PART I

EVALUATION OF TUR [*Cajanus cajan* (L.) Millsp.] GERMPLASM FROM MAHARASHTRA

PART II

CYTOGENETIC ANALYSIS AND EVALUATION OF SOME TUR [*Cajanus cajan* (L.) Millsp.] MUTANTS

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH

(AGRICULTURAL UNIVERSITY)

RAHURI, District : Ahmednagar,

(Maharashtra State)

In partial fulfilment of the requirements for the degree of

Master of Science (Agriculture)

in

Botany : Cytogenetics & Plant Breeding

By

Shankar Babu Gundewadi

B. Sc. (Agri.)

DEPARTMENT OF BOTANY

Post - Graduate School, Rahuri

May, 1975

Part-I

EVALUATION OF TUR (*Cajanus cajan*(L)Millsp.) GERMPLASM FROM MAHARASHTRA

Part-II

CYTOGENETIC ANALYSIS AND EVALUATION OF SOME TUR (*Cajanus cajan* L Millsp.) MUTANTS

By

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B.Sc.(Agri.)

A Thesis
Submitted to the
Mahatma Phule Krishi Vidyapeeth
Rahuri, Dist. Ahmednagar (Maharashtra)
in partial fulfilment of the requirements for the degree of
MASTER OF SCIENCE (AGRICULTURE)
in
CYTOGENETICS AND PLANT BREEDING
May, 1975

Approved by the Advisory Committee :

Research Guide (Dr. Y.S. Nerkar)

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Member (Dr. N.K. Sawant)

CERTIFICATE

This is to certify that the thesis entitled "Part I - Evaluation of tur (Cajanus cajan L. Millsp.) germ plasm from Maharashtra and Part II - Cytogenetic analysis and evaluation of some tur (Cajanus cajan L. Millsp.) mutants," submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirement for the degree of Master of Science (Agriculture) in Cytogenetics and Plant Breeding by Shri Shankar Babu Gundewadi, embodies the results of bonafide research work carried out by him under my guidance and that no part of the thesis has been submitted for any other degree or publication.

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Dated : 31st May, 1975.

ACKNOWLEDGEMENTS

I take this opportunity to acknowledge and express my gratitude towards Dr. Y.S. Nerkar, Plant Breeder, Department of Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri and research guide for his profound interest in this research, constructive criticisms and encouragement throughout the course of the investigation and in preparing this dissertation.

I am indebted to Dr. R.A. Sangave, Head of the Department of Botany and Dr. V.R.Kale, then Head of the Department of Botany and now Associate Dean (Research), Mahatma Phule Krishi Vidyapeeth, Rahuri, for providing facilities for this work.

I am indebted to Dr. N.K. Sawant, Associate Professor of Agricultural Chemistry and Soil Science, Post-Graduate School, Rahuri for his versatile advice and help during this investigation.

Thanks are also due to Dr. S.S. Tamhan, Animal Breeder, Department of Animal Science and Dairy Science and Shri V.R. Karandikar, S.V. Mahajan, Associate Professors of Statistics for their valuable suggestions regarding the statistical part of the manuscript.

I am also grateful to Prof. D.C. More, Associate Professor, R.D. Deshmukh, Asstt. Professor and the other members of Botany Department, Post-Graduate School, Rahuri, for their help and co-operation.

I sincerely acknowledge the help rendered by my friend J.D. Vibhute, M.Sc. student and all staff members of Pulse Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Finally, I avail this opportunity to thank Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, for awarding me merit scholarship that was great help to me during my post-graduate studies.

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INTRODUCTION

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CHAPTER I

INTRODUCTION

Pulses occupy a unique position in Indian Agriculture as they not only provide the high protein component of the average diet but also restore the fertility of Indian soils in the absence of adequate manuring by virtue of their symbiosis with the nitrogen fixing *Rhizobia*. Pulses offer perhaps the only, and certainly the most practical, means of solving the protein-malnutrition problem in India at the present stage, as it may take many years to bring about a major advance in the production of high protein foods of animal origin (Swaminathan and Jain, 1973). These crops also derive their importance from their relatively low water requirement, because of which they occupy a significant position in dryland agriculture.

Unfortunately, the pulse yields remain at a low level and pulse production is either stagnant or dropping. The per capita per day availability of pulses in Maharashtra State is 39.4 gm as against the requirement of 89.2 gm in a balanced vegetarian diet. This demands shooting up of the present yield level of 335 kg per hectare to 724 kg in the immediate future as the possibility of extending area under pulses is meagre. By the turn of the century the present State population of 590 lakhs is likely to get almost doubled and so also the demand for pulses.

Tur (*Cajanus cajan*) is the most important pulse crop of Maharashtra State. Maharashtra ranks first in the Indian Union as far as area under this crop is concerned. The area and production of tur in the State are 5.09 lakh hectares and 1.99 lakh tonnes respectively (1972-73). However, the productivity remains as low as 392 kg per hectare. Substantial increase in the productivity of this crop could only be brought about by collecting and evaluating diverse germ plasm and using suitable parents with wide genetic base in the crossing to build up a diverse gene pool.

Cajanus has been reported to occur in the wild state in Africa, in the region of the upper Nile and the coastal districts of Angola. It was found in the Egyptian Tombs of the twelfth Dynasty (2200-24 B.C.). Hence, Watt (1908) concluded that *Cajanus* might have been native of Africa. However, Vavilov (1951) considered India as the origin of *Cajanus*. The first archaeological record in India comes from Satavahan Bhokardan which dates to 200 B.C. - 200 A.D. (Kajale, 1974). Nearly complete chromosome homology has been reported between *Cajanus* and *Atylosia*, a wild plant growing in the Western Ghats of Maharashtra (Kumar and Thombre, 1956). Notwithstanding the controversy regarding the centre of origin of *Cajanus*, it would be worthwhile to evaluate the wealth of diverse types of Cajanus being grown in different parts of the State and to extract hitherto unexplored useful genes.

The discoveries of the high lysine 'opaque2' and 'floury-2' mutants of maize (Mertz et al., 1964; Nelson, et al., 1965) and the high protein and lysine gene 'Hiproly' in barley (Hageberg and Karlson, 1969) have stimulated the search for genes concerning the nutritional aspects of important cultivated crops.

With the objectives discussed in the preceding paragraphs, 180 cultures of tur selected from the local collection from Maharashtra and 19 spontaneously occurred tur mutants were screened for economic characters and seed protein content. Some of the mutants exhibit a syndrome of characters and some degree of sterility. Hence, they were suspected to be associated with chromosomal anomalies. They were, therefore, subjected to cytogenetical analysis. The results obtained in this investigation are presented in this dissertation.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

I) Cytological studies

Basudeo Roy (1933) was the first to report the somatic chromosome number of pigeon pea as 2n=22. This number was confirmed by the studies of Krishnaswami and Rangaswami (1935), Naithani (1941), Pathak and Yadav (1951), Kajjari (1956) and Joglekar and Deshmukh (1958). From their cyto-taxonomic studies Deokar and Thakar (1956) reported that the diploid chromosome number of *Cajanus indicus*, *Atylosia lineata* and *A. serica* is 22. Recently Akinola *et al.* (1972) also reported that in pigeon pea 2n number is 22.

II) Polyploidy

Kumar *et al.* (1945) induced auto-tetraploidy by the application of colchicine in arhar. Due to multivalent formation in meiosis, tetraploid was partially sterile. Pathak and Yadav (1951) observed spontaneously originated hexaploid and tetraploid plants. Hexaploids were sterile and tetraploids were partially sterile. D'Cruz and Jadhav (1972) reported aneuploidy (2n+1) with 23 chromosomes, pairing being irregular.

III) Mutations

Singh *et al.* (1942) described a mutant having obcordate leaves with obtuse or mucronate leaf apex.

They named it as <u>Cajanus obcordifolia</u> Singh. Deshpande and Jeswani (1952) observed a prostrate mutant with weak stem and branches and prostrate habit of growth.

Chaudhari and Patil (1953) reported a creeping mutant in <u>Cajanus cajan</u> which put forth all its lateral branches close to ground. The stem and branches were weak, giving creeping appearance. Pandya et al. (1954) observed two mutants in the progeny of a cross between I-24 and 101 W.S. : (i) " Round leaf mutant " having obvate leaflets with rounded base and apex, and (ii) " Tiny leaf mutant " which was dwarf, early maturing and having small leaflets.

Kajjari (1956) reported a mutant with obcordate leaflets and keel petals united at top. Further, its pistil was polycarpellary and apocarpus.

Joglekar and Deshmukh (1958) reported two mutants (i) Unifoliate (simple leaf) and (ii) Oval-oblong trifoliate (compound leaf) which they considered as new varieties i.e. <u>Cajanus cajan</u> var. <u>unifoliata</u> and <u>Cajanus cajan</u> var. <u>oval-oblongtrifoliata</u>.

Deshmukh (1959) observed two mutants in tur. One of them was tall, unbranched, sterile and with bigger leaflets, while in the other, which also was sterile, the flower buds developed into branches, having threadlike sepals. Deshmukh and Phirke (1962) observed a flat pod mutant in <u>Cajanus cajan</u>. Abrams and Velez-Fortuno (1962) isolated a number of mutants in the variety 'Kaki' following irradiation with gamma rays and neutrons.

Pathak and Singh (1964) reported a new sterile mutant which was bushy, taller than the parent and xerophytic in nature. Bhatnagar <u>et al</u>. (1967) observed a fasciated mutant with purple colouration on the stem, which was weak and curved in several places. The branches were fused with the main stem at the place of emergence.

IV) <u>Anthesis and Pollination</u>

Howard <u>et al</u>. (1919) observed that under Pusa conditions, the flowers opened at any time during the day from 9 a.m. to 5 p.m. and remained open for about a day and half. In bud the anthers burst a day before opening of flowers. Though cleistogamy is a rule in this crop, natural cross-pollination brought about by bees and other insects was found to be common. Howard found 2.25 to 12 per cent crossing in this crop. Similar were the observations of Mahata and Dave (1931). Shaw <u>et al</u>.(1933) reported that natural crossing, brought about by insects, ranged from 0.15 to 7.59 per cent under Pusa conditions, the average being 3.4 per cent.

Kadam <u>et al</u>. (1945) found that under Niphad conditions cross-pollination in tur was to the extent of 15 per cent. They classified this crop under " Often cross pollinated group ". Subramanyam (1950) reported that anthesis took place between 9 a.m. to 10 p.m., the maximum rate of anthesis being between 10 a.m. to 12. noon.

Durga Prasad and Narsimha Murthy (1963) reported that the dehiscence of anthers took place at 36° to 40°C temperature. Abrams (1967) observed that cross pollination ranged from 5.47 to 6.33 per cent. Veerswamy *et al.* (1973 c) found that the maximum anthesis occured between 10 to 10.30 a.m. and gave maximum setting of pods.

V) Genetic Studies

1) Habit of growth

Krass (1927) was the first to study the inheritiance of different characters in pigeon pea. He found 1 tall : 2 intermediate : 1 dwarf segregation in the crosses of dwarf and tall types. D'Cruz *et al.* (1971) reported the ratio of 3 tall : 1 dwarf in the cross between obcordifolia and rahar.

Kumar and Thombre (1956) studied the intergeneric cross *Atylosia lineata* (semi-erect) x *Cajanus cajan* (erect). They found that semi-erect habit was dominant over the erect habit of growth. Deokar and D'Cruz (1972) studied the inheritance of growth habit in the cross between obcordifolia (N. black) and purple grained. They found 3 spreading : 1 erect segregation in F_2.

Deokar *et al.* (1972) reported that branching habit was governed by two complementary genes and obtained the ratio of 9 spreading : 7 erect. Markhede (1971) observed the ratio of 3 spreading : 1 erect in the cross between N.P. 82 and white grained type.

Deshpande and Jeswani (1952) observed that the segregation of normal and prostrate plant habit followed 3:1 segregation. Patil (1971) observed similar monogenic inheritance of 3 erect : 1 prostrate in two crosses, viz., tiny leaf x prostrate and prostrate x obcordifolia (N. black). Deokar *et al.* (1971) reported in a cross between creeping 3-2-8 and prostrate, three genes giving the ratio of 45 erect : 9 creeping : 10 prostrate. Shinde *et al.* (1972) reported the digenic ratio of 13 creeping : 3 erect in the cross between creeping 3-2-8 and red grained.

2) Leaflet number and shape

Divakaran and Ramabhadran (1958) detected a marker gene in *Cajanus cajan* which produced oblong leaflets with obovate apex.

Deshmukh and Rekhi (1960) studied the inheritance of leaf in tur and observed that the trifoliate condition and pointed apex of leaf were dominant over the unifoliate and roundish apex respectively. These two characters segregate on 9:3:3:1 ratio.

Deshmukh (1969) studied the inheritance of leaflet shape in the crosses between obcordifolia (N.Gr.) and arhar and obtained the ratio of 49 lanceolate : 15 obcordate. He concluded that two duplicate ($\underline{Obclt}_1$ and $\underline{Obclt}_2$) genes and one inhibitory (I $\underline{Obclt}$) gene were responsible for leaflet shape.

Patil (1971) reported the ratio of 9 oval : 3 lanceolate : 4 obcordate in the cross between the prostrate and obcordifolia (N.Bl.) mutants. Chaudhari (1973) observed a ratio of 39 lanceolate : 25 round in the cross round leaf x N.P.51.

3) <u>Stem colour</u>

Nayeem (1970) observed the ratio of 45 purple : 19 green in the cross of roundleaf with white grained. However, the studies of Pharande (1970), D'Cruz and Deokar (1970), Patil (1971) and D'Cruz et al.(1971) indicated monogenic dominance of purple colour over green colour of stem. Veerandaj (1973) studied the inheritance of stem colour in the crosses obcordifolia (N.Bl.) x N.P.82, and obcordifolia (N.Gr.) x N.P. 51 and obtained the ratio of 9 purple : 7 green. He also reported the ratio of 3 purple : 1 green in the cross between creeping 3-2-8 and N.P. 82. Mujawar (1973) observed the ratio of 3 purple : 1 green in the cross obcordifolia (N.Bl.) x arhar, and gave the gene symbol 'Pst' for stem colour.

4) Flower colour :

Shaw et al. (1933) observed 15 types of flower colour in tur. Dave (1934) stated that the flower colour in tur was generally either plain yellow or with yellowish red veins. In addition to these, three other forms viz., orange, purple and yellow with purple veins and diffused purple base were also found by him.

Patil and D'Cruz (1962) studied the inheritance of white flower colour and obtained the ratio of 49 yellow : 15 white. Pharande (1970) reported the ratio of 9 purple with yellow strips : 3 purple : 4 yellow for colour on the dorsal surface of standard.

Deokar and D'Cruz (1972) observed the ratio of 9 orange yellow : 7 yellow, for colour of ventral surface (V.S.) of standard petal while the colour of dorsal surface (D.S.) of standard petal showed the ratio of 3 orange yellow : 1 yellow. Mujawar (1973) observed the segregation for colour of V.S. of standard petal as 3 orange yellow (with diffused purple base) : 1 yellow. Jambhale (1973) reported the segregation for the colour of V.S. of standard as 207 yellow : 49 white.

5) Pod colour

Krass (1927) reported the dominance of maroon, blotched pod colour over self coloured light tinted.

Deshmukh (1969) observed the ratio of 39 greenish black : 25 green with purple streaks in the cross creeping 3-2-8 x white. In another cross, obcordifolia (N.Gr.) x arhar, he observed the ratio of 3 green with purple streaks : 1 green. Nayeem (1970) found the ratios of 15 green with black streaks : 1 green with purple streaks for raw pod colour, and 3 maroon : 1 plain for the colour of dry pods in the cross between dwarf and creamy-white. Deokar et al. (1972) reported that pod colour was controlled by two complementary, one inhibitory and one anti inhibitory genes. They obtained the ratio of 117 purple with green streaks : 139 green with purple streaks. Shinde et al. (1972) found the ratio of 3 black diffused : 1 black streaked. Teerandaj (1973) observed the ratio of 9 green with purple patches : 3 green with streaks : 4 green with diffused purple colour for raw pod colour in the cross creeping 3-2-8 x N.P. 82.

6) Seed coat colour

Dave (1934), in the cross of white and purplish black seed coat colour, reported that F_1 was having purplish black seed and F_2 segregated into 9 purplish black : 3 white with purple spot : 3 brown : 1 white. Thus, the inheritance of seed coat colour was determined by the interaction of two genes.

