811-4.

Das, P.;Lenka P.C.; Mohapatra, P ; Patra, S.K. and Das, R.C. (1970). Quality planting materials through stem cuttings in Spine gourd, OUAT J. of Research. Vol.IX, No.1 & 2, pp.119-121.

Doulta, M.S. & Chauhan, K.S.(1964). Heterosis studies on some berry and seed characters in grapes (Vitis vinifera L.) Indian Jour. of Hort. 21 (1/2) : 73 - 79.

Desai, M.S. and others (1966). Response of bitter gourd to nitrogen, phosphate and Potash fertilization, Indian J. of Hort. 23, 169-71.

Drude, O. (1917). Bull. off. Agric. Hawaii. Sant. 7 : 109-113.

Dutchie, J.F. (1872). Taxonomic description of Nagarlian species, Flora of Upper Gangetic plain and of the Adjacent Siwalik and Sub Himalayan Tract. Vol.I, Part I & II pp. 367-370.

Erwin, A.T. and Haber, E.S. (1929). Species and varietal crosses in cucurbits. Bull. Iowa. Agric. Expt. Stati. 263 : 341 - 372.

Freytag, G.F. (1970). Heterosis effects on pod size development in the common bean. Journal of Heridity 70(6) : 444-446.

Ghosh, N.S. and Jose T.K. (1972). Endine an effective growth retardent for sex modification in some cucurbitaceous plants, Indian Agril. 16 (4). 295-300.

Ghosh, S. and Basu, P.K. (1982). Effect of some growth regulators on sex expression on Momordica charantia L. ; Scientia Hort. 17 (2) 107-112.

Haines, H.H. (1961) Taxonomy of Momordica dioica and classification of genus Momordica. The Botany of Bihar, Orisa. Part. III & IV. pp. 336-340 & 304-305.

Holl, R. (1969) Bitter gourd, a Kerala favourite. Indian Farming 19(5) 30-1 (illus.).

Iyer, R.L.; Nagar, P.K. and Sircar, P.K. (1961). Endogenous cytokinins in seeds of bitter gourd (M. charantia L.) Indian J. of Experimental Biology 19(8) 766-767.

Jackson, M.L. (1962). Soil chemical analysis, Prentice Hall, Inc. New Jersey.

Judson, J.E. (1929). The morphology and vascular anatomy of the pistillate flower of the cucumber. Amer. J. Bot., 16, 69-83.

Judson, J.E. (1935). The floral development of the staminate flower of the Honey Rock musk-melon. Proc. West Va. Acad. Sci., 8, 99-08.

Judson, J.E. (1940). The floral development of the pistillate flower of Cucumis melo. Proc. W.Va. Acad. Sci. 20, 76-84.

Kadir, Z.B. and Mohammed, Yahoob (1965). Colchiploidy in Momordica charantia L. Ind Univ. Res. J. 83-88 West Pakistan.

Kaushik, M.P. and Sharma, J.K. (1975). Effect of gamma radiation on the sex modification in Momordica charantia L. Sci. and Culture 41 (3) 134-136.

Kedar P and Chakravarty, C.L. (1982). Effect of bitter gourd (M. charantia) seeds and Glibenclamide in streptozotocin induced Mahotes nellitus Indian Journal of Ent. Bio. 10(3):237-235.

Khalifa, A. Azzouz, S.; Yousef, M. Hendy, Z. M.; E.L.Masry, M. (1980) Effect of source of pollen on the physical and chemical quality of Amhat date variety. Agril. Res. Review 58 (3) :15-23.

Khanna, P and Jain, J.C. (1979). A hypoglycemic polypeptide from vegetable source with an alternate mode of action. (Abstract) Journal of Natural Product. 42 (6) 634.

Kim, J.H.; Yim, M.S.; Shin, Y.U.(1979). The selection of crabapple cultivars on pollinators for single cultivar commercial apple orchards. Res. Report of the Office of Rural Dev. Agril. and Agri.Eng. 21 37-44.

