FORMULATION OF A KEY FOR IDENTIFICATION OF THE DIFFERENT TYPES OF PEPPER, *Piper nigrum* L.

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Formulation of a key for identification of the different types of pepper, Piper nigrum L." is a bonafide record of research work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
30-9-1982.

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CERTIFICATE

Certified that this thesis entitled "Formulation of a key for identification of the different types of pepper, *Piper nigrum* L." is a record of research work done independently by Kum. Kanakamany, M.T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

Pepper (*Piper nigrum* L.) ranks first in importance among the perennial spioes grown in India. Its traditional role in the nation's economy and as a foreign exchange earner is well recognised. During the year 1980-81, India exported 25,337 tonnes of black pepper valued at Rs.36.84 orores. The production was 27,410 tonnes from an area of 1.1 lakh hectares during the same period. Average yield of pepper in India during 1980-81 was only 248 kg per hectare as against 551 to 925 kg in Indonesia, 4067 kg in Malaysia, 3333 kg in Brazil and 636 kg per hectare in Madagascar.

Kerala leads the reat of the states in production, contributing 96.75 per cent of India's total production from an area of 1.07 lakh hectares, with an average of 248 kg per hectare.

Pepper being a native of Kerala, the state is a rich gene pool of the plant. Many fundamental informations about the botany of the plant are still unavailable. Knowledge is meagre or completely lacking on morphological descriptions of important cultivars, floral biology, anatomy and cytology of the plant. This is a serious gap in our knowledge about the plant and its behaviour in relation to productivity. Some of the characters such as internodal length, flowering

time and pattern, spike maturity etc. are known to have a direct bearing on the productivity of the plant. So detailed studies on these aspects are quite essential for formulating an efficient and effective crop improvement programme.

There are many cultivated varieties of pepper in India. Each tract has its own selection of popular varieties known by different vernacular names such as Balankotta, Kalluvally, Cheriyakodi etc. Several varieties are named after the places in which they are produced. A precise knowledge of the various varieties is essential for their identification which would help to select the best variety for future work. The earlier descriptions of pepper varieties are very sketchy and deal with only a few characters of the plant. Therefore, it is highly important to record standard descriptions of the different varieties and to classify them.

So the present studies have been undertaken in pepper at the College of Horticulture, with the following objectives in view.

1. To make available a key for identification of the different types.

2. To classify the different cultivars based on definite morphological characters.

Review of Literature

REVIEW OF LITERATURE

A review of the available literature on the various aspects of the problem is attempted here. In cases where information from the published work in pepper is scanty, examples from other vegetatively propagated perennial crops are also drawn in order to give an overall dimension of the problem.

The systematic position of pepper (Piper nigrum L.) is a matter of controversy among the taxonomists and conflicting opinions have been put forward.

DeWaard and Zeven (1969) placed pepper under the family Piperaceae, of the Piperales which was one of the most primitive branches originated from the Ranales. They considered the family as dicotyledonous but the stem characteristics were intermediate between those of the dicotyledons and those of the monocotyledons. Engler and Prantl as quoted by Benson (1970) considered the Piperales to be among the most primitive flowering plants, but Randle believed them to be related to the Polygonales in the trimerous relation of the flower and the orthotropous solitary ovule. Meeuse (1972 reported that the order Piperales although somewhat eurypolynous in the sense of Erdtman (1969) did not have the tricolpate or colporate pollen type so common in many dicotyledonous groups.

Contrary to the views of the above scientists, it is now considered that the family Piperaceae is an independent and terminal offshoot of direct Ranalian ancestry (Shukla and Misra, 1979).

1. Related species of *Piper nigrum*

Koorders (1908) and Trelease (1930) reported the occurrence of 600-2900 *Piper* species. Diagnostic characteristics of the largest number of *Piper* species have been reported by Hooker (1886).

Several investigators (Koorders, 1908; Rutgers, 1949; Martin and Gregory, 1962 and Melchior, 1964) have reported 9 species of *Piper* as economically important. They are the following.