Ahire (1967) observed the ratio of 9 red : 7 light red, in the cross unifoliate x obcordifolia (N.Gr.). In another case he observed the ratio of 45 light brown : 19 white, in the cross obcordifolia (N. Gr.) x obcordifolia (Delhi). Deshmukh (1969) found 3 brown : 1 white segregation in one cross and 9 fawn : 3 brown : 4 white in another. Patil (1971) also reported 9 fawn : 3 brown : 4 white in the cross tiny leaf x prostrate. Pharande (1970) confirmed the same ratio in the cross white grained x obcordifolia (N. Gr.). In the cross creeping 3-2-8 x prostrate, Deokar et al. (1971) observed the ratio of 3 brown : 1 white. Patil et al. (1972) reported the ratio of 63 reddish brown : 1 white. In the cross between creeping 3-2-8 and purple grained, Chaudhari (1973) obtained the ratio of 3 purple : 1 brown. In another cross, purple grained x N.P. 64, he observed the segregation of 45 purple : 19 brown.

7) Linkage studies :

Kross (1927) reported a linkage between certain characters like flower colour, pod colour, seed coat colour, seed shape, pod size and position of inflorescence. Dave (1934) detected a complete linkage between orange yellow flowers and purplish black seeds.

Several workers have detected linkage between different characters in different crosses which are listed below.

Author	Cross	Characters linked
Patil and D'Cruz(1965)	Creeping 3-2-8 x Round leaf	Growth habit with pod colour.
Deshmukh (1969)	Creeping 3-2-8 x White; Obcordifolia (N.Gr.) x Arhar	Pod colour with seed coat colour; vein colour on dorsal surface of standard with pod colour and seed coat colour.
Pharande (1970)	N.P. 82 x Obcordifolia (N.Gr.)	Stem colour with leaflet shape.
Aher (1970)	Roundleaf x N.P. 82	Branching habit with leaflet shape, seed coat colour and stem colour.
Chaudhari (1973)	Creeping 3-2-8 x purple grained; Round leaf x N.P. 51	Colour of D.S. of standard petal with seed coat colour; Leaflet shape with vein colour, leaflet shape with seed coat colour.
Mujawar (1973)	Prostrate x Arhar	Vein colour with habit of growth and seed coat colour
	Arhar x purple grained	Colour of V.S. of standard petal with seed coat colour.
Narkhede (1971)	N.P. 82 x Red Grained	Seed coat colour with seed shape; seed coat colour with length of petiolule; seed shape with length of petiolule; Seed shape with leaflet shape, Length of petiolule with pod constriction

VI) Yield and yield components

Abrams *et al.* (1969)reported that yield, date of flowering, plant height and seed weight were more influenced by the interaction of variety x year than the interaction of variety x location x year. Ganguli and Shrivastava (1969) observed a wide range of phenotypic variation in the number of leaves, pods and seeds per plant plant height and seed yield per plant and a narrow range in the number of total and fruiting branches per plant, pod length, number of seeds per pod and 100 seed weight

Dasappa and Mahadevappa (1970) reported that plant spread and number of pods per plant were significantly correlated with yield of seed per plant. Sharma *et al.* (1971) stated that yield was positively correlated with spread of the plant, number ofsecondary branches, effective pod bearing length and pod number.

Munoz and Abrams (1971) observed that seed yield was highly positively correlated with number of pods per plant, to a lesser extent positively correlated with plant height and 100-seed weight and was negatively correlated with days to flowering.

Khan and Rachie (1972) reported that seed yield was positively correlated with plant width, length of main branch, number of pods per main branch and per plant, threshing factor and grain : straw ratio. Lochar and Nigam (1972) reported that seed yield per plant was correlated positively with number of branches per plant. They also reported that there was positive correlation between number of branches and number of pods per plant. Veeraswamy et al. (1973 b) reported that number of branches, clusters of pods and pods per plant were main characters which contributed to yield of red gram. However plant height and number of days to flower were also useful as phenotypic indices for selection.

Soloman et al. (1957) obtained 24.5 per cent hybrid vigour for grain yield in tur. Veeraswamy et al. (1973 a) studied intervarietal hybrids and observed heterosis for plant height, plant spread, number of branches, number of clusters, number of pods and days to 50 per cent flowering.

Sharma et al. (1973) studied general and specific combining ability in a diallel set. They observed higher heterotic effect for plant height and seed yield. The general combining ability variances showed predominance of additive gene action.

VII) Quality aspects

Pal (1939) reported that red gram contains fairly good amount of the amino acids, lysine (7.03 per cent) and Arginine (5.84 per cent). Thorat (1955) reported that there was wide range of variation for protein and coocking quality.

Shankaran and Shrinivasan (1963) reported that the exotic type M.S. 9311 was poorer in coocking quality than SA.1. They also observed that the medium and small sized dals coocked easily as compared to the big sized ones. Sanchez-Nieva *et al.* (1960) observed that when pigeon pea matures, there was an increase in the starch, alcohol-insoluble solids and total solids content and in specific gravity and decrease in the intensity of green pigment. Krober *et al.* (1970) reported that in pigeon pea, the differences due to variety were about as great as those due to locations and both variety and location had significant effect on the protein content.

Singh *et al.* (1971) reported that protein content was not affected by dates of sowing, plant population or row spacing. Pietri *et al.* (1971) reported that the fertilizer treatments had no effect on protein content of dry seed of tur.

Singh *et al.* (1974) reported that there were significant genotypic effects and genotypic x season interactions. None of the quality characters were associated with seed size and days to maturity. Heritability values for protein, methionine and tryptophan were 57, 70 and 79 per cent respectively.

VIII) Response to G.A.

Abrams (1960) reported that the effect of gibberellic acid on plant height, flowering period and yield of green pods of pigeon pea was non-significant.

CHAPTER III

MATERIALS AND METHODS

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CHAPTER III

MATERIAL AND METHODS

Part-I

Material

The material for the Part-I of this investigation consisted of 180 cultures of tur selected from the local germplasm collection being maintained by the Pulses Improvement Scheme of Mahatma Phule Krishi Vidyapeeth, Rahuri. The names of the cultures are listed in Table 1.

Table 1 : Germplasm cultures used for the investigation.

Sr. No.	Name of the culture	Sr.No.	Name of the culture
M-1	74	M-15	124-10-19-1
M-2	84	M-16	132-U-3-4
M-3	43	M-17	112-4-20-A
M-4	45	M-18	3-71
M-5	112-2-1	M-19	4-1-1
M-6	112-2-2	M-20	101-W-2-22-A
M-7	111-13-14	M-21	101-WS
M-8	116-2-5-34	M-22	Gwalior-40
M-9	106-B-9	M-23	M-23-10
M-10	106-B-9-2	M-24	M-82-2
M-11	116-1	M-25	39-27
M-12	126-1	M-26	7-10-11
M-13	126-WS	M-27	7-14-3
M-14	101-W-4-7	M-28	7-10-4

Cont'd

Table 1 (Contd.)

Sr. No.	Name of the culture	Sr. No.	Name of the culture
M-29	5-18-4	M-53	170-4
M-30	5-18-7	M-54	196-6
M-31	31-23	M-55	101-B-14
M-32	31-25	M-56	3-35
M-33	76-18-1	M-57	3-36
M-34	76-18-2	M-58	41-9-2-4
M-35	36-22-B	M-59	M-282-7
M-36	36-22-W	M-60	M-290-21
M-37	36-2-Br	M-61	288-20
M-38	36-2-W	M-62	228-3
M-39	36-3-	M-63	249-16
M-40	31-21-Br	M-64	238-12-1
M-41	21-21-W	M-65	238-12-2
M-42	76-9-1	M-66	252-11
M-43	76-12-Br	M-67	258-52
M-44	76-17	M-68	238-11
M-45	76-2	M-69	240-8
M-46	76-9-2	M-70	248-13
M-47	76-9-3	M-71	251-14
M-48	148-12	M-72	223-15
M-49	157-4	M-73	258-2
M-50	159-5	M-74	246-3
M-51	165-11	M-75	244-39
M-52	56-1	M-76	255-35-Br

Cont'd

Table 1 (Contd.)

Sr. No.	Name of the culture	Sr. No.	Name of the culture
M-77	259-35-W	M-101	T
M-78	237-14	M-102	C-132-1-11-4-5
M-79	73-1 (C x M type)	M-103	Minani 3-8-1-4-3-11-A
M-80	90-1 (C x M type)	M-104	Barchi
M-81	104-A (C x M type)	M-105	Dhulia-3-25
M-82	112-A (C x M) type)	M-106	Dhulia-4-45
M-83	M-7-B	M-107	Dhulia-5-84
M-84	M-4-N	M-108	Dhulia-54
M-85	A	M-109	Strain 14-15-15-1
M-86	B	M-110	Strain Vijapur
M-87	C	M-111	Strain-141-31
M-88	D-1	M-112	Pusa-2-30
M-89	D-2	M-113	M-132(U.P.)
M-90	F	M-114	P-132(U.P.)
M-91	G	M-115	[illegible]-66 (Blackish)
M-92	H-br	M-116	[illegible]-66-W
M-93	1-1-115-W	M-117	[illegible]-58
M-94	J	M-118	Kanpur-140
M-95	L	M-119	Kanpur-147
M-96	M	M-120	M-1-40-5
M-97	N	M-121	[illegible].1 - Red grain
M-98	P	M-122	[illegible]-1(U.P.)
M-99	R	M-123	[illegible]-5-69
M-100	S	M-124	Prostrate

Cont'd

Table 1 (Contd.)

Sr. No.	Name of the culture	Sr. No.	Name of the culture
M-125	Round leaf	M-149	2-2-3-11
M-126	Creamy 9-1	M-150	3-1-3-1
M-127	Creamy-6	M-151	3-1-4-6
M-128	Obcordifolia	M-152	3-2-4-6
M-129	Partialsterile 24-8-1	M-153	8-1-6-5
M-130	Partial sterile 139-A	M-154	10-1-2
M-131	Partial sterile Prostrate	M-155	10-1-2-16
M-132	1-46-401(Louthen)	M-156	1-4-2-7
M-133	No.2	M-157	1-12-1-16
M-134	1-2-2-6	M-158	54-1-2
M-135	2-13-1-3	M-159	12-2-2-3
M-136	1-2-9-3	M-160	5-9-5
M-137	1-16-1-1	M-161	5-77-1
M-138	6-6-2-2	M-162	3-108-2
M-139	7-12-5-B	M-163	5-82-1
M-140	16-3-3-2	M-164	1-3-21
M-141	3-1-5-2	M-165	5-18-3
M-142	1-75-2-7	M-166	12-165-1
M-143	1-10-5-11	M-167	12-67-3
M-144	7-1-5-7	M-168	12-99-3
M-145	1-3-2-16	M-169	12-101-1
M-146	1-3-2-16	M-170	12-143-1
M-147	1-3-2-1	M-171	12-148-1
M-148	12-2-2-11	M-172	12-141-1

Cont'd

(Table 1 contd.)

Sr. No.	Name of the culture	Sr. No.	Name of the culture
M-173	12-146-2	M-177	49-1
M-174	12-1 6-2	M-178	50-1
M-175	3-1	M-179	5-3-1
M-176	3-3	M-180	5-5

Methods

Sowing

The experimental material was sown in the kharif season of 1973 in medium black soil, fertilized with 15 cartloads of F.Y.M., 20 kg N in the form of urea and 50 kg P_2O_5 in the form of single superphosphate per hectare. Two rows, each of 5 metre length, were sown per culture. The spacing between two rows was 2' and between plants within a row was 1'. Five plants were selected randomly in each culture for studying various characters.

Characters studied

1) Habit of growth

Habit of growth was noted at the time of maturity and culture were grouped broadly into following classes.

i) Erect (ii) semi-erect and (iii) spreading

2) Plant height

Height was recorded at maturity and was measured in centimetres from the soil surface to the tip of the main stem.

3) Leaflet shape

This was recorded before maturity on fully developed, representative leaf and cultures were grouped into following classes.

1) Linear (2) Lanceolate (3) Obovate/obcordate (4) Ovate and (5) Oval

4) Colour of stem

Observations on stem colour were recorded at the time of flowering. Stem was eighter light or dark purple or green in colour.

5) Flower colour

The colour of flower was noted when most plants flowered and when flowers were fully open. Colours of back of standard petal, veins and eye spot on the standard petal were also recorded.

6) Days to flowering

The date on which 50 per cent of plants in the plot had flowered was taken as date of flowering. From this the number of days for flowering was calculated.

7) Days to maturity

The number of days for maturity was calculated from the date of sowing and date of maturity. The date on which almost all of the pods were dry and ready for harvest was taken as date of maturity.

8) Number of pods per plant

Five plants of each culture were selected and on each of the selected plants all the pods containing seeds were counted.

9) Number of seeds per pod

On each of the selected five plants five fully developed pods were taken and number of seeds per pod were recorded.

10) Grain yield

The grain yield was recorded on plot basis from which yield per plant was computed.

11) Test weight

For this well developed 1000 grains of each culture were counted and weight was recorded.

12) Protein content

The nitrogen content was determined by Micro-Kjeldahl's method (A.O.A.C., 1964) as follows.

100 mg of powdered sample was transferred to micro-Kjeldahl's flask. To this were added 2 ml of 1 per cent salicylic acid (1 gm salicylic acid into 100 ml of conc. H_2SO_4), 1 crystal of sodium thiosulphate, 1 ml of 60 per cent perchloric acid and 2-3 drops of conc. $CuSO_4$ solution and the contents were digested. Digested material was transferred to distillation flask. To this were added 10 ml of 70 per cent NaOH. NH_3 evolved after distillation was collected

in 10 ml of 0.01 N HCl solution containing few drops of methylred indicator. After complete distillation the excess of the acid in the solution was titrated against 0.01 N NaOH solution.

$$\% N = \frac{(\text{ml of HCl} \times N) - (\text{ml of NaOH} \times N)}{\text{Weight of sample}} \times 0.014 \times 100.$$

A conversion factor of 6.25 was used to calculate protein content from the nitrogen content.

Statistical procedure

i) Analysis of variance

The numerical results were presented in an analysis of variance table. The gross variation was split up into variation between cultures and within cultures. The standard error of mean and significance of mean sum of squares by 'F' test were worked out (Steel and Torrie, 1960).

Analysis of variance table

Source of variation	d.f.	Sum of squares	Mean * squares	F
Between cultures	t-1			
Within cultures (Error)	t(r-1)	by subtraction		
Total	rt-1			

* Mean square is a sum of squares divided by corresponding d.f.

$$S.E. = \frac{S.D.}{\sqrt{N}}$$

$$C.D. = S.E. \times \sqrt{2} \times t \text{ at error d.f. at } 5\%$$

ii) Co-efficient of correlation

Karl Pearson's correlation coefficient formula was adopted to calculate the coefficients of correlation (Panse and Sukhatme, 1967).

$$r = \frac{\sum xy - \frac{(\sum x)(\sum y)}{N}}{\sqrt{\left\{\sum x^2 - \frac{(\sum x)^2}{N}\right\}\left\{\sum y^2 - \frac{(\sum y)^2}{N}\right\}}}$$

Where,

x and y are the variables

N = total population

r = coefficient of correlation

Significance of correlation was varified by the application of 't' tests reproduced below.

$$t \text{ (by calculation)} = \frac{r\sqrt{N-2}}{\sqrt{1-r^2}}$$

Where,

r = coefficient of correlation

n = number of paris of observations

Degrees of freedom for t are n - 2

iii) Multiple regression

The multiple regression of 3 independent variables viz., pod number, seed number and test weight on a dependent variable viz., yield was calculated by Abbreviated Doolittle method (Steel and Torrie, 1960).

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3$$

Where, Y = dependent variable

a = constant

b_1, b_2 and b_3 = partial regression coefficients

x_1 , x_2 x_3 = independent variables.

Part-II

Material

The material for the Part-II of this investigation consisted of 19 mutants of tur maintained in the Botany Section, College of Agriculture, Poona. The mutants are listed in Table 2.

Table 2 : Tur mutants used for the investigation.

Sr.No.	Code No	Name of the mutant
1	I-276	Prostrate
2	I-277	Tiny leaf
3	I-278	Creeping 3-2-8
4	I-279	Round leaf
5	I-280	Obcordifolia (M.P.)
6	I-281	Obcordifolia (M.Gr.)
7	I-283	Obcordifolia (Mutant)
8	I-284	Obcordifolia (Delhi)
9	I-285	White grain mutant
10	I-286	Red grain mutant
11	I-287	Monocarpel
12	I-298	Kanpur mutant
13	I-299	Serpentine
14	I-300	Dwarf
15	I-305	Unifoliate
16	I-309	Bifoliate
17	I-317	N.P. 82 (check)
18	I-320	Multifoliate
19	I-325	Bicarpel
20	I-326	Tricarpel

Methods

The material was grown in the same manner as that in Part-I and observations on morphological and economic characters were recorded in the similar manner. The mutants were also studied for meiotic behaviour pollen viability, seed protein content and response to gibberellic acid.

Cytological studies

Floral buds of suitable size were fixed in Carnoy's fluid (6 Absolute alcohol : 3 chloroform : 1 Acetic acid) between 11.15 and 11.45 a.m. The buds were kept in the fixative for 48 hours after which they were stored in 70 per cent alcohol. Anthers were dissected out and squashed in a drop of propiono-carmine. The slide was warmed judiciously over the flame of a spirit lamp for few seconds and coverslip was placed on the slide which was then examined under the microscope. Slides having satisfactory stages were sealed with paraffin. The slides were made permanent the next day as follows.