Kirkwood J.C.(1905). Comparative embryology of the Cucurbitaceae Bull. N.Y.Bot. Gar. 3. 313-402.

Lal, G.M.; Seth, J.N.;Solanki, S.S; (1976). Note on the heterosis in bitter gourd. Indian Journ. of Agril. Res. 10(3). 195-197.

Lal, B.M.; Datta, N.; and Madaan, T.R.(1983). A study of Kernel oils of some cultivated cucurbits Qualitas Plantarum Plant Food for human nutrition. 32(1). 82-85.

Maharana, T. and Maharana, U.K.(1983). Growth, yield & propagation study in Momordica dioica Roxb. unpublished research thesis, M.Sc. (Ag.) BHU.

Mangal, J.L.; Pandita, L.; and Singh, G.R. (1981). Effect of various chemicals on growth, flowering and yield of bitter gourd, Indian J. of Agril. Res. 15 (2). 125-130.

Mann, L.K. and Robinson, J. (1950). Fertilization, seed development and fruit growth as related to fruit set in the cantaloupe (C. melo), Amer. J. Bot. 37, 696-7.

Mattenlan, E.T. (1964). Microcarpology of cucurbitaceae anatomy of the fruit of squart cucumber (Cehallium elaterium and Momordica Charantia (Russian) Bot. Zurnal. 49 : 1461-82.

Maurya, I.B. (1976). Sweet gourd. A neglected vegetable, Indian Hort 21 : 11-12.

Mehetre, S.S. and Khambre, M.V. (1930), Meiotic studies in Momordica cymbalaria. Current Sci. 42 (7) 230.

Mishra, K.S. and Sahu, R.P. (1983). Large scale cultivation of small bitter gourd problems and possibilities. Ind. Hort. 28(3) 6-8.

Mitsch, J.P.; Barts, E.B.; Liverman, J.L. and Went, F.W. (1952). The development of sex expression in cucurbit flowers. Amer. J. Bot. 39, 32-42.

Osman, A.M.; Reuther, W. and Erickson, L.C. (1976). Xenia and metaxenia studies xin the date palm Phoenix dactylifera. Into Growers Institute Annual Report. 31, 6-16.

Parija, P. (1967). Monoecy in M. dioica Roxb. Current Sci. 36 ; 106-107.

Prakash, O.(1976). Effects of plant growth substances and vernalization on sex expression in M. charantia L. Indian J. of Ent. No.

Prasad, A. and Tyagi, I.D. (1963). Effects of Maleic hydrazide the sex expression and sex ratio of bitter gourd (M.charantia L.) Sci. & Culture. 22 : 696-6.

Ravindran, P.N. and Rajasekaran, L.R. (1971). Effect of ethrel on bitter gourd (M. charantia L). Indian J. of Agril. Sci. 41(9).794-795.

Ragnon, F. Lamothe, M; Xen, L.E. (1976). Xenia and combined ability in the coconut Oleagineux 31 (12): 531-537.

Roy R.P.; Thakur, U. and Trivedi, R.N. (1966). J. Cyto. Genet. 1 : 1-5.

Sadhu, M.K. and Chakravarty, U (1980). Indian Hort. 25 : 5-6.

Sahoo, P.C. and Maharana, T.(1984). Taxonomy, flower biology and crossability study in Momordica species. Bhubaneswar Research Thesis H.Sc.(Ag) 1984.

Saimbhi, M.S. (1976). Effects of 2-chloro ethyl phosphonic acid on the growth and sex expression of bitter gourd (M. charantia L). Haryana J. of Hort Sci. 4 (3/4) 157-160.

Sankhla, N. (1971). Effect of morphactin on leaf morphology & tendril formation in M. charantia L. Current Sci. 40, 140-141.

Sensarma, P. (1955). Tendril of Cucurbitaceae, their morphological nature an anatomical evidences. Proc. Natl.Inst. Sci.India. 21.161-0.