1. *Piper adincum* L.
2. *P. augustifolium* Vahl.
3. *P. betel* L.
4. *P. cubeba* L.f
5. *P. guineense* Schum.
6. *P. longum* L. (*P. perpuloides* Rox and *P. retrofractum* Vahl.) (syn. *P. officinarum* C.DC)
7. *P. methysticum* Forst.
8. *P. nigrum* L.
9. *P. ornatum* N.E. Br.

2. Important diagnostic characters for identification

For the identification of different species and varieties, emphasis was laid on the vegetative, floral and fruit characters by many authors.

2.1. Vegetative characters

Crane and Lewis (1940) working on the genetics of pears concluded that the leaf and the shoot characters were the most useful in classification on account of the fact that the fruit characters (like the shape of the fruit) were quantitative and controlled by a number of genes.

Upshall (1924), Alderman and Shoemaker (1925), Winter (1925) and Roberts and Colby (1943) have stressed the importance of shape of the leaf or the size of the leaf in the rapid identification of varieties, these characters according to them were constant. Drain (1925) agreed with the view and added that apple varieties could be recognized by the leaves in the middle of the shoots, which were constant for a variety.

The flat or folding nature of leaves, their reflection or crinkling nature and waviness were of diagnostic value in variety identification according to Grub (1922), Upshall (1924), Thomson (1932), Babone (1932, 34), Sefick and Blake (1937) and Meader and Blake (1939).

Shaw (1914) and Alderman and Shoemaker (1925) have pointed out the taxonomic importance of the shape of the leaf base and leaf tip. According to Alderman and Shoemaker (1925) the shape of the leaf base in apples ranged from broad roundish to tapering or cuneate, which were the reliable characteristics of the varieties. Blake and Connors (1936) stated that the apices of the blades of different varieties of peaches formed angles which ranged from narrow to broad and further inferred that margins of leaves of some varieties tapered towards the apex in straight lines while in the case of some varieties they curved to the apex. They opined that the shape of the leaf tips varied with the growth status.

Shaw (1914) found that the leaf colour was not helpful in recognizing varieties as the shade of the green depended on the vigour of tree. Alderman and Shoemaker (1925) and Thomson (1932) have shown clearly the importance of colour of young foliage in taxonomy.

2.2. Floral characters

Farrel (1917), Thomson (1932) and Babone (1932, 34) have all emphasized the value of flower characters for the identification of fruit varieties. Hedrick (1925) and Pearl (1932) pointed out that the inflorescence characters were the least variable and more constant than any other

characters even under varying conditions. Pearl (1932) considered that the floral characters of apples provided easy methods of identification of varieties.

Farrel (1917) and Bunyard (1934) have observed that the flower bud colour or the colour of the flowers were important diagnostic features.

Popenoe (1941) indicated that the proportion of perfect and staminate flowers to be varying with the different varieties and races and were constant in each.

Farrel (1917) considered the season of blooming to afford to a reliable varietal character. Pearl (1932) and Bunyard (1934) stated that a knowledge of the comparative time of blooming furnished a distinguishing feature among varieties.

2.3. Fruit characters

Several workers (Hedrick, 1925; Babone, 1934; and Hogg, 1966) have given the importance of fruit characters in their classification.

Durham (1920), Drain (1925) and Babone (1932, 34) have paid attention to characters as the fruit shape, volume, size, length and breadth and the ratio between the two in their systematic studies. Hedrick (1925) and Drain (1925) pointed out that shape of the fruit was the best of all the characters for identification.

The colour of the skin or the rind was given importance in the systematic studies of fruits by Drain (1925), Hedrick (1925) and Babone (1932, 34). Boswel (1933) added that the colour of the immature fruit also was helpful in identifying varieties.

3. Sex and sex ratio

Koorders (1908) reported that the most wild Piper species and some wild forms of Piper nigrum in the Western Ghats were dioecious. But Nambiar et al. (1978) observed several hermaphrodite types among the wild types.