Sealing was removed and slide was kept inverted in fine ridged porscelein dish containing 45 per cent of propionic acid. Five minutes after the coverslip was detached from the slide, the slide and coverslip were passed through following series keeping in each for 3 minutes.

1) 1:1 propionic acid and n-butyl alcohol.

2) 1:3 propionic acid and n-butyl alcohol.

3) n - butyl alcohol.

The slide was dried by tapping over a blotting paper, a drop of Canada balsam was placed and coverslip was replaced in its original position. Photomicrographs were taken using PZO, Warszawa photographic microscope on 35 mm Agfa film (400 ASA) under the magnification of 12.5 x 100 x using the oil immersion lens.

Pollen viability

Pollen grains from mature anthers were collected on the slide and stained in a drop of propiono-carmine. Different microscopic fields were selected at random on the slide and filled (stained) and unfilled (shrivelled and unstained) pollen grains were counted. Pollen viability was expressed as percentage.

Response to G.A.

Gibberellic acid (GA) was applied as foliar spray at 150 ppm in three sprays, 4, 6 and 8 weeks after sowing respectively. Height of the untreated and treated plants was measured three weeks after the last spray.

The 't' test was used to test the differences in height of GA treated and control plants.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where,

$\bar{X}_1$ and $\bar{X}_2$ are two sample means

n_1 and n_2 are sample sizes

$$s^2 = \frac{(n_1 - 1)\ s_1^2 + (n_2 - 1)\ s_2^2}{n_1 + n_2 - 2}$$

s_1 and s_2 are sample S.D.

CHAPTER IV

EXPERIMENTAL RESULTS

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CHAPTER IV

EXPERIMENTAL RESULTS

Part-I

Nature of variation for different characters

The results obtained in this investigation are presented below. The characteristic features and mean values of each of the 180 cultures are presented in the Appendices I and II.

1) Habit of growth

Habit of growth was noted at the time of maturity. There were 7 erect, 139 semi-erect and 34 spreading types.

2) Plant height

The analysis of variance for plant height is given in Table 1, while the frequency distribution for different height groups is presented in Fig. 1.

Table 1 : ANOVA for plant height.

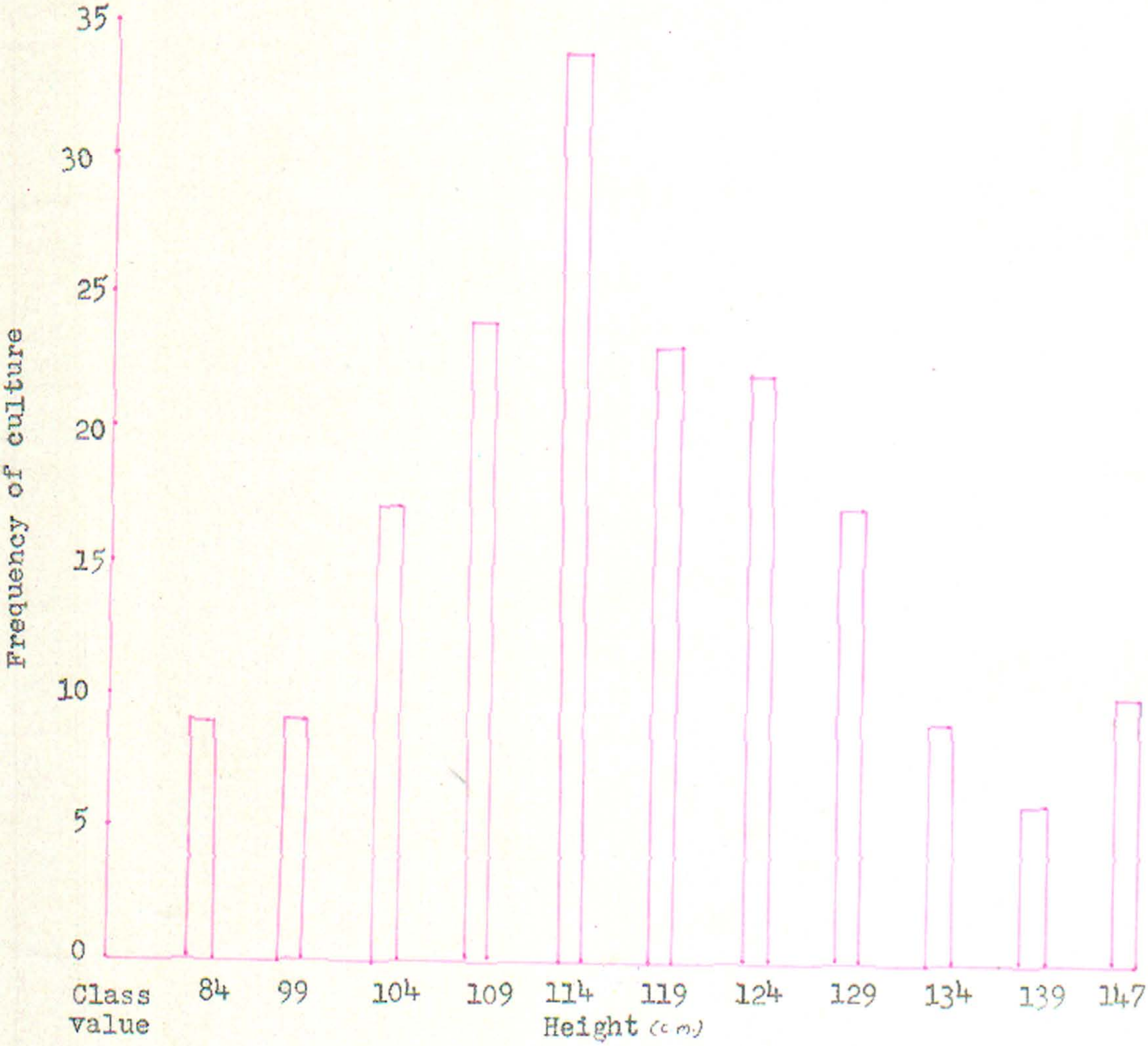
Source of variation	d.f.	S.S.	M.S.	F
Between cultures	179	163513.14	913.48	19.30 **
Within cultures	715	33842.40	47.33	
Total S.S.	894	197355.54		

** Significant at 1 per cent level.

From Table 1 it can be seen that differences among the cultural means in respect of height were highly

FIG.1

NATURE OF VARIATION FOR HEIGHT



significant. The range of variation for height was from 72 to 152 cm. The cultures were grouped into 11 classes of height. The maximum frequency of cultures was in the height group of 114 cm. The S.D. and C.V. were 13.98 cm and 11.98 per cent respectively.

3) Leaflet shape

There were five types of leaflet shapes. The distributionof the cultures according to leaflet shape was : 169 Lanceolate, 2 linear, 2 obovate/obcordate, 3 ovate and 4 oval.

4) Colour of stem

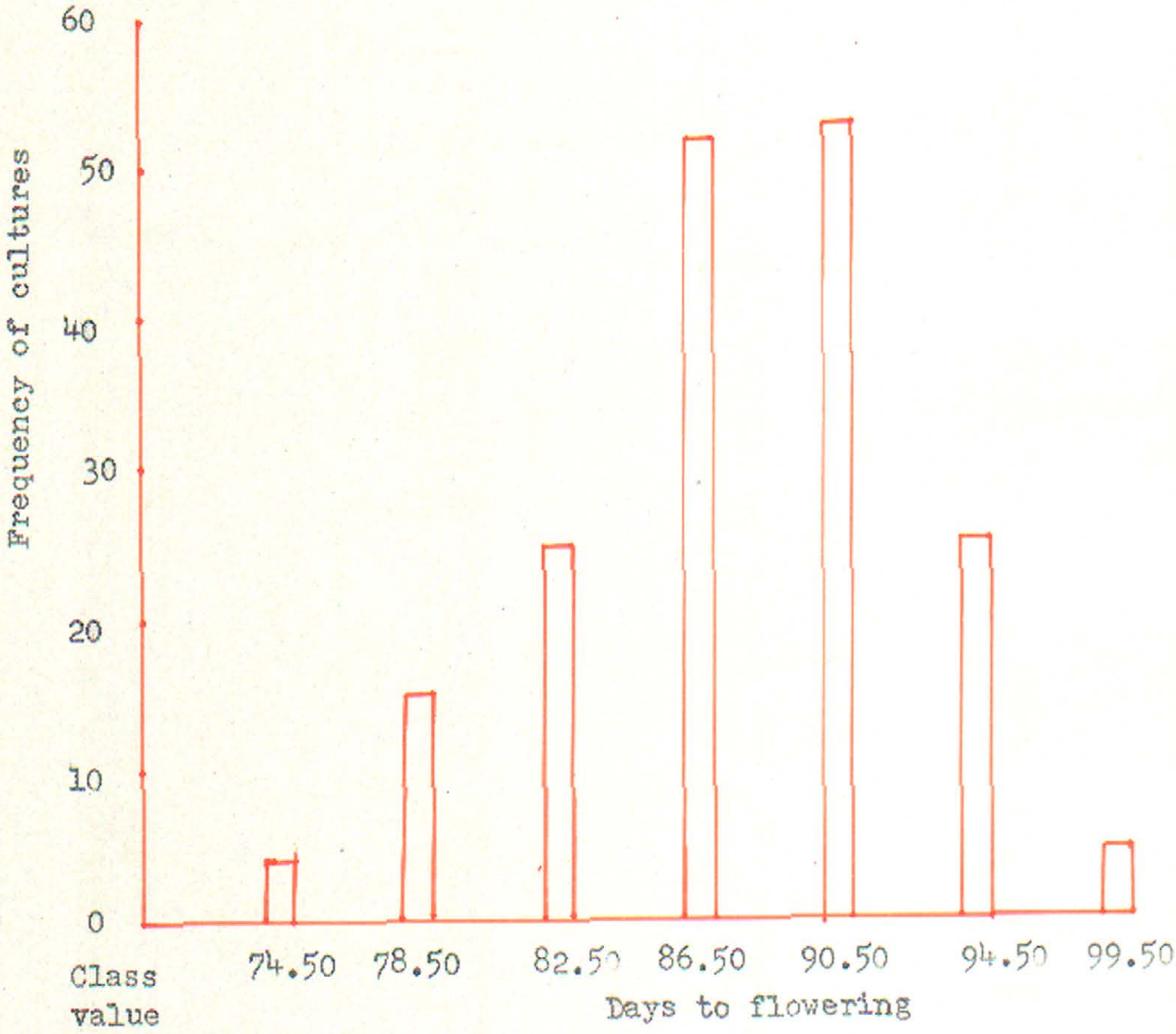
In tur there are two types of stem colours i.e. purple and green. However purple colour could be differentiated into light purple and dark purple. There were 111 cultures with light purple stem, 37 with dark purple stem and 32 with green stem.

5) Flower colour

There were only two types of flower colours viz., yellow and creamy while. But when colour of veins and eye spot on the back of standard petal were considered, there were 147 cultures with yellow flowers, 20 having yellow flower with red veins on the back of standard petal, 3 having yellow flower with eye spot on the back of standard petal, 8 having yellow flowers with red veins and eye spot on the back of standard petal. There were two cultures with creamy while flowers.

Fig. 2

NATURE OF VARIATION FOR DAYS TO FLOWERING



6) Days to flowering

Based on days to flowering, all the 180 cultures were grouped into 7 classes (Fig 2). The range of variation was from 73 to 102 days. There were only 4 cultures in the earliest group flowering within 73-76 days. The second group flowered in 77 to 80 days and there were 15 cultures. There were 25 cultures which flowered in 81 to 84 days. A total of 105 culures flowered in the range of 85 to 92 days. There were 26 cultures which flowered in 93 to 96 days. Five cultures flowered in 97 to 102 days. The S.D. and C.V.were 5.29 days and 6.00 per cent respectively.

7) Days to maturity

All the 180 cultures were grouped into 7 classes based on days to maturity (Fig 3). The range of variation was from 128 to 168 days. The first group consisted of 13 cultures maturing in 130 days. The second group consisted of 37 cultures maturing in 135 days. There were 34 cultures in the third group which matured in 140 days. There were 45 cultures with the maturity of 145 days. This was the largest group. 31 cultures matured in 150 days while 12 matured in 155 days. The last group consisted of 8 cultures maturing in 163 days. The S.D. and C.V.were 7.99 days and 5.50 per cent respectively.

8) Number of pods per plant

The analysis of variance for number of pods per plant is presented in Table 2.