Shafeat, M. and Thobana, R. (1980). Metaxenia effects in date palm fruit, Zeitrone zur. Tropischen Landwirtschaft und veterinarmedizin 18(2) 117-123.

Singh, D.(1963). Studies on the structure and development of seeds of Cucurbitaceae, phytomorphology. 2 : 72.

Singh H.N., Srivastava, J.P. and Prasad, R. (1977). Genetic variability and correlation studies in bitter gourd. Indian Jour. Agril. Sci. 47 (12) : 604-7.

Singh, N.(1978). Parthenocarpy in Trichosanthes Dioica and T. dioica Current Sci. 47(19)735-36.

Srivastava, V.K. (1972). Studies in bitter gourd seed production. Indian J. of Hort. 29(2) 206-211.

Stanesvic, A.S (1971). Metaxenia in the sweet cherry. The effect of pollen of parental variety on the time of ripening of some varieties of sweet cherry. Jugoslovenskin Vocarstvo 15 (5) : 11-17.

Trivedi, R.N. and Roy, S.P. (1973). Cytogenetics of M. charantia and its polyploids, Cytologia 38 (2) 317 - 325.

Vijay, O.P. (1978). Note on sex percentage on dioecious Kakrol, Current Res. 7(10) 174.

Vijaya, O.P.; Jalikop, S.N. and Nath, P.; (1977). Studies on the floral biology in Kakrol (M. charantia Spreng, Indian J. of Hort. 34 (3) 234-38.

Walkley, A.H and Black, I.A. (1934). Determination of organic carbon. Soil Sci. 37 : 29-31.

Wall, J.N. and York, T.L. (1960). Genetic diversity as an aid to interspecific hybridization in Phaseolus and in Cucurbita. Proc. Amer. Soc. Hort. Sci. 75 : 419-26.

Wanjari, K.B. and Phadnis B.A. (1971). Flowering behaviour of colchicine induced seeto tetraploids in cucurbits. Sci. & Culture. 137(12)574-576.

Mallung, F. (1955). Zutcher 25 : 33-57

Whitaker, T.W. (1931). Sex ratio and expression in cultivated cucurbits Amer. J. Bot. 18 : 350-65.

Whitaker, T.W. and Bohn, G.W. (1950). The taxonomy, genetics, production and use of cultivated species of Cucurbits. Econ. Bot. 4 : 52-81.

Whitaker, T.W. (1952). Natural cross pollination in Muskmelon; Proc. Amer. Soc. Hort. Sci. 60 : 301-306.

Whitaker, T.W. and Davis, G.N.(1962). Cucurbits. Interscience Sci. pp.63.

Yasuda, A. (1903). On the comparative anatomy of the Cucurbitaceae, wild and cultivated in Japan. 18, 1-66.

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APPENDIX

Table on analysis of variance for fruit characters.

Sources of variation	Degree of freedom	Individual fruit weight(gm)	Length of fruit (cm)	Diameter of fruit (cm)	Rind thickness (cm)	Day required for fruit development.
Replication	4	31.883	0.266	0.034	0.078	1.626
Treatment	3	2479.036**	40.500**	3.179**	10.605**	56
Error	12	19.506	0.439	0.022	0.075	4.702
Total	19					

APPENDIX II

Table on analysis of variance for fruit quality.

Source of variation	Degree of freedom	Total no. seeds per fruit	No. of perfect seeds per fruit	No. of rodimentary seeds per fruit.
Replication	4	3.175	3.35	0.2
Treatment	3	751.533**	1057.65**	86.85**
Error	12	6.075	36.94	4.1
Total	19			

Table analysis of variance on seed character.

Sources of Variation	Degree of freedom	Hundred seed weight	Cotyledon weight (%)	Seed coat weight (%)
Replication	4	0.147	3.393	3.393
Treatment	3	243.007**	178.731**	178.731**
Error	12	0.113	2.556	2.556
Total	19