Most of the cultivated types of pepper were monoecious as reported by Hasan Iljas, 1960; Nambiar and Sayed, 1962; and Martin and Gregory, 1962. According to them the cultivar Kuthiravally produced hermaphrodite, female and male flowers, whereas Uthirancotta appeared to possess female organs only. Hasan Iljas (1960) reported that stamens present in a rudimentary form embedded in the tissue below the surface would provide an explanation for the restricted hermaphroditism in some of the cultivars. Male plants were rare and could be easily recognized by their vigorous, vegetative appearance (Koorders, 1908; Marinet, 1953; and Hasan Iljas, 1960).

Krishnamurthi (1969) observed that the cultivars exhibited great variability in the percentage of hermaphrodite

flowers on the spikes and according to him most of the high yielding and popular cultivars produced as much as 70-98 per cent bisexual flowers. The male flowers on a spike varied from 0 to 19 per cent, while bisexual flowers showed a wide variation of 2 to 93 per cent (Nambiar *et al.*, 1978). They also found that the proportion of female flowers increased with an increase in the intensity of shade, and the spikes produced during the off season were also characterised by more number of female flowers than in those produced during the normal flowering season. The sex of the pepper vine was greatly influenced by season as reported by Shanmugavelu and Rao (1977). Rema Menon (1981) found that the mean number of flowers per spike in Panniyur-1 was 107.74, with 97.18 per cent hermaphrodite and 2.82 per cent pistillate flowers. In Karimunda the spike had a mean of 46.23 flowers, which were all hermaphrodite.

A very high ratio of hermaphrodite flowers was essential for high potential production as reported by Cramer (1907) and Blacklock (1954).

4. Morphological descriptions of *Piper* species and cultivars of *Piper nigrum* L.

Hooker (1978) in his flora of British India has given the key to the species of *Piper* (45 numbers). Lewis *et al.* (1975) reported the occurrence of about 70 pepper cultivars

in India. According to them the cultivars had a localised distribution from very early times and they differed in size and colour of berries, length and shape of the spikes, yields, resistance to diseases, etc. They have given the distribution of some recognized cultivars on a regional basis as given below.

1. Kerala (Travancore-Cochin)

   Karimunda, Kuthiravally, Perumkodi, Narayakodi, Chumala, Kumbhakodi, Cheriyakaniyakadan, Chola, Karuvilanchi, Valiyakaniyakadan, Kottanadan, Padappan.

2. Kerala (Malabar) and Karnataka (South Canara)

   Kalluvalli, Cheriyakodi, Karinkotta, Arikotta, Kottavalli, Balancotta, Uthirancotta.

3. Karnataka (North Canara)

   Malligesara, Morata, Doddaga, Kare Malligesara, Arisina, Morata, Uddakarekduregunta.

4. Assam

   Khasi Hill, Deragoni, Cachar

Shanmugavelu and Rao (1977) have given the distinguishing characters of the pepper varieties grown in Malabar and South Canara namely, Kalluvally, Balancotta, Cheriakody, Uthirankotta and Karimkotta and the varieties grown in Karnataka like Workaria Marata, Karimarata, Arasilamarata,

Doddagya, Malligesara and Tattisara and some Travancore forms which included Karimunda, Veluthanamban, Cheriyakaniyakkadan, Kuthiravally, Chola, Karuvilanchy, Chumala, Kumbhakodi and Kottanadan. At the Pepper Research Station, Panniyur, the morphological studies of five cultivars from Malabar region and twelve cultivars from Travancore region were completed (Nambiar et al., 1978). The important morphological characters recorded were the size, shape, colour and angle of insertion of leaves, branching habits, length of spike, size, shape and volume of berries. They also studied the development of spikes and flower in 20 pepper cultivars. Observations were made on the number of days taken for the emergence of the spikes from its sheath, the first flower to open after emergence of spike, complete opening of all flowers on a spike, period of receptivity of last flower (stigma) and period between opening of first flower and first anther.

5. Blossom studies in pepper

DeWaard and Zeven (1969) reported that in pepper the inflorescence was produced on the current season growth, opposite to a leaf. They reported the presence of two successive primordials of a raceme within a single bud giving rise to abundant flowering.