Fig. 3

NATURE OF VARIATION FOR DAYS TO MATURITY

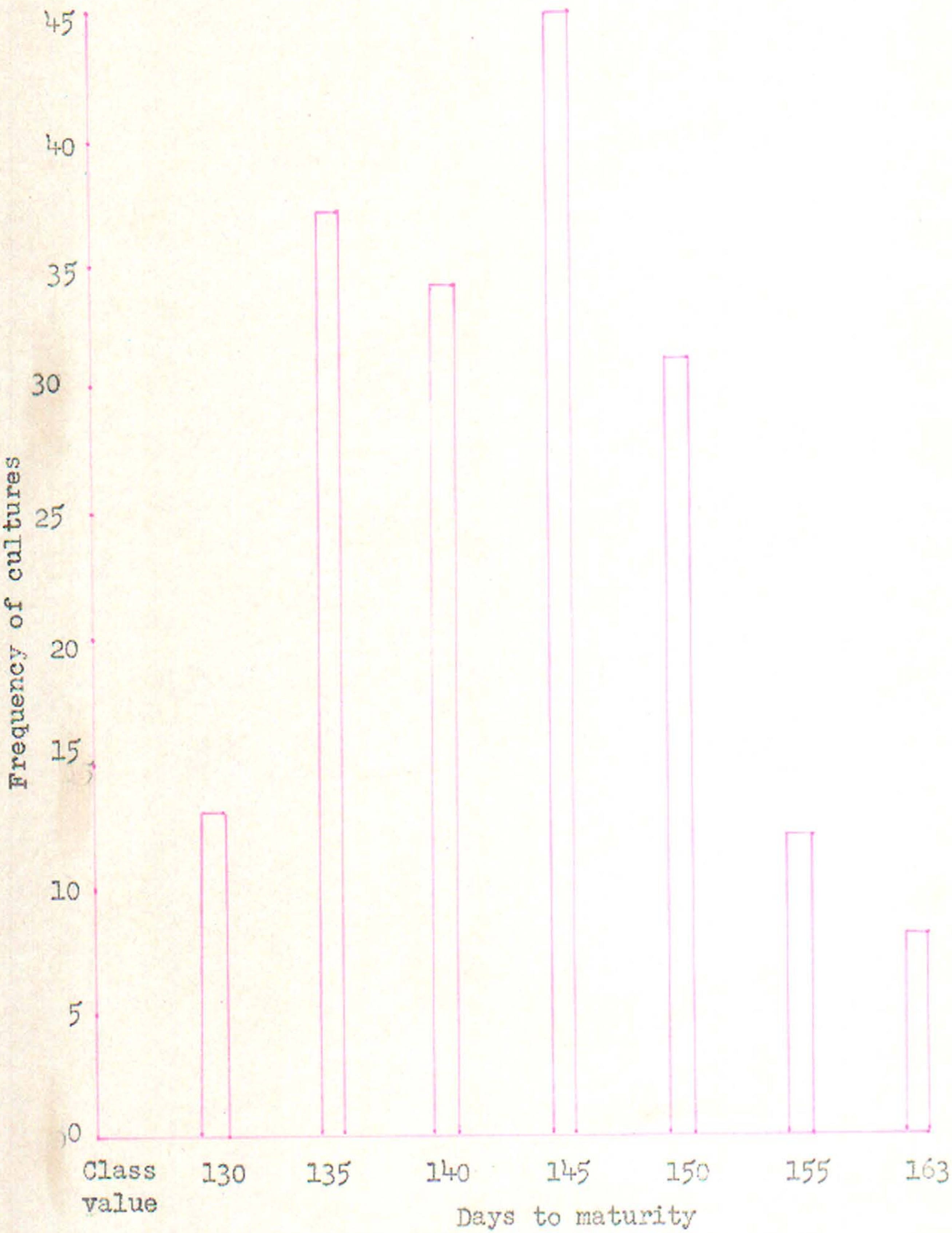


Fig.4

NATURE OF VARIATION FOR NUMBER OF PODS PER PLANT

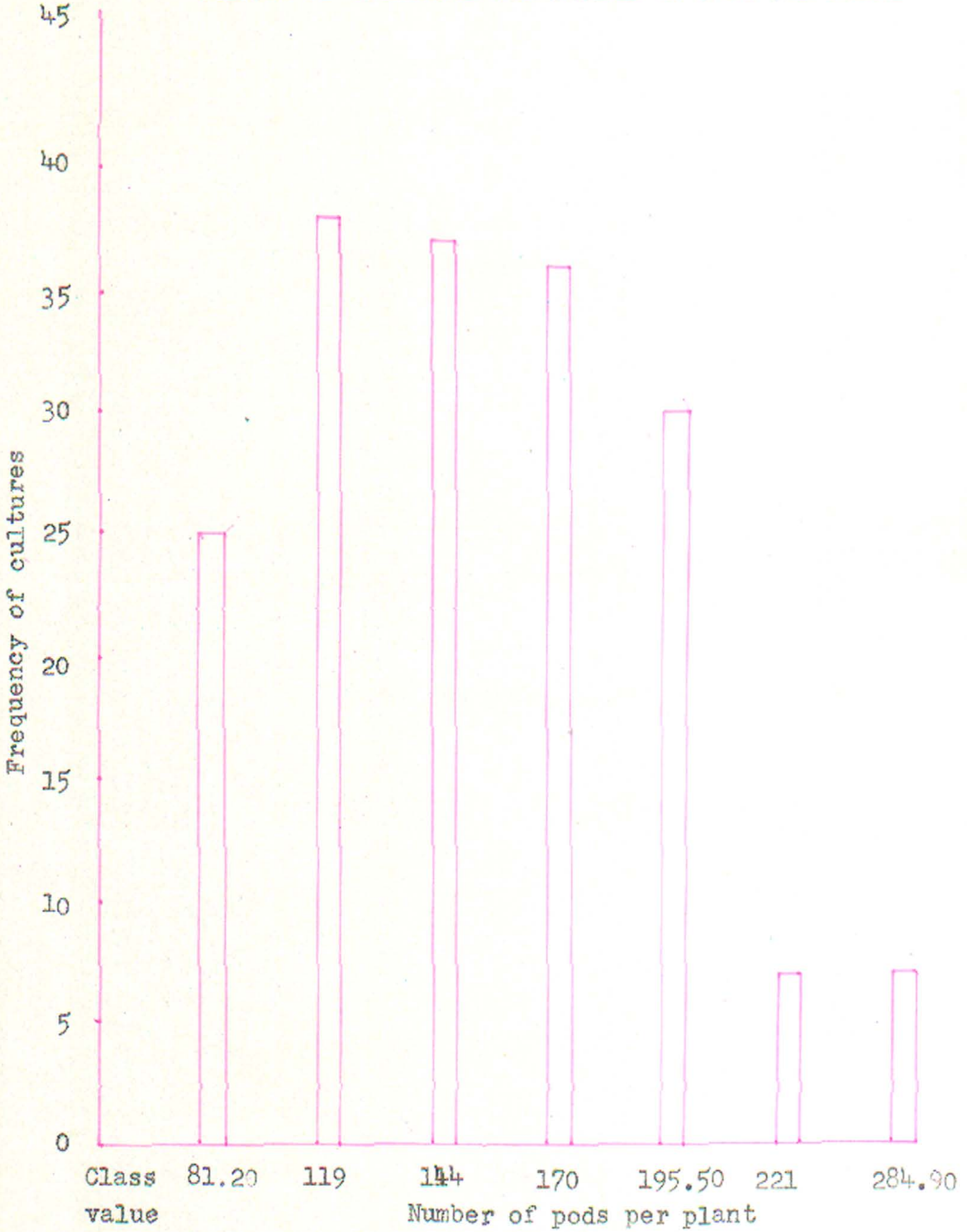


Table 2 : ANOVA for number of pods plant.

Source of variation	d.f.	S.S.	M.S.	F
Between culture	179	8895905.67	46697.7970	12.75**
Within cultures	715	2786931.00	3897.8064	
Total	894	11682837.27		

** Significant at 1 per cent level.

It is obvious from Table 2 that there existed cultural differences in respect of number of pods per plant. The frequency distribution for number of pods per plant is presented in Fig. 4. All the 180 cultures were grouped into 7 classes as per the C.I. The highest group had 284.9 pods while the lowest had 81.2 pods per plant. The modal class had 119 pods per plant. The S.D. and C.V. were 46.79 and 30.71 per cent respectively. The highest pod number of 336 was found in the culture 7-18-4 (M- 28).

9) <u>Number of seeds per pod</u>

The results of analysis of variance for number of seeds per pod are presented in Table 3.

Table 3 : ANOVA for seeds per pod .

Source of variation	d.f.	S.S.	M.S.	F
Between cultures	179	50.94	0.2845	3.23**
Within cultures	715	62.97	0.0880	
Total	894	113.91		

** Significant at 1 per cent.

Fig.5

NATURE OF VARIATION FOR NUMBER OF SEEDS PER POD

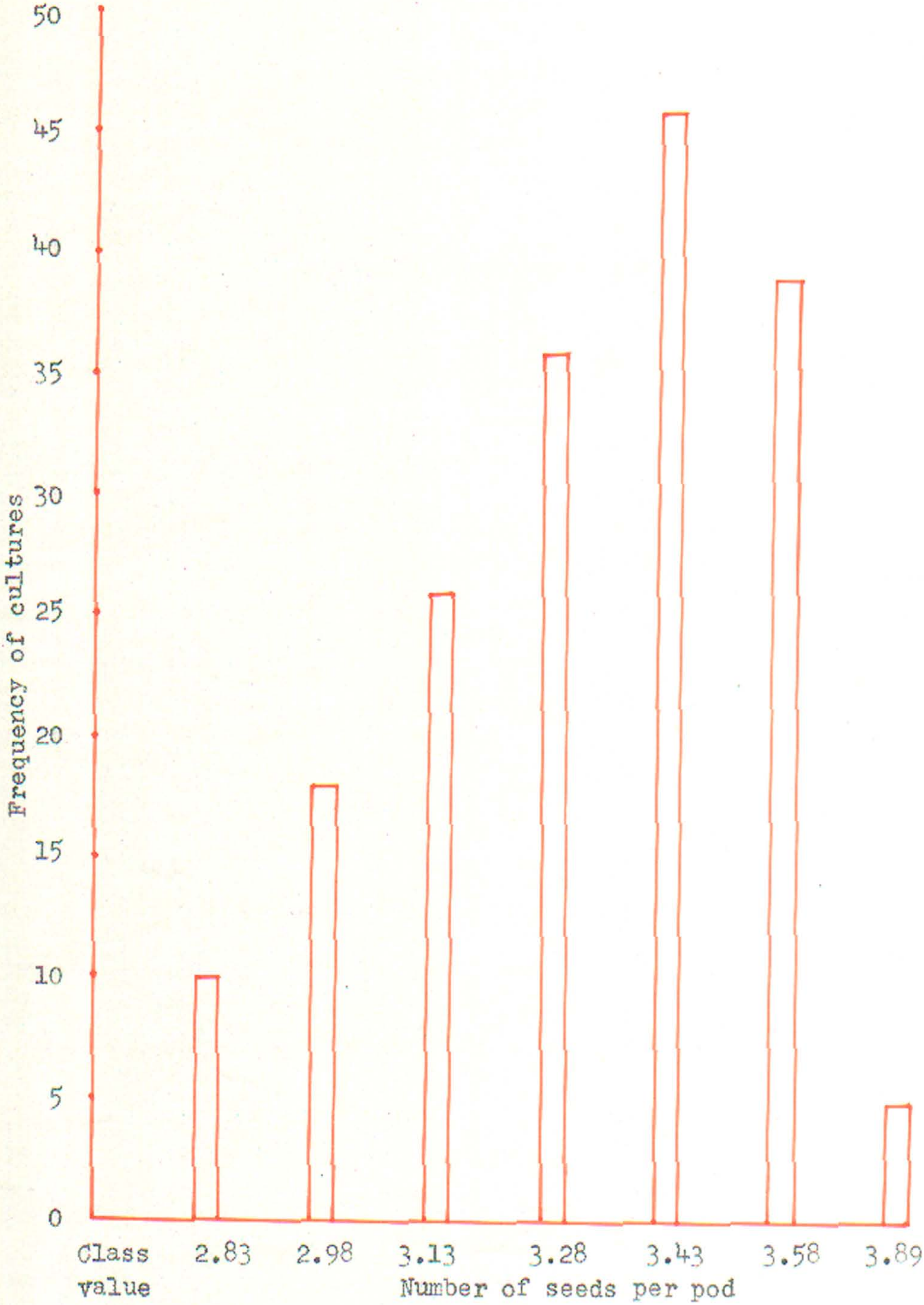
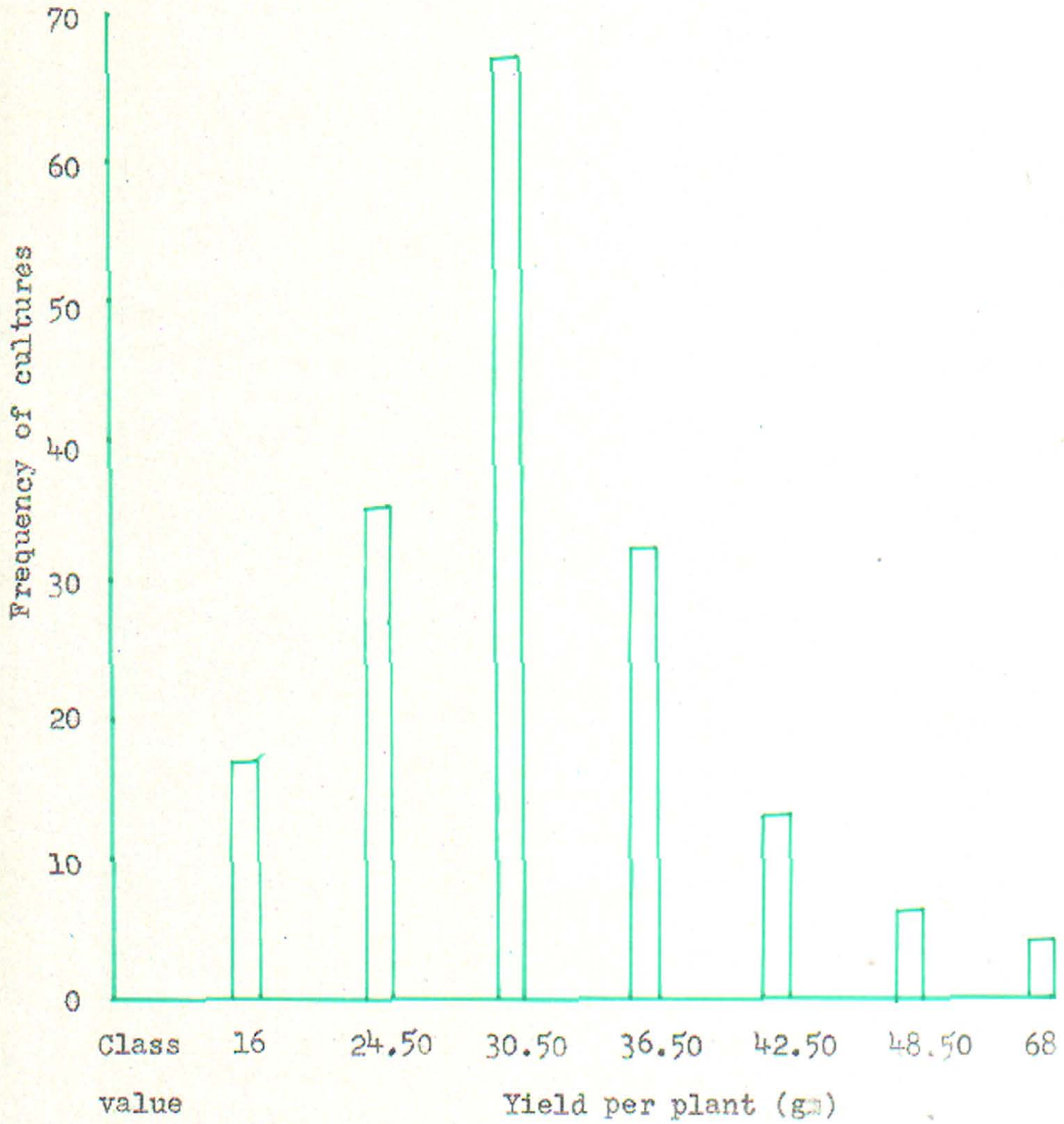


FIG.6

NATURE OF VARIATION FOR YIELD PER PLANT



The differences between cultures for number of seeds per pod were significant at 1 per cent level of significance. The frequency distribution for seeds per pod is presented in Fig 5. The whole collection of 180 cultures was grouped into 7 classes. The highest group and lowest group had 3.89 and 2.83 seeds per pod respectively. The modal value was 3.43 seeds per pod. The S.D. and C.V. were 0.24 and 7.20 per cent respectively. The highest seed number per pod of 4.12 was found in the culture A (M-85).

10) Grain yield per plant

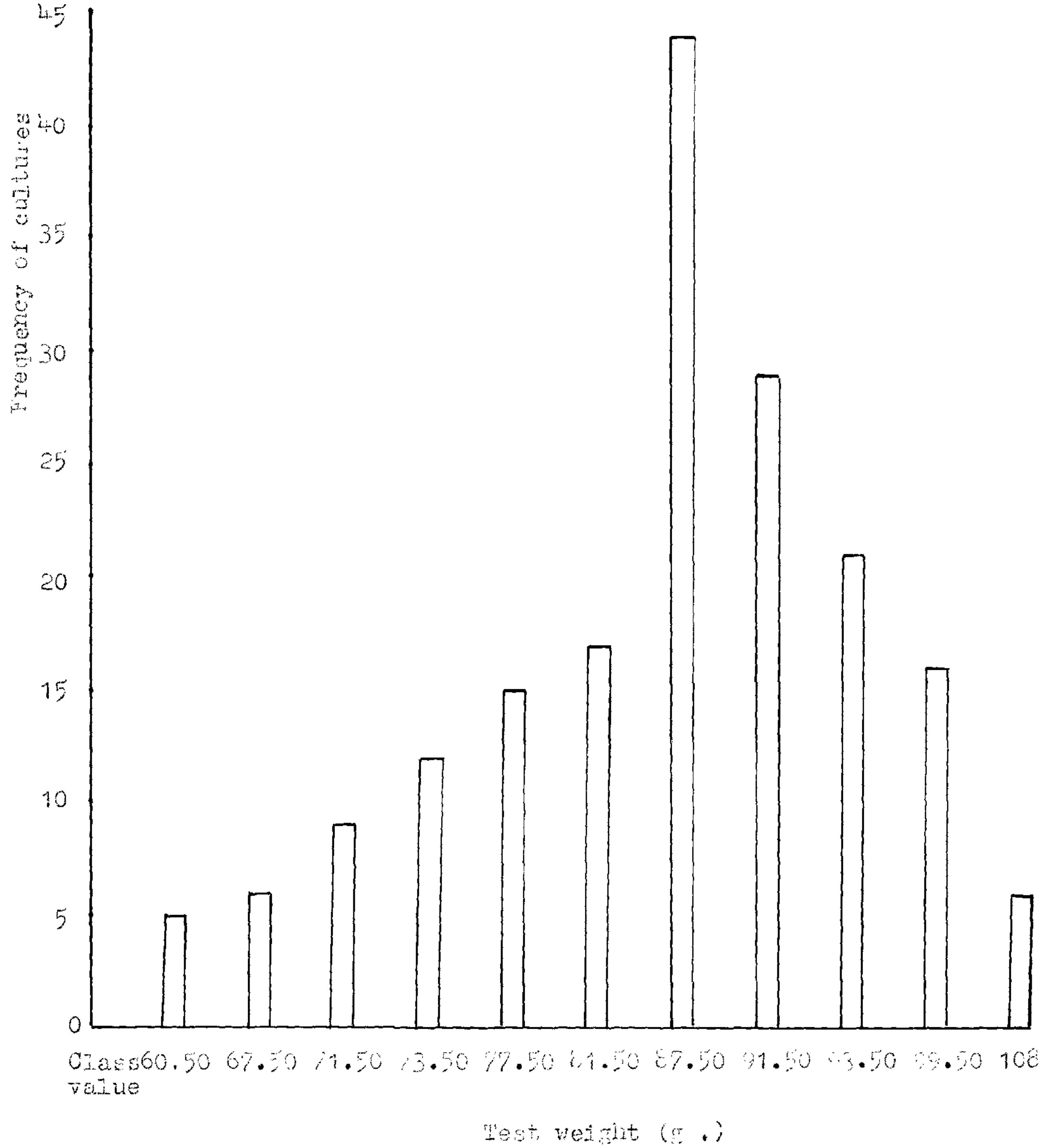
The results for yield per plant are presented in Fig.6. The range of variation for yield per plant was from 11.19 to 84.00 gm. There were 17 cultures with mean value of 16.00 gm, while 35 cultures had mean value of 24.50 gm. The modal group consisted of 67 cultures with mean value of 30.50 gm. The mean value of 36.50 gm was observed in 33 cultures. There were 18 and 6 cultures with mean yield of 42.50 and 48.50 gm respectively. The highest group had yield of 68 gm in 4 cultures. The S.D. and C.V. were 10.91 gm and 29.30 per cent respectively. The highest grain yield per plant of 84.00 gm was obtained in the culture M-128 (Obcordifolia).