According to DeWaard and Zeven (1969) the inflorescence of pepper was a catkin supporting 50-150 small sessils flowers,

but Cobley and Steele (1976) described them as long slender pendulous spike.

DeWaard and Zeven (1969) studied the development of the inflorescence in detail. They found that the spike exhibited positive geotropism several days after emergence. After 15 days, the length of immature spikes increased and flower appeared from the basal portion. A protogyny stage developed and existed for five days and later the stamens appeared from the base of the spike. Four or five days later each stigma was accompanied by one or two stamens. The development was fundamentally centripetal, but an irregular appearance was frequently observed.

Nambiar et al. (1978) conducted experiments at the Pepper Research Station, Panniyur and the following observations were made. The spike emerged covered in a sheath, the colour of which varied from green to pinkish or even violet. It took about 20 to 25 days for the full emergence of the spike from the sheath. The flower opened 8 to 14 days after the emergence of the spike, starting from the base and progressively advancing towards the tip. The complete opening of the flowers on a spike took about 6 to 9 days.

The period of existence of the protogynic stage was found to vary. Under Indian conditions, protogyny extended over a period of 7 to 8 days (Anandan, 1924; and Cobley

and Steele, 1976). Martin and Gregory (1962) observed that in Puerto Rico a period of 3 to 8 days passed before anther dehiscence was observed. According to Hasan Iljas (1960) protogyny was a varietal character, which sometimes did not exist. Recent reports revealed that though protogyny was seen in majority of the cases, the simultaneous opening of the male and female flowers and protandry were exceptions (Nambiar et al., 1978).

Benson (1970) and Rendle (1971) described the flowers in pepper as naked, minute, bracteate, usually bisexual, sometimes unisexual with no perianth, and the flowers were more or less sunk in the fleshy axis of the spike on which they closely occurred.

Rendle (1971) reported that in Piperaceae, the number of stamens varied from 1 to 10, but most of the flowers might have derived from a trimerous type with two whorls, 3 stamens each, but Piper nigrum was found to possess two stamens, the posterior one of the inner whorl being aborted. Cobley and Steele (1976) and Purseglove (1977) reported the number of stamens as 2 to 4, occurring on either side of the ovary in hermaphrodite flowers. DeWaard and Zeven (1967) found that the stamens pushed its way through the catkin tissue and appeared as a white spherical body on the top of a short thick filament.

The ovary has been described as ovate, unilocular and superior (Cobley and Steele, 1976; Purseglove, 1977; Shukla and Misra, 1979). The number of carpels varied from 1 to 4 as reported by Benson (1970) and 1 to 5 as reported by Shukla and Misra (1979). The ovule was observed to be single, solitary and orthotropous with two or sometimes one integument (Benson, 1970; Shukla and Misra, 1979). Shukla and Misra (1979) also described the placentation as basal. Benson (1970) reported the number of stigma to be 2 to 5, while DeWaard (1967) and Purseglove (1977) found the number to be 3 to 5. According to Cobley and Steele (1976), the stigma was star shaped and sessile, the number corresponding to the number of carpels.

6. Anthesis, anther dehiscence and receptivity of stigma

Nambiar et al. (1978) reported that anthesis in pepper commenced from 19.30 hours. Flower opening started from the base of the spike and continued towards the tip. Rema Menon (1981) observed that anthesis started between 18.00 and 18.30 hours and continued upto 02.30 hours of the next day. The peak was recorded between 18.30 and 0.30 hours.

Temperature and relative humidity partially controlled the longitudinal dehiscence of pollen sac (Hasan Iljas, 1960; and Martin and Gregory, 1962). Work in Sarawak indicated that dehiscence usually took place between 12.00 and 14.00

hours on days when a relative humidity of approximately 60 per cent was attained at a temperature of 32°C and in conditions of bright sunshine (DeWaard, 1967). DeWaard and Zeven (1969) observed that anther dehiscence within pairs was not simultaneous as a rule. Studies conducted at the Pepper Research Scheme, Vellanikkara, by Rema Menon (1981) showed that dehiscence of anther started from 14.30 hours and continued upto 16.30 hours, with the maximum between 14.30 and 15.30 hours. But Nambiar et al. (1978) suggested that in case of protogyny the anthers dehisced at any time within four days after the stigma became receptive.

Martin and Gregory (1962) showed in Puerto Rico that the stigmas were receptive for 10 days with peak receptivity 3 to 5 days after excertion. DeWaard and Zeven (1969) studied the receptivity of stigma and according to them a viscous condition indicated receptivity and the period of peak receptivity occurred three to five days after emergence and extended to ten days, depending on the cultivar and environment. Nambiar et al. (1978) observed that the period of receptivity of stigma varied based on the position of flowers on the spike. Flowers at the base of the spike had a receptive period of 7 to 9 days while it was only 3 to 5 days for those towards the tip.

6.1. Pollen studies

The knowledge of pollen morphology was important in taxonomic studies, as variations in pollen grains were correlated with the evolution of angio-sperms.

Considerable work on pollen size measurement has been done in other crops. Large variations were not noticed in pollen size among the varieties of perennial phlox (Post 1938a) and Lilium longiflorum (Post 1938b). Pollen sizes of 14 Mangifera species and 27 varieties of M. indica were found to be almost the same by Mukherjee (1951). Mallick (1957), however, reported that the pollen grains differed in size in different varieties of mango. Randhawa and Nair (1960) noticed slight variation in pollen size among six plum varieties. They added that pollen size was found almost constant within the same variety. Hasan Iljas (1960) and Martin and Gregory (1962) reported that the pollen grains of pepper were small with 10 µ diameter irrespective of cultivars.

For testing the viability of pollen grains, Zirkle (1937) suggested a method by mounting them in acetocarmine. The grains which stained well, looked plumpy and well shaped, were taken by him to be fertile and the unstained shrivelled ones - nonviable or sterile. The same method has been adopted by Balasubramanian (1959) in guava, Nirmalendunath and Randhawa (1959) in pomegranate, Singh (1961) in mango,

Singh (1962) in Litchi, Nalawadi et al. (1977) in sapota, Thankamma Pillai et al. (1978) in ginger and Rema Menon (1981) in pepper to find out the percentage of pollen fertility.

The methods to study the output or production of pollen in flowers have been constantly improved upon since the year 1935. Knowlton (1935) estimated pollen output by allowing one another to dehisce on a glass slide, ruled into squares and counting all the pollen grains. He found this cumbersome and employed the haemocytometer. Oberle and Geortzen (1952) standardized the haemocytometer method. They recommended a suspension size of ten samples of hundred anthers each and four subsampling for taking counts with 100 anthers per sample. Pozzi (1953) has successfully employed the method with several varieties of grapes, peaches, plums, cherries and apples.

The influence of inherent and seasonal factors is felt on the pollen output also. Varietal and seasonal variation in pollen output among the 14 varieties of apples during the two years of study was reported by Knowlton (1935). He explained this variation as due to differences in the size of pollen grains and anthers among the varieties as well as within each variety. Oberle and Geortzen (1952) studied the variation in pollen output among the different varieties of

grapes, apples, peaches and plums during two consecutive years 1949 and 1950. Rao and Khader (1962) have observed significant varietal variation in their studies with papaya, sapota and pomegranate.

In Indian pepper cultivars each spike yielded 500000-700000 pollen grains of 10 μ in diameter each (Marinet, 1955). Martin and Gregory (1962) suggested that the pollen grains per spike varied from 100,000 to 300,000.

7. Fruitset and ripening

Detailed studies on fruitset and ripening were done in pepper by Martin and Gregory (1962). The ovaries of spikes developed into three types namely the completely developed fruit, underdeveloped fruit and the undeveloped ovaries. The ovaries of undeveloped fruits started growing and stopped at a certain moment and they opined that insect damage was the cause. The presence of undeveloped ovaries was due to lack of fertilization, insufficient pollination, poor quality pollen and loss of receptivity of the stigma when pollen grains were available.