11) Test weight

The frequency distribution for test weight is presented in Fig. 7. The cultures were grouped into 11

FIG. 7

NATURE OF VARIATION FOR TEST WEIGHT

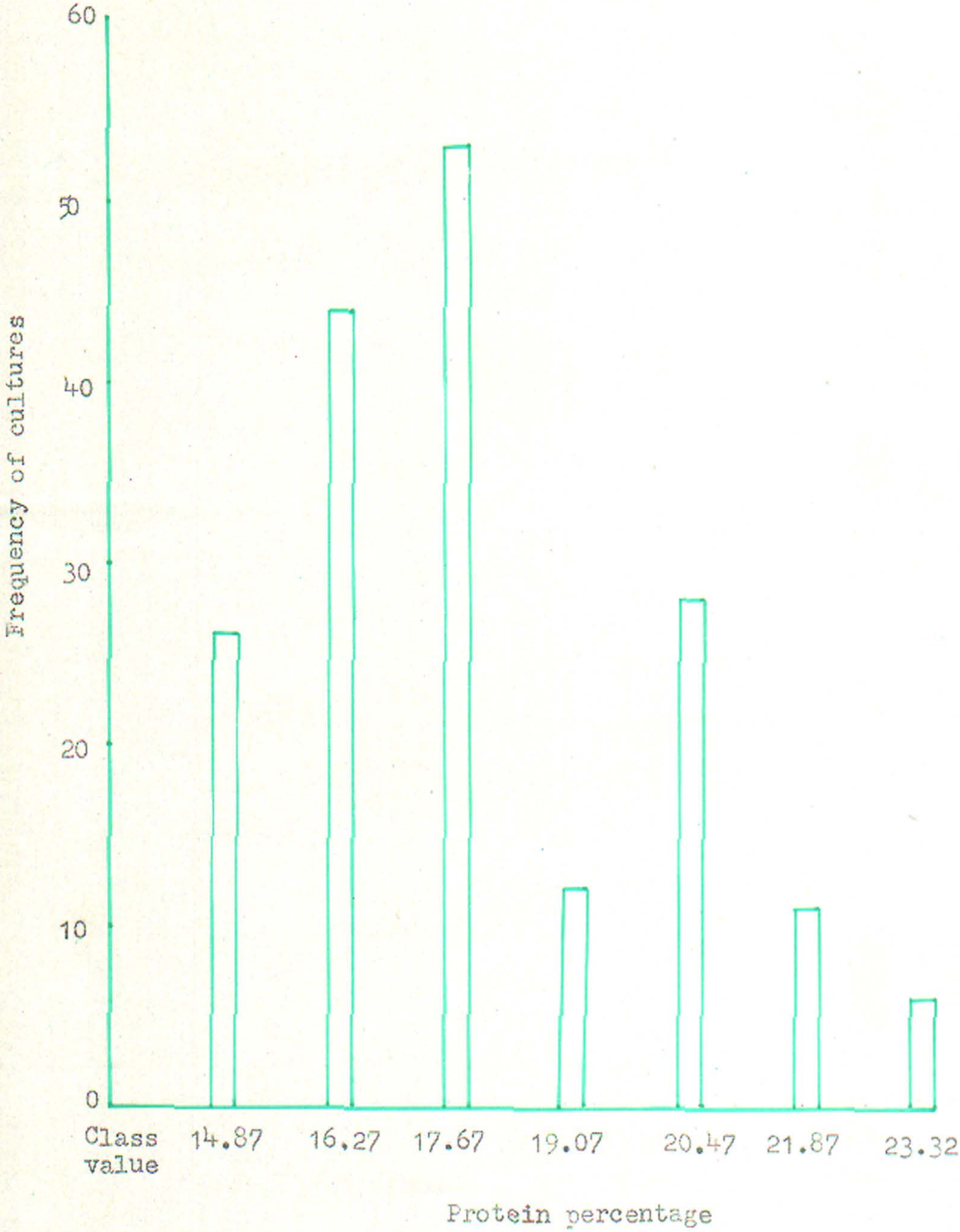


classes. The range of variation was from 58 to 112.54 gm. There were 5 cultures with mean values of 60.50 gm. The test weight of 67.50 and 71.50 gm were found in 6 and 9 cultures respectively. There were 12, 15 and 17 cultures which represented mean values of 73.50, 77.50 and 81.50 gm respectively. There were 44 cultures in the modal group with mean value of 87.50 gm. The mean test weights of 91.50, 93.50, 99.50 and 108.00 gm were found in 29, 21, 16 and 6 cultures respectively. The S.D. and C.V. were 10.1316 gm and 11.7700 per cent respectively. The highest test weight of 112.54 gm was observed in the culture D-2(M-89).

12) Protein content

The frequency distribution for protein content is presented in Fig. 8. The range of variation for protein content was from 14.18 to 24.06 per cent. The cultures were classified into 7 groups. In the first group there were 26 cultures which showed mean value of 14.87 per cent. The second group with 44 cultures had mean value of 16.27 per cent. The third and largest group with 53 cultures had mean value of 17.69 per cent. There were 12, 28 and 11 cultures with the mean values of 19.07, 20.47 and 21.87 per cent respectively. The highest mean protein content of 23.32 per cent was found in 6 cultures. The S.D. and C.V. for protein content were 2.247 and 12.500 per cent respectively. The highest protein content of 24.06 per cent was found in the culture H-Br (M-92).

NATURE OF VARIATION FOR PROTEIN CONTENT



Perusal of Table 4 reveals that the characters yield per plant was highly positively associated with number of pods per plant, number of seeds per pod and test weight. Yield was also correlated to a lesser extent positively with protein percentage, whereas it was negatively associated with days to flowering and days to maturity. Correlation of yield with height was non-significant.

Number of pods per plant was highly positively correlated with height, days to flowering and days to maturity, while its correlation with the remaining characters was non-significant.

Number of seeds per pod was highly positively associated with height and days to flowering, while its association with test weight and days to maturity was highly negative. The correlation of seeds per pod and protein content was non-significant. The character test weight was highly positively correlated with height while its correlation with days to flowering, and days to maturity was highly negative. It showed no correlation with protein content.

The association between height and days to flowering was highly positive, whereas the association of height with days to maturity and protein percentage was non-significant.

Correlation studies

The correlation coefficients of the different characters studied in pairs are presented in Table 4. The different characters are given abbreviations as follows.

Y.P.P.	:	Yield per plant
P.P.P.	:	Number of pods per plant
S.P.P.	:	Number of seeds per plant
T.W.	:	Test weight
Ht.	:	Height
Fl.days	:	Days to flowering
Mat. days	:	Days to maturity
Prot. %	:	Protein percentage

Table 4 : Coefficients of correlation among different characters.

	P.P.P.	S.P.P.	T.W.	Ht.	Fl. days	Mat. days	Prot. %
Y.P.P.	0.39**	0.46**	0.69**	0.01	-0.76**	-0.43**	0.18*
P.P.P		0.06	0.02	0.31**	0.31**	0.28**	0.14
S.P.P.			-0.49**	0.21**	0.56**	-0.53**	0.06
T.W.				0.26**	-0.42**	-0.36**	-0.13
Ht.					0.24**	-0.003	0.10
Fl. days						0.59**	-0.02
Mat. days							-0.001

* Significant at 5 per cent ** Significant at 1 per cent

The correlation of days to flowering and days to maturity was highly positive. The correlation of protein percentage with days to flowering and days to maturity was very low and non-significant.

Multiple regression

The multiple regression of 3 variables with one dependent variable was calculated by Abbreviated Doolittle method.

Yield was taken as dependent variable (Y) on test weight (X_1), number of pods per plant (X_2) and number of seeds per pod (X_3). It was seen from Table 5 that partial regression coefficients b_1, b_2 and b_3 were statistically significant at 1 per cent level.

Table 5 : Multiple regression of X_1, X_2 and X_3 on Y

Character		Values
Multiple regression of X_1, X_2 and X_3 on Y		
Due to X_1	...	$b_1 = 8.71^{**}$
Due to X_2	...	$b_2 = 4.87^{**}$
Due to X_3	...	$b_3 = 3.35^{**}$

** Significant at 1 per cent.

Part-II

Description of the mutants

The general characteristic features of the mutants are described below.

1) I-276 (Prostrate)

It was dwarf and bushy with prostrate habit of growth. The main stem had bent down within a certain height. Leaflet was normal lanceolate (Fig. 9). The stem was green but cortex was pigmented. Flowers were yellow.

2) I-277 (Tiny leaf)

The growth habit was erect. The leaflets were small and somewhat linear in shape (Fig. 10) and flowers were yellow.

3) I-278 (Creeping 3-2-8)

It had weak main stem and branches. It put forth all lateral branches close to ground. The leaflet shape was normal lanceolate (Fig. 9). Stem was green and flowers were yellow with red veins and eye spot on the back of standard petal.

4) I-279 (Round leaf)

It had leaflets with rounded base and apex (Fig.10). Growth habit was semi-erect. The colour of stem was dark purple and flowers were yellow.

Fig. 9 : Leaflet shape of the mutants I-276, I-278, I-299 and check I-317.

Fig.10 : Leaflet shape of the mutants I-279, I-277, I-300 and check I-317

Fig.11 : Leaflet shape of the mutants I-280, I-281, I-283, I-284 and check I-317.

Fig. 9

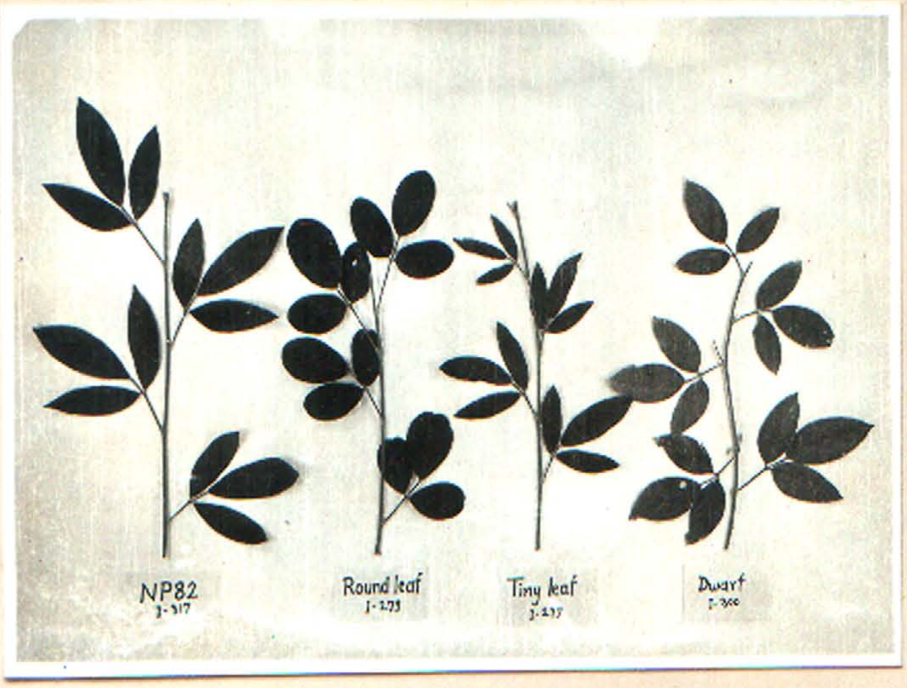


Fig. 10

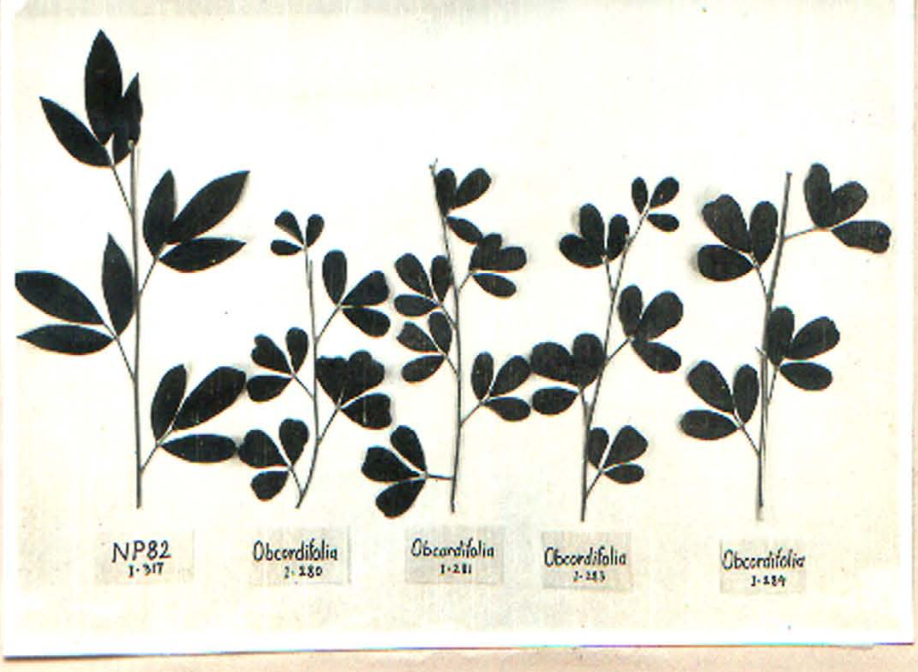


Fig. 11

5) I-280 (Obcordifolia, M.P.)

It was dwarf and had semi-erect growth habit. The leaflets were obcordate (Fig. 11). The stem was light purple. Flowers were yellow, wings protruding from the standard petal before flower opening; keels separate and narrow.

6) I-281 (Obcordifolia, M.Gr.)

Similar to I-280 (Fig. 11 and 14).

7) I-283 (Obcordifolia-mutant)

This mutant was comparatively taller and more spreading than the above obcordifolia types (Fig. 11). Other characters were similar to those of the above types.

8) I-284 (Obcodifolia, Delhi)

Similar to I-283 (Fig. 11).

9) I-285 (White grain mutant)

The growth habit was semi-erect. Leaflet shape was normal, stem was dark purple, flowers were yellow and grains were white.

10) I-286 (Red grain mutant)

The habit of growth was erect. Stem was light purple, leaflets were normal. The flowers were yellow with red veins on the back of standard.

Fig. 12 : Leaflet shape of the mutants I-305, I-309, I-320 and check I-317.

Fig. 13 : Leaflet shape of the mutants I-287, I-325, I-326 and check I-317.


Unifoliate
Bifoliate
J-309
Trifoliate
NP-82
Multifoliate
J-320

Fig. 12

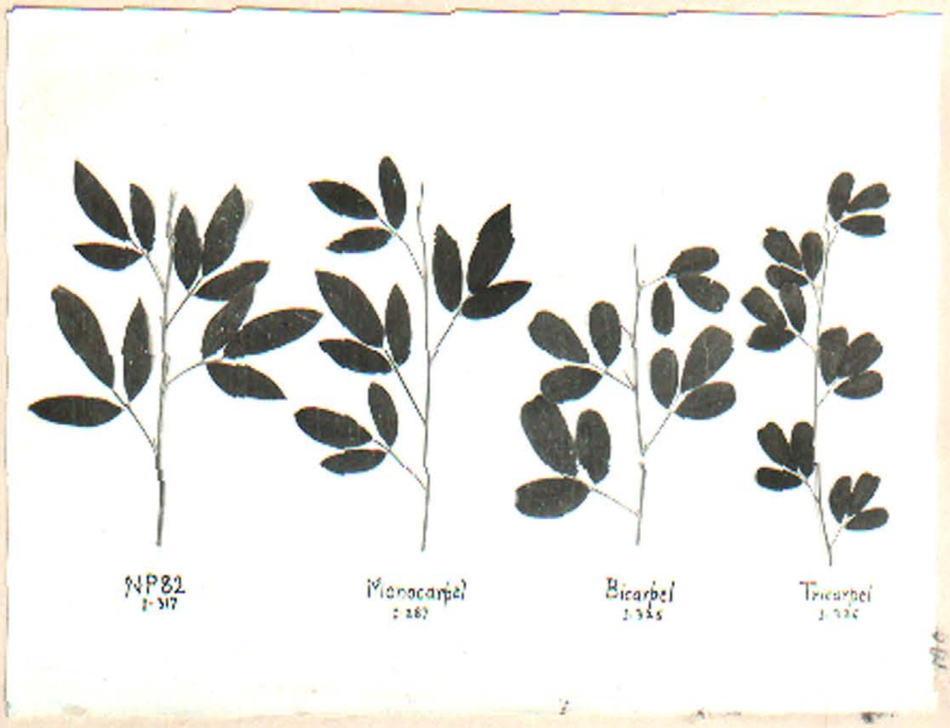

NP82
J-317
Monocarpel
Bicarpel
Tricarpel

Fig. 13

11) I-287 (Monocarpel)

The growth habit was semi-erect. Stem was purple. Leaflet shape was normal (Fig. 13) and flowers were yellow.

12) I-298 (Kanpur mutant)

The growth habit was erect and leaflet shape was normal. The stem colour was light purple and flowers were yellow.

13) I-299 (Serpentine)

It had serpentine habit as a result of which it completely lay on the soil. Leaflet shape was normal (Fig. 9) stem colour was green and flowers were yellow. Pod setting was poor.

14) I-300 (Dwarf)

This mutant was characterized by its dwarf and spreading habit and bushy appearance. It had profuse primary and secondary branches and normal leaflets (Fig. 10). The stem was brittle. Pod setting was poor. The stem colour was green and flowers were yellow.

15) I-305 (Unifoliate)

Theleaf was simple and unifoliate (Fig. 12). However, at a few nodes trifoliate leaves were developed. The growth habit was semi-erect with very few branches. The flowers were yellow with red veins on the back of standard.

Fig. 14 : Floral parts of the I-317 and I-281.

Fig. 15 : Floral parts of the I-317 and I-325.

Fig. 16 : Floral parts of the I-317 and I-326.

Fig. 14

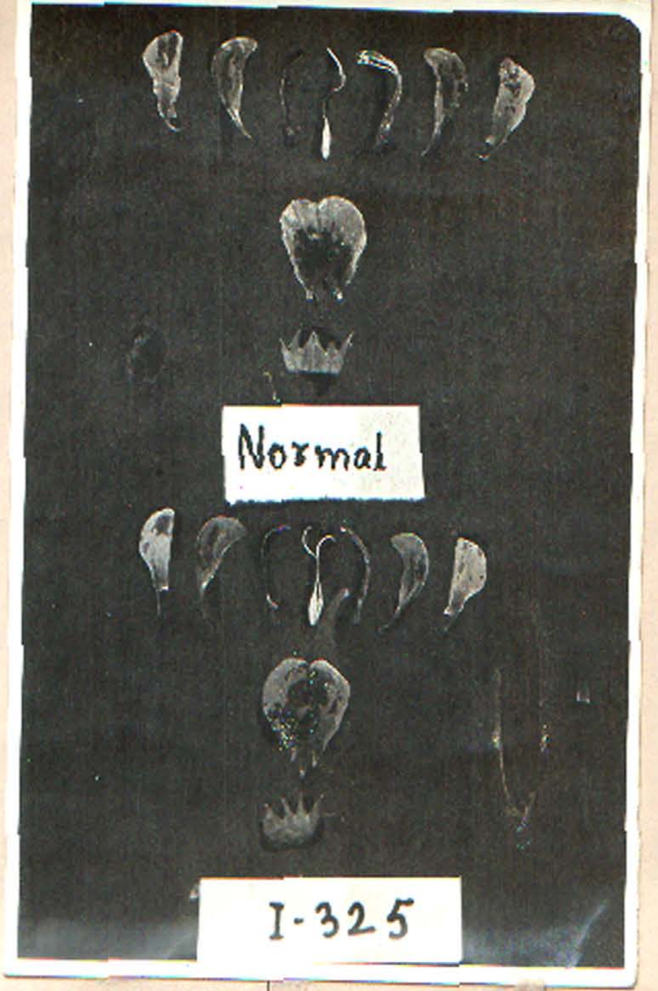


Fig. 15

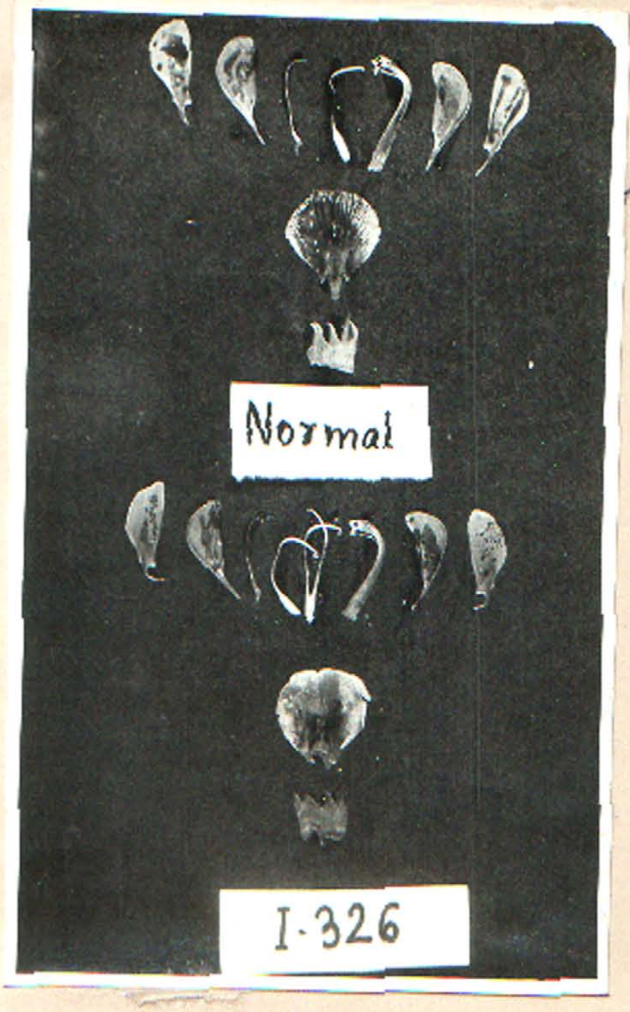


Fig. 16

16) <u>I-309</u> (Bifoliate)

The leaf compraised of two leaflets (Fig. 12). Occassionally trifoliate leaves were developed. The growth habit was semi-spreading. The leaflet shape was normal, stem colour was green and flowers were yellow.

17) <u>I-317</u> (N.P. 82, check)

The growth habit was erect. Leaflet shape was normal (Fig. 9) and (Fig. 14). Stem was light purple and flowers had red shades on yellow background.

18) <u>I-320</u> (Multifoliate)

The leaf of this mutant was characterized by having 4-6 leaflets (Fig. 12). The growth habit was semi-erect, stem colour was dark purple and flowers were yellow.

19) <u>I-325</u> (Bicarpel)

It had two carpels fused together (Fig. 13 and 15). The growth habit was spreading. Leaf-lets were obcordate. The stem was green in colour and flowers were yellow.

20) <u>I-326</u> (Tricarpel)

This mutant was characterized by the presence of 3 carpels, two of them fused and one separate (Fig. 13 and 16). It flowered profusely but pod setting was very poor. It was spreading in habit, having obcordate leaflets, green stem and yellow flowers.

Economic characters of the mutants

Observations recorded on plant height, days to flowering, maturity, number of pods per plant, number of seeds per pod, test weight, yield per plant and protein content are presented in Table 6.

Meiotic behaviour, pollen viability and response to G.A.

Analysis of meiotic metaphase-I and anaphase-I revealed that all the mutants had normal meiotic behaviour. There were 11 bivalents at metaphaseIand chromosome separation was normal at anaphaseI(Fig. 17 and 18).

Data on pollen fertility are presented in Table 7.

Most of the mutants had normal pollen fertility. The mutant, I-300 (Dwarf) had reduced pollen fertility to the extent of 10.29 per cent.

Response of the mutants to G.A. in terms of height is presented in Table 8.

Fig. 17 : Normal meiotic metaphase-I showing 11 II.

Fig. 18 : Normal meiotic anaphase-I showing 22 chromosomes.

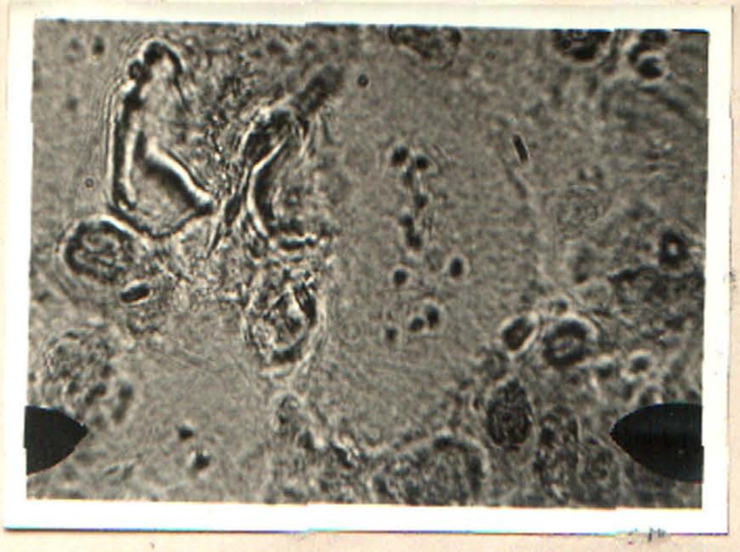


Fig. 17

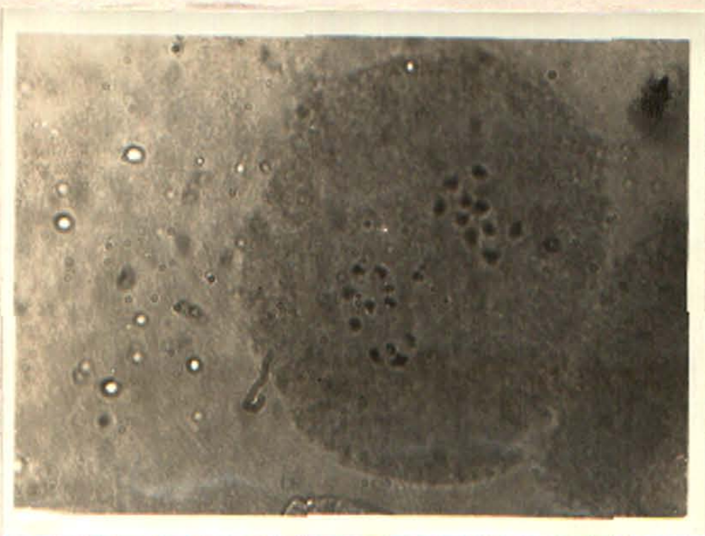


Fig. 18

Table 6 : Economic characters of the mutants.

Code No.	Name of Mutant	Height (cm)	Days to flowering	Days to maturity	No. of pods/ plant	No. of seeds/ pod	Test weight (gm)	Yield per plant (gm)	Protein content (%)
I-276	Prostrate	60	110	150	181.80	2.56	70.40	24.44	21.43
I-277	Tiny leaf	73	82	156	237.40	3.24	81.60	48.07	18.08
I-278	Creeping 3-2-8	71	78	166	190.00	3.24	79.50	21.87	19.50
I-279	Round leaf	158	90	164	115.60	3.32	72.50	19.68	22.75
I-280	Obcordifolia(M.P.)	89	87	173	163.40	2.80	68.25	25.30	19.25
I-281	Obcordifolia(M.Gr.)	88	84	166	289.00	2.72	83.60	54.50	19.25
I-283	Obcordifolia (mutant)	99	80	163	171.00	3.00	77.65	27.52	21.00
I-284	Obcordifolia (Delhi)	99	83	167	167.80	3.00	85.20	29.20	19.87
I-285	White grain mutant	113	94	167	150.20	3.60	85.57	33.05	21.12
I-286	Red grain mutant	115	105	166	171.40	3.16	90.20	41.20	15.93
I-287	Monocarpel	103	86	173	205.00	3.44	64.40	38.12	19.50
I-298	Kanpur mutant	136	125	179	335.20	3.32	69.54	52.34	25.68
I-299	Serpentine	86	140	174	89.20	2.92	78.00	10.00	21.43
I-300	Dwarf	40	141	174	107.00	4.24	54.[illegible]	15.33	15.50
I-305	Unifoliate	102	141	174	251.00	3.20	75.60	27.75	16.95
I-309	Bifoliate	131	85	167	181.40	3.12	81.50	30.57	22.75
I-317	M.P. 82 (check)	181	139	176	315.20	3.16	84.26	57.71	17.06
I-320	Multifoliate	99	86	170	261.60	3.08	64.40	38.12	16.81
I-325	Bicarpel	114	133	173	110.60	2.84	72.25	22.50	17.37
I-326	Tricapel	113	127	165	160.00	2.96	80.10	28.40	16.25

Table 7 : Pollen fertility of the mutants.

Code no.of mutant	Number of fertile pollen	Number of sterile pollen	Total	Fertility per-centage
I-276	604	12	616	98.05
I-277	294	12	306	96.08
I-278	604	34	638	94.67
I-279	362	17	379	95.52
I-280	786	14	800	98.25
I-281	935	18	953	98.12
I-283	745	25	770	96.76
I-284	445	22	467	95.29
I-285	876	30	906	96.69
I-286	733	31	764	95.95
I-287	373	21	394	94.67
I-298	520	22	542	95.94
I-299	586	26	612	95.56
I-300	1482	170	1652	89.71
I-305	981	44	1025	95.71
I-309	964	20	984	97.97
I-317	376	14	390	96.41
I-320	431	22	499	94.90
I-325	933	30	669	96.88
I-326	1220	71	1291	94.50

Table 8 : Response of the mutants to G.A.

Code No.	Name of Mutant	Height (cm)	
		Untreated	Treated(G.A.)
I-276	Prostrate	42.40	47.20
I-277	Tinyleaf	51.80	71.80*
I-278	Creeping 3-2-8	29.40	32.20
I-279	Round leaf	39.40	46.00
I-280	Obcordifolia(N.P.)	43.00	52.40
I-281	Obcordifolia(N.Gr.)	36.00	47.00
I-283	Obcordifolia(mutant)	36.80	47.60
I-284	Obcordifolia(N.Bl.)	29.20	43.30
I-285	White grain mutant	37.40	39.60
I-286	Red grain mutant	37.00	40.40
I-287	Monocarpel	39.40	62.00**
I-298	Kanpur mutant	45.80	53.40
I-299	Serpentine	36.60	43.60
I-300	Dwarf	33.80	46.80**
I-305	Unifoliate	52.60	66.00*
I-309	Bifoliate	44.20	66.80*
I-317	N.P.82	34.00	36.00
I-320	Multifoliate	26.60	36.80
I-325	Bicarpel	30.00	35.60
I-326	Tricarpel	38.20	55.00*

* Significant at 5 per cent ** Significant at 1 per cent.

The mutants tiny leaf, dwarf, unifoliate, bifoliate and tricarpel exhibited significant increase in height due to G.A.treatment while the increase in the height of the other mutants was not significant.

CHAPTER V

DISCUSSIONS

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CHAPTER V

D I S C U S S I O N

Part-I

This investigation was undertaken with the object to study the nature of variation in the local tur germplasm collection of the Pulses Improvement Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri in respect of certain qualititive and quantitative characters. These cultures were studied for morphological characters like habit of growth, leaflet shape, stem colour and flower colour, physiological characters like days to flowering and maturity, yield and yield components like pod number, seeds per pod, test weight and quality aspect like crude protein content of seeds.

Correlation studies are important asset to the breeder in his selection programme. Therefore, it is necessary to determine the relationships between yield and yield components as well as quality characters. Improvement in yield, yield components and quality may be made by selecting for other simple characters which are positively associated with yield and other characters. It also happens that, due to certain negative correlations, improvement in respect of one character may have been led at the expenses of another. Knowledge of these associations and intensity of these relationships is important in breeding programme.

Variation for qualitative characters

Habit of growth

In respect of this character there was less variation because most of the cultures had semi-erect habit of growth, and very few were spreading or erect.

Leaflet shape

Five types of leaflet shapes viz., lanceolate, linear, obovate/obcordate ovate and oval were observed. Out of the 180 cultures 169 cultures had lanceolate leaflet shape and remaining 11 cultures were distributed into 4 groups.

Colour of stem

Three types of stem colour were observed in the cultures studied. Majority of the cultures had light purple stem while few had dark purple or green stem.

Flower colour

There were five types of flower colour. Out of the 180 cultures 147 had yellow flower colour and remaining 33 cultures were distributed into 4 groups.

Thus, the cultures were more or less homogeneous as far as the above qualitative characters are concerned.

Variation for quantitative characters

Plant height

There was wide variation for plant height and the differences among the cultural means in respect of height were highly significant. Practically the cultures could be classified into three height groups : (i) The dwarf or bushy group-ranging from 72 to 104 cm, (ii) The medium group-ranging from 105 to 136 cm and (iii) the tall group-ranging from 137 to 152 cm.

Days to flowering

The cultures differed widely for flowering time. Though the 180 cultures were distributed over 7 classes (Fig. 2), from the practical point of view they could be grouped into 4 classes only :

i) Early flowering : The cultures which flowered upto 75 days.

ii) Medium flowering: The cultures which flowered within 76 days to 85 days.

iii) Midlate flowring: The cultures which flowered within 86 to 95 days.

if) Late flowering : The cultures which flowered after 95 days.