DeWaard and Zeven (1969) reported that the berry weight and size and rate of fruit development were superior for the cultivars Balancotta and Uthirankotta.

In pepper, the ripening of the fruit was uneven and the

period between flowering and ripening ranged from five to nine months with an average of seven months in India (Menon, 1949).

8. Spike shedding

Spike shedding in pepper, has so far been considered as a natural phenomenon. But various observations made on this aspect in recent years, have indicated that it is influenced by various external agencies as well. Pillai et al. (1977) have reported that loss of crop due to spike shedding might be as high as 40 per cent, especially during unfavourable years. Rema Menon (1981) observed 23.82 per cent spike shedding in Panniyur-1. The spike shedding in three cultivars viz., Panniyur-1, Kottanadan and Karimunda was found to be significantly different, with maximum shedding observed in Panniyur-1 (18.04%) followed by Kottanadan (5.38%) and minimum in Karimunda (2.80%) (Geetha, 1981).

Materials and Methods

MATERIALS AND METHODS

The investigations reported herein were undertaken in the Department of Agricultural Botany, College of Horticulture, Vellanikkara, during the years 1981, 82 with the objective of formulation of a key for identification of the different types of pepper.

A. Materials

From the germplasm available in the Pepper Research Scheme, College of Horticulture, Vellanikkara, fifty types of diversified origin representing the wide spectrum of variability present in the material were ear-marked for the study. All the selected types were planted during July 1977 and hence were of five year old. They have all been receiving uniform management practices as suggested in the Package of Practices for pepper published by Kerala Agricultural University. These types were numbered from PN 1 to PN 50. Details of the types selected are given in Table 1.

Table 1. Details of types selected for study

Sl.No.	Accession No.	Local name	Place of origin
PN 1	70	Munda	Louli Estate, Konni
PN 2	69	Chengalum-II	Louli Estate, Konni
PN 3	86	Veluthanamban	Pattam Colony
PN 4	101	Perumkodi	Palai

Sl.No.	Accession No.	Local name	Place of origin
PN 5	100	Cholamundi	Palai
PN 6	99	Cheriyakaniyakadan	Palai
PN 7	97	Karimunda	Palai
PN 8	96	Narayakodi	Palai
PN 9	95	Poovathanum I	Palai
PN 10	94	Arakulamundi	Palai
PN 11	81	Kumili	Ranni
PN 12	82	Chumala	Ranni
PN 13	80	Chankupazhuppan	Madathara
PN 14	79	Ambryon	Madathara
PN 15	64	Palvella	Comel Estate, Konni
PN 16	72	Kotta	Koodal
PN 17	78	Kuthiravalli	Anchal
PN 18	76	Murithathum	Anchal
PN 19	73	Karinadan	Koodal
PN 20	77	Karuvilanchi	Anchal
PN 21	58	Arikottanadan	Louli Estate
PN 22	57	Mundakodi	Louli Estate
PN 23	59	Louli Type I	Louli Estate
PN 24	56	Vallikodi	Louli Estate
PN 25	61	Periyan	Louli Estate
PN 26	55	Panthan	Louli Estate
PN 27	63	Karivalli	Louli Estate

Sl.No.	Accession No.	Local name	Place of origin
PN 28	53	Padappan II	Panniyodu Tribal settlement - Nedumangadu Taluk
PN 29	52	Padappan I	Panniyodu Tribal Settlement - Nedumangadu Taluk
PN 30	46	Kottanadan	Peringamala (TVM)
PN 31	47	Kottanadan	Peringamala (TVM)
PN 32	48	Kottanadan	Peringamala (TVM)
PN 33	51	Narayakodi	Peringamala (TVM)
PN 34	50	Kottanadan	Peringamala (TVM)
PN 35	49	Kottanadan	Palodu
PN 36	42	Lodika	PRS, Panniyur
PN 37	41	Kottanadan (Kottaram)	PRS, Panniyur
PN 38	32	Kuthiravally	PRS, Panniyur
PN 39	20	Balancotta	PRS, Panniyur
PN 40	102	-	-
PN 41	84	Thevarmundi