Thus, there exists scope for selection in respect of flowering time.

Days to maturity

The C.V. value for days to maturity was 5.50% and the range of variation was from 128 to 168 days. This indicated that there existed wide variation for this character. On the basis of frequency distribution the cultures were classified into 7 groups but practically they could be classified into four maturity groups :

i) Early maturing	:	The cultures which matured upto 135 days.
ii) Medium maturing	:	The cultures which matured within 136 to 145 days.
iii) Midlate maturing	:	The cultures which matured within 146 to 155 days.
iv) Late maturing	:	The cultures which required more than 156 days for maturity.

Number of pods per plant

The number of pods per plant differs from variety to variety and is a component of yield (Dasappa and Mahadevappa, 1970 Ganguli and Shrivastava, 1969). In the cultures studied, pod number per plant varied from 56.20 to 336.00. From Table 2 it was seen that there existed significant cultural differences in respect of number ofpods per plant. The C.V. value of 30.71 per cent indicated that there was wide variation amongst the cultures studied. On the basis of frequency distribution (Fig. 5) the cultures were grouped into 7 classes.

Number of seeds per plant

Ganguli and Shrivastava (1969) reported a narrow range of phenotypic variation in respect of seeds per plant. Munoz and Abrams (1972) also reported similar results.

However, in the present study significant differences were observed between the cultures in respect of number of seeds per pod (Table 2). The C.V. value for this character was 8.20 per cent which indicated that there was wide variation. The number of seeds per pod varied from 2.76 to 4.12

Grain yield per plant

From Fig. 6 it was seen that there existed cultural differences for grain yield per plant. Grain yield varied from 11.19 to 84.00 gm. There were 7 distinct groups.

The C.V. was 37.22 per cent which indicated that there was wide variation for grain yield per plant.

Test weight

Dasappa and Mahadevappa (1970) reported that there were significant varietal differences in respect of weight of 1000 grains and yield of seed per plant. The results presented in Fig. 7 revealed that there was wide variation for 1000 grain weight ranging from 58 to 112.54 gm.

Protein content

Singh et al. (1974) reported that variation due to varieties was statistically significant for protein content, and high heritability for protein content. Studies of Singh et al. (1971) revealed that environmental factors had no effect on seed proteincontent of pigeon pea. Thus, the trait of high protein content can be easily transferred from the high protein cultures. In the present study the range of crude protein content was found to be from 14.18 to 24.06 per cent. C.V. value for protein content was 12.50 per cent. Thus, scope exists for selecting high protein lines.

Correlation studies

Association of yield with other characters

Munoz and Abrams (1972) reported that seed yield was highly positively correlated with number of pods per plant, to a lesser extent positively correlated with plant height and 100 seed weight and was negatively correlated with days to flowering. Deohar and Nigam (1972) reported that yield was correlated positively with number of branches per plant and number of pods per plant. In the present study it was found that yield was highly positively associated with number of pods per plant, number of seeds per pod, test weight and to a lesser extent correlated with protein content. There was no correlation between yield and plant height. There was negative correlation between yield and days to flowering and days to maturity. This means early varieties have higher yield than the late maturing varieties. This may be due to escape of early varieties from pod borer infestation and also grain filling is adversely affected in the late varieties under receding soil moisture conditions.

Correlation among other characters

Number of pods per plant was positively associated with height, days to flowering and days to maturity. This indicates that when height is more there are more pods and when period required for flowering and maturity are more then also pods are more. Because due to longer growth period more pods will be produced. There was no correlation between number of pods per plant and the rest of the characters. Number of seeds per pod were positively correlated with height and days to flowering. There was negative cor-elation between number of seeds andtest weight and days to maturity. This means that when seed number increases seed weight decreases. The negative correlation of days to maturity with number of seeds per pod may be the result of reduction in seed number due to severe insect attack during seed development. Test weight showed positive assodiation with height and negative association with days to flowering and days to maturity. Plant height was positively correlated with days to flowering Correlation of height with maturity was non-significant.

There existed positive association between days to flowering and days to maturity. Thus, flowering time can be considered an index of maturity period.

Protein content was negatively correlated with days to maturity, days to flowering and test weight. However, the correlations are non-significant. Protein content showed positive but non-significant correlation with number of pods per plant, number of seeds per pod and height. This indicated that the protein content is independent of the rest of the characters and can be improved without affecting other characters.

Multiple regression studies

Multiple regression indicated that yield is independent on test weight, number of pods per plant and number of seeds per pod. The partial regression coefficients of these variables were statistically significant at 1 per cent level. This indicated that when there is increase in test weight, number of pods per plant and number of seeds per pod there is proportionate increase in the yield.

Part II

The discoveries of the high lysine maize mutants ('opaque-2' and floury-2') by Mertz et al. (1964) and Nelson et al. (1965) and the high protein high lysine barley mutant (' Hiproly') by Hageberg and Karlson (1969) have stimulated thinking and search for mutants affecting nutritional aspects in many crop plants. At the College of Agriculture, Poona manytur mutants have been maintained and studied extensively for the genetics of morphological characteristics. However, so far these mutants were not subjected to detailed economic evaluation. It was thought worthwhile to subject these mutants to biochemical screening for crude protein content of seed as well as other economic characters.

It is apparent from Table 6 that there were differences in the crude protein content of the mutants, the range being from 15.50 per cent to 25.68 per cent. The mutant I-298 (Kanpur mutant) had the highest protein content of 25.68 per cent. The mean protein content of different varieties of tur has been reported to be 22 per cent (Anonymous, 1971). Thus, a mutant with the protein content as high as 25.68 per cent is certainly an asset and should be exploited for breeding purposes. This mutant has also good yielding ability (52.34 gm per plant as against 57.71 gm per plant of the check variety N.P. 82), and has the highest pod number (335.2 pods per plant as against 315.2 pods of the check). It would be interesting and fruitful to further study the protein and amino acid profile, especially cystine and methionine of this mutant.

Other mutants that could be of breeding value are 'tiny leaf' (I-277) and 'dwarf' (I-300). 'Tiny leaf' mutant is erect and with small, linear leaflets. The 'dwarf' mutant is only 40 cm tall as against L.A. 82 (check) which is 181 cm in height. This mutant has profuse primary and secondary branches. The reduction in height is due to reduction in internodal length. In tur the ratio of grain : total dry matter production is very low due to excessive vegetative growth. By using mutants like 'tiny leaf' and 'dwarf' as parents in the breeding programme this ratio could certainly be increased. 'Tiny leaf' has good podding capacity (237.4 pods per plant) and yield (48.07 gm per plant). 'Dwarf' has poor pod setting but the highest grain number per pod (4.24) among the mutants studied.

Many of the mutations like 'prostrate','creeping', 'serpentine', 'obcordifolia' types, 'bicarpel', 'tricarpel', 'unifoliate', 'bifoliate' and 'dwarf' have been shown to be governed oligogenically (Deshpande and Jeswani, 1952; Deshmukh and Rekhi, 1960; Deshmukh, 1969; D'Cruz et al. 1971; Deokar et al. 1971, Patil, 1971 and Shinde et al. 1972). However, these mutations exhibit changes in more than one character. Most of them also show considerable reduction in pod setting. Therefore, these mutants were studied for their meiotic behaviour and pollen fertility. All the mutants had normal meiotic behaviour, there being 11 bivalents at metaphase-I and normal chromosome separation at anaphase (Fig. 17 and 18). Thus, these mutations may not be associated with chromosomal changes, or if they are associated with such cryptic changes, these might have been fixed. These mutations affecting an array of characters might be associated with pleiotropic gene action or tightly linked gene blocks. There exists scope for further genetic analysis. Almost all of these mutants had very high degree of pollen fertility (above 90 per cent). In the absence of cytological anomalies and with highdegree of pollen fertility, the sterility observed could be attributed to ovule abortion due to some reason or to incompatibility.

With the object of finding out response of genes governing plant habit the mutants were treated with gibberellic acid in the seedling stage. Abrams (1960) reported that the effect of gibberellic acid on height of pigeon pea was non-significant. However, in the present study, significant increase in plant height was observed in the case of the mutants 'dwarf', 'monocarpel', 'tricarpel' 'tiny leaf' 'unifoliate' and 'bifoliate'.

Thus, these mutations are G.A. sensitive. As found by Abrams (loc. cit.) mutations with normal growth habit seem to be G.A. insensitive.

CHAPTER VI

SUMMARY AND CONCLUSIONS

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CHAPTER VI

SUMMARY AND CONCLUSIONS

Part-I

A total of 180 tur culturess collected from different parts of Maharashtra were studied for qualitative as well as quantitative characters. Apart from the evaluation for economic characters these cultures were also screened for crude protein content. Correlations among various characters and multiple regressions were worked out. The results obtained are summarized below.

1. The cultures appeared to be more or less homogeneous for the qualitative characters. Most of the cultures were spreading/semi-spreading in habit, with purple coloured stem, lanceolate leaflets and yellow flowers.

2. There was wide variation for quantitative characters. Differences due to cultures were significant in respect of plant height, number of pods per plant, number of seeds per pod.

   i) Variation in height ranged from 72 to 152 cm.

   ii) Based on days to flowering and days to maturity the cultures could be classified into four groups viz., early, medium, midlate and late. The range of variation for days to flowering was from 73 to 102 days, while the range for days to maturity was from 128 to 168 days. There were 13 cultures in the early group maturing within 130 days.

iii) The range of variation for number of pods per plant was from 56.20 to 336.00. The maximum pod number of 336 was found in the culture 7-18-4 (M-28).

iv) Number of seeds per pod varied from 2.76 to 4.12. The maximum seed number of 4.12 was found in the culture 'A' (M-85).

v) Grain yield per plant ranged from 11.19 to 84.00 gm. The highest grain yield of 84 gm was found in the culture obcordifolia (M-128).

vi) Variation for test weight (1000 grain weight) ranged from 58 to 112.54 gm. The highest test weight of 112.54 gm was found in the culture D-2 (M-89).

3. Wide variation was found among the cultures for crude protein content ranging from 14.18 to 24.06 per cent. The highest protein content of 24.06 per cent was observed in the culture 'M-Br' (M-92).

4) Correlation studies revealed that yield was highly positively correlated with number of pods per plant, number of seeds per pod and test weight. There was negative correlation between yield and days to flowering and days to maturity. Crude protein content showed positive correlation with yield per plant and no correlation with number of pods per plant number of seeds per pod and plant height.

The multiple regression coefficients of test weight, pods per plant and seeds per pod were found to be highly significant. Thus, these are the major yield components.

Part-II

A total of 19 mutants and a check (H.P. 82) were studied for economic characters, crude protein content, meiotic behaviour, pollen fertility and response to gibberellic acid.

1) The protein content of the mutants varied from 15.50 to 25.68 per cent. The highest protein content 25.68 per cent was found in the 'Kanpur mutant' (I-298). This mutant has also good yielding ability.

2) Mutants like 'tiny leaf' (I-277) and 'dwarf' (I-300) were found to be useful donors to increase the ratio of grain : total dry matter production.

3) All the mutants under study had normal meiotic behaviour with 11 bivalents and normal chromosome separation at anaphase I. Almost all the mutants had very high degree of pollen fertility (above 90 per cent). Thus, sterility observed in some of the mutants could be attributed to ovule abortion or to incompatibility.

4) The mutants 'dwarf', 'tiny leaf', 'monocarpel' 'tricarpel', 'unifoliate' and 'bifoliate' were found to be G.A. sensitive

The present studies have helped in identifying genotypes from among the local germplasm and mutants, which could serve as useful donors for improving yield and protein content of tur.

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A P P E N D I X

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APPENDIX I

Data on qualitative characters

(Abbreviations)

1) Habit of growth : E - erect; S.E. - semi-erect ; S - sprreading.

2) Leaflet shape : Lin.-Linear; Lant. - lanceolate; Ob. - obovate/obcorucate; Ovt.-ovate; Ovl.- oval.

3) Colour of stem : L.P. - light purple ; D.P. - dark purple; G - green.

4) Flower colour : Y - yellow; Y.V. - yellow colour with red veins on the back of standard petal; Y.E. - yellow colour with red eyespot on theback of standard petal; Y.V.E. - yellow colour with red veins and red eyespot on the back of standard petal; C.W. - Creamy white.

Data on qualitative characters.

Culture No.	Habit of plant	Leaflet shape	Colour of stem	Flower colour
M-1	S.E.	Lant	L.P.	Y
M-2	S.E.	"	L-P.	"
M-3	S.E.	"	L.P.	"
M-4	S.E.	Lin.	L.P.	Y.V.E.
M-5	S.	Lant.	D.P.	Y.
M-6	S.E.	"	D.P.	"
M-7	S.	"	L.P.	Y.V.
M-8	S.E.	"	L.P.	Y
M-9	S.E.	"	D.P.	"
M-10	S.E.	"	D.P.	"
M-11	S.E.	"	D.P.	Y.V.
M-12	E.	"	G.	Y.
M-13	E.	"	G.	"
M-14	S.E.	Ovl.	D.P.	"
M-15	S.	Lant	L.P.	"
M-16	S.	"	L.P.	"
M-17	S.E.	"	L.P.	"
M-18	S.E.	"	L.P.	"
M-19	S.E.	"	L.P.	"
M-20	S.E.	"	D.P.	"
M-21	S.E.	"	D.P.	"
M-22	S.E.	"	D.P.	Y.E.
M-23	S.E.	"	L.P.	Y.
M-24	S.	"	G.	"
M-25	E.	"	G.	"
M-26	S.	"	L.P.	"
M-27	S.E.	"	G.	Y.V.
M-28	S.E.	"	L .P.	Y.
M-29	S.E.	"	"	"
M-30	S.E.	"	"	"
M-31	S.E.	"	"	"
M-32	S.E.	"	"	" Cont'd)

Culture No.	Habit of plant	Leaflet shape	Colour of stem	Flower colour
M-33	S.E.	Lant	L.P.	Y
M-34	"	"	"	"
M-35	E.	"	"	"
M-36	S.E.	"	"	"
M-37	"	"	"	"
M-38	"	"	G	"
M-39	"	"	L.F.	"
M-40	"	"	"	"
M-41	"	"	"	"
M-42	"	"	"	"
M-43	"	"	G	"
M-44	"	E.	L.P.	Y.V.
M-45	"	"	"	"
M-46	"	"	D.P.	Y.V.E.
M-47	S.	"	L.P.	"
M-48	S.E.	"	"	Y.
M-49	"	"	"	"
M-50	"	"	"	"
M-51	"	"	"	"
M-52	S.	"	"	"
M-53	S.E.	"	"	Y.V.E.
M-54	"	"	"	Y.
M-55	"	"	"	Y.V.
M-56	"	"	"	Y.V.E.
M-57	S.	"	"	Y.
M-58	S.E.	"	G.	"
M-59	"	"	D.P.	"
M-60	"	"	L.P.	"
M-61	"	"	"	Y.V.
M-62	S.	"	"	Y.
M-63	S.E.	"	"	"
M-64	"	"	G.	"

Culture No.	Habit of plant	Leaflet shape	Colour stem	Flower colour
M-65	S.E.	Lant.	G.	Y.
M-66	"	"	"	"
M-67	S.	Lin.	"	"
M-68	S.E.	Lint.	"	"
M-69	"	"	L.P.	"
M-70	"	"	"	"
M-71	"	"	G.	"
M-72	"	"	L.P.	"
M-73	"	"	"	"
M-74	"	"	"	"
M-75	"	"	"	"
M-76	"	"	"	"
M-77	"	"	"	"
M-78	"	"	D.P.	"
M-79	"	Ovt.	L.P.	"
M-80	"	Lant.	"	Y.V.E.
M-81	S.	"	E	Y.V.E.
M-82	S.	Ob.	G.	Y.
M-83	S.E.	Lant.	D.P.	"
M-84	"	"	L.P.	"
M-85	"	"	D.P.	"
M-86	"	"	L.P.	"
M-87	"	"	G.	"
M-88	S.E.	"	L.P.	"
M-89	"	"	"	"
M-90	"	"	G.	"
M-91	"	"	"	"
M-92	"	"	"	"
M-93	"	"	"	"
M-94	"	"	L.P.	"
M-95	"	"	"	"
M-96	"	"	"	Y.V.

Culture No.	Habit of plant	Leaflet shape	Colour stem	Flower colour
M-97	S.E.	Lant. L.P.	D.P.	Y.V.
M-98	S.E.	"	L.P.	Y.
M-99	S.	"	D.P.	"
M-100	S.	"	L.P.	Y.V.
M-101	"	"	D.P.	Y.
M-102	"	"	L.P.	"
M-103	"	"	"	"
M-104	"	"	"	"
M-105	"	"	"	Y.V.
M-106	"	"	"	Y.
M-107	"	"	G.	"
M-108	"	"	L.P.	Y.V.
M-109	"	"	D.P.	Y
M-110	"	"	G.	"
M-111	"	"	D.P.	"
M-112	"	"	L.P.	"
M-113	"	"	D.P.	"
M-114	"	"	L.P.	"
M-115	"	"	"	"
M-116	"	"	"	"
M-117	S.E.	"	"	"
M-118	S.	"	D.P.	"
M-119	S.E.	"	"	"
M-120	"	Ovt.	"	"
M-121	"	Lant.	D.P.	Y
M-122	"	"	L.P.	"
M-123	S.	"	"	"
M-124	S.E.	"	D.P.	"
M-125	"	"	L.P.	"
M-126	S.	"	"	C.W.
M-127	S.E.	Ovl.	D.P.	"
M-128	"	Ob.	L.P.	Y

Culture No.	Habit of Plant	Leaflet shape	Colour of stem	Flower colour
M-129	S.	Lant.	L.P.	Y.
M-130	S.E.	"	G.	"
M-131	"	"	L.P.	"
M-132	S.	"	G.	"
M-133	"	"	L.P.	"
M-134	S.E.	"	D.P.	"
M-135	S.	"	L.P.	Y.V.
M-136	"	"	"	Y.
M-137	"	"	"	"
M-138	S.E.	"	D.P.	Y.V.
M-139	"	"	L.P.	Y.E.
M-140	"	"	D.P.	Y.V.
M-141	S.	"	G.	"
M-142	"	"	L.P.	"
M-143	"	"	G.	"
M-144	"	"	L.P.	"
M-145	"	"	"	"
M-146	"	"	"	"
M-147	"	Ovl.	D.P.	"
M-148	S.E.	Lant.	G.	"
M-149	"	"	L.P.	"
M-150	S.	"	"	"
M-151	S.E.	"	"	Y.
M-152	"	"	D.P.	"
M-153	"	"	"	"
M-154	"	"	L.P.	"
M-155	"	"	D.P.	Y.V.
M-156	S.	"	G.	Y.
M-157	"	"	"	"
M-158	S.E.	"	"	"
M-159	"	"	"	"
M-160	"	"	"	"

Culture No.	Habit of Plant	Leaflet shpae	Colour of stem	Flower colour
M-161	S.E.	Lant.	D.P.	Y.V.
M-162	"	"	"	Y.
M-163	S.	"	L.P.	"
M-164	S.E.	"	"	"
M-165	"	Ovt.	"	"
M-166	"	Lant.	"	"
M-167	"	"	D.P.	"
M-168	"	"	L.P.	"
M-169	"	"	G	"
M-170	"	"	L.P.	"
M-171	"	"	"	"
M-172	"	"	"	Y.V.E.
M-173	S.	"	"	Y
M-174	S.E.	Ovl.	D.P.	Y.V.
M-175	"	Lant.	"	Y.
M-176	"	"	L.P.	"
M-177	"	"	"	Y.V.
M-178	E.	"	"	Y.E.
M-179	S.E.	"	G.	Y.V.E.
M-180	"	"	L.P.	Y.

APPENDIX II

Data on quantitative characters.

Culture No. (1)	Yield/ plant (2)	Test weight (3)	No.of pods per plant (4)	No.of seeds per pod (5)	Plant height (6)	Days to flowering (7)	Days to maturity (8)	Protein % (9)
M-1	34.06	93.32	183.60	3.52	128	83.0	141	18.06
M-2	29.53	82.53	91.20	3.28	135	83	141	20.47
M-3	27.83	60.24	128.20	3.56	114	87	144	21.13
M-4	20.89	72.90	125.50	2.76	103	87	144	18.42
M-5	27.60	87.84	123.00	3.52	113	86	147	18.01
M-6	26.66	77.70	202.80	3.44	104	96	147	18.06
M-7	35.85	98.60	174.00	3.28	116	92	149	20.47
M-8	26.66	81.80	219.00	2.88	103	102	154	18.01
M-9	32.91	98.50	166.80	3.20	118	90	155	17.81
M-10	30.92	78.00	203.80	3.16	116	94	148	18.18
M-11	22.59	82.20	123.60	3.36	101	89	148	15.15
M-12	1[illegible].65	74.62	161.60	3.48	123	87	147	15.25
M-13	17.08	81.20	89.40	3.20	100	94	155	15.94
M-14	29.16	83.00	155.00	3.36	121	90	154	15.50
M-15	28.40	96.54	131.60	3.08	125	85	145	15.25
M-16	23.28	74.24	193.40	2.84	109	92	146	15.12
M-17	26.25	99.56	76.20	2.96	112	86	152	16.81
M-18	28.20	77.10	67.40	3.16	101	92	148	15.50

(Cont'd)

Contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-19	22.26	81.44	151.20	3.28	95	84	162	15.50
M-20	27.11	76.20	161.20	3.00	118	92	146	16.31
M-21	42.00	97.80	124.40	3.12	116	94	145	15.12
M-22	30.40	87.60	118.40	2.96	110	90	144	16.93
M-~~1~~23	47.08	86.30	188.80	3.00	103	96	154	16.12
M-~~M~~ 24	31.25	89.60	119.20	3.40	108	86	143	20.12
M-25	33.56	98.42	234.00	3.12	113	93	150	15.94
M-26	41.81	93.60	119.80	3.16	108	83	143	23.18
M-27	25.10	96.34	131.80	3.56	110	87	148	23.06
M-28	30.20	91.04	336.00	3.36	118	90	148	21.81
M-29	45.41	94.84	186.80	4.56	115	89	141	19.93
M-30	34.73	92.02	205.60	3.40	117	93	147	20.93
M-31	37.03	87.47	171.20	3.20	117	79	146	17.18
M-32	21.61	90.76	191.80	3.12	126	93	155	15.68
M-33	31.81	91.56	118.00	2.96	131	92	143	21.81
M-34	29.82	89.20	143.40	3.28	127	92	146	23.93
M-35	33.28	89.04	136.00	3.56	136	90	145	16.93
M-36	31.82	95.28	112.40	3.44	131	88	141	17.68
M-37	31.66	98.84	156.00	3.08	110	95	149	18.31
M-38	30.00	89.64	103.00	3.32	122	81	134	17.00
M-39	26.16	87.04	104.20	3.08	114	88	145	14.37

(Cont'd)

Contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-40	45.07	81.16	162.20	3.28	138	83	145	14.18
M-41	37.28	87.24	153.60	3.20	134	94	155	2.43
M-42	40.08	89.00	209.20	32.0	129	89	146	14.31
M-43	33.03	94.95	158.40	3.52	145	85	139	17.68
M-44	35.22	101.52	128.60	3.72	138	91	148	16.43
M-45	35.89	72.80	186.00	3.44	123	87	142	18.06
M-46	32.56	98.10	242.20	3.16	112	90	150	19.00
M-47	40.37	96.40	180.40	3.32	105	89	150	18.31
M-48	34.66	88.98	164.40	3.24	112	79	145	14.18
M-49	46.57	91.80	196.40	3.00	120	89	141	17.93
M-50	36.18	61.04	246.20	3.64	111	101	155	19.75
M-51	52.19	97.08	204.60	3.36	115	96	164	19.62
M-52	26.50	97.60	110.60	2.92	109	87	145	17.31
M-53	56.96	93.24	190.20	3.04	124	94	154	18.06
M-54	44.28	101.60	200.00	3.12	143	92	152	17.50
M-55	34.25	96.40	161.00	3.18	113	87	152	16.06
M-56	69.04	87.50	304.60	3.28	116	95	164	16.25
M-57	32.25	85.60	153.80	3.32	129	87	142	19.68
M-58	21.93	87.80	96.40	3.48	124	89	143	21.56
M-59	28.28	80.80	96.80	3.64	123	85	137	17.81
M-60	26.75	87.10	102.40	3.52	115	80	144	15.50

(Cont'd)

Contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-61	32.60	72.60	147.00	3.40	118	90	137	20.80
M-62	28.66	78.50	101.20	3.44	116	85	134	18.31
M-39 M-63 M-39.57	87.04	132.60	3.56	126	79	128		14.18
M-64	19.00	72.70	97.40	3.32	119	91	144	20.25
M-65	31.87	86.00	135.60	3.40	136	85	132	16.18
M-66	30.83	100.20	154.40	3.44	148	87	142	17.93
M-67	32.57	84.50	127.00	3.44	122	90	141	16.68
M-68	35.28	86.10	113.20	3.40	149	82	142	21.12
M-69	31.10	87.08	157.00	3.40	130	86	134	15.93
M-70	40.71	96.76	185.40	3.32	152	90	149	16.37
M-71	33.13	97.40	113.20	3.56	146	90	134	17.37
M-72	30.93	84.81	106.00	3.32	127	96	149	17.81
M-73	27.50	79.63	109.00	3.34	127	89	148	20.43
M-74	23.54	88.40	163.80	3.04	100	87	147	19.75
M-75	24.40	91.22	158.80	3.28	112	86	134	21.00
M-76	33.03	85.96	145.40	3.28	115	82	135	15.50
M-77	30.62	85.80	101.40	3.32	104	87	138	17.31
M-78	32.91	106.60	121.00	3.44	132	78	136	20.68
M-79	32.77	92.00	127.00	3.36	115	97	168	19.68
M-80	37.91	94.20	141.80	3.28	118	95	142	16.68

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-81	33.33	93.00	167.40	3.56	120	91	141	17.06
M-82	49.28	92.88	150.80	3.04	110	87	141	20.06
M-83	43.16	93.52	175.80	3.40	117	89	151	17.31
M-84	49.61	67.42	187.80	3.04	110	87	151	21.56
M-85	36.44	60.86	192.00	4.12	106	99	150	21.31
M-86	31.42	76.00	92.20	3.60	107	83	137	20.93
M-87	42.38	63.86	82.60	3.52	103	88	141	20.37
M-88	31.86	77.00	201.00	3.24	111	86	135	17.00
M-89	33.79	112.54	143.20	3.12	113	78	134	20.43
M-90	38.54	74.54	186.60	3.56	117	80	134	15.31
M-91	30.56	70.24	151.00	3.16	119	89	133	21.56
M-92	27.42	86.00	140.40	3.32	142	86	138	24.06
M-93	25.00	67.78	173.60	3.84	130	86	144	22.25
M-94	24.75	67.60	155.20	3.56	126	82	137	16.93
M-95	23.70	74.40	100.40	3.76	114	81	165	16.62
M-96	26.96	58.16	163.00	3.40	125	87	140	17.12
M-97	21.15	76.40	114.80	3.20	129	92	144	20.31
M-98	32.50	66.60	150.60	3.48	125	87	139	20.81
M-99	24.65	74.42	104.80	3.40	92	83	139	18.68
M-100	29.31	76.80	162.00	3.64	104	82	134	19.56

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-101	33.39	80.00	106.80	3.40	110	77	134	15.93
M-102	28.92	75.00	142.40	3.44	120	89	145	17.87
M-103	28.84	78.00	122.00	3.48	112	81	132	16.43
M-104	30.12	80.92	155.00	3.24	109	92	147	21.68
M-105	23.46	62.46	187.00	3.64	124	83	140	20.68
M-106	28.50	72.72	187.00	3.72	124	78	133	16.81
M-107	45.35	86.10	224.00	3.64	116	90	150	18.31
M-108	29.31	84.36	222.60	3.04	118	87	135	18.00
M-109	40.80	83.90	220.60	3.24	135	90	148	18.18
M-110	33.27	91.94	149.40	3.40	130	87	153	21.00
M-111	45.65	102.20	155.30	3.28	137	82	153	17.18
M-112	43.88	92.20	278.40	3.56	127	75	141	17.37
M-113	36.50	37.00	165.80	3.60	110	72	132	15.12
M-114	34.56	95.24	197.00	3.00	103	76	134	17.31
M-115	24.10	80.66	204.80	3.48	124	82	144	16.56
M-116	33.45	88.10	159.60	3.52	127	77	133	22.12
M-117	35.59	88.10	149.40	3.32	124	81	131	20.12
M-118	34.80	87.24	172.30	3.08	112	81	134	17.56
M-119	35.40	96.12	175.40	3.52	130	85	147	22.12
M-120	34.00	87.80	152.00	3.56	126	77	165	20.05

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-121	45.50	86.20	219.00	3.40	127	95	142	23.43
M-122	31.80	80.00	145.80	3.08	105	90	137	17.18
M-123	28.00	66.10	190.60	3.52	112	95	144	17.18
M-124	31.07	86.80	138.50	3.28	108	90	144	16.68
M-125	30.37	61.50	115.60	3.32	116	91	136	17.06
M-126	31.13	91.50	98.40	3.40	107	87	137	16.37
M-127	44.50	88.60	223.00	3.40	106	96	149	20.06
M-128	84.00	89.12	148.00	3.48	83	90	141	19.87
M-129	37.71	89.04	132.80	3.48	109	79	134	15.93
M-130	33.46	93.00	167.80	2.84	103	89	148	24.00
M-131	21.36	90.60	192.40	3.00	116	76	135	16.43
M-132	35.40	89.70	117.00	3.24	97	88	144	17.50
M-133	14.43	73.80	171.20	3.16	97	87	134	18.68
M-134	23.03	90.50	261.40	2.76	105	85	131	17.18
M-135	26.12	94.68	128.80	3.52	117	90	142	16.50
M-136	26.42	83.24	164.80	3.08	115	88	135	16.00
~~M-137~~	~~26.42~~	~~34.17~~	~~92.20~~	~~129.60~~	~~3.46~~	~~114~~	~~79~~	~~128~~
M-137	34.17	93.20	129.60	3.48	114	79	128	16.87
M-138	27.19	92.00	177.00	3.28	142	97	150	16.75
M-139	30.00	88.00	229.60	3.48	136	87	132	15.18
M-140	45.17	99.12	199.60	3.24	122	87	146	16.50

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-141	35.09	89.16	197.20	3.56	121	83	131	17.62
M-142	37.66	94.68	126.60	3.60	107	87	141	15.75
M-143	33.64	85.28	124.60	3.60	134	81	132	20.31
M-144	37.75	98.28	191.80	3.52	139	89	135	18.12
M-145	37.41	100.28	179.60	3.52	143	87	135	18.12
M-146	39.25	80.00	123.20	3.44	110	88	141	15.75
M-147	37.04	92.68	134.60	3.32	113	88	141	18.00
M-148	29.34	96.60	159.60	3.44	136	91	131	17.01
M-149	31.29	99.20	192.20	3.48	137	83	139	15.66
M-150	29.83	85.84	131.00	4 56	124	92	150	16.28
M-151	27.86	82.68	168.40	3.56	112	89	140	17.06
M-152	22.00	90.80	124.80	3.40	113	92	148	17.50
M-153	23.68	87.00	118.40	3.56	109	95	144	18.56
M-154	22.56	92.12	125.60	3.32	118	82	146	15.18
M-155	19.33	84.80	85.60	3.00	105	91	145	17.18
M-156	28.90	69.40	164.20	3.52	107	92	145	16.00
M-157	16.39	83.04	112.60	2.96	103	83	168	15.18
M-158	11.19	84.60	101.20	3.52	87	96	144	15.25
M-159	20.69	98.72	107.00	3.08	105	94	152	14.68
M-160	18.65	94.10	137.40	3.36	91	89	136	16.06

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M-161	15.57	94.20	90.60	3.56	101	96	144	15.25
M-162	17.73	100.92	93.40	3.36	100	92	145	17.08
M-163	22.38	98.40	93.00	3.64	101	92	141	16.81
M-164	27.32	91.60	194.80	3.40	120	91	134	15.50
M-165	28.70	95.60	157.20	3.48	146	86	131	17.93
M-166	25.70	87.70	139.00	3.36	117	89	134	16.81
M-167	22.17	89.04	169.00	2.96	117	88	143	17.37
M-168	41.87	102.50	206.40	3.40	128	87	150	15.75
M-169	18.90	78.80	56.20	2.72	72	~~15.94~~ 87	137	15.94
M-170	22.57	90.80	90.40	3.28	85	92	152	16.00
M-171	17.14	87.80	126.20	2.68	91	87	141	19.56
M-172	28.78	82.60	187.80	2.88	114	92	149	14.06
M-173	31.00	86.42	167.20	3.28	113	84	135	15.31
M-174	30.36	101.76	159.40	2.80	122	87	141	17.56
~~M-175~~	~~87.26~~	~~163.00~~	~~2.92~~	~~121~~	93 ~~16.06~~	~~146~~		
M-175	35.71	87.26	163.00	2.92	121	93	146	16.06
M-176	29.48	90.40	121.00	2.92	102	77	132	16.62
M-177	28.53	88.50	171.60	3.24	111	94	136	20.62
M-178	18.42	80.38	136.60	3.16	138	93	167	20.81
M-179	29.31	72.30	165.40	2.84	109	96	157	20.87
M-180	23.50	87.44	137.20	3.32	90	77	128	15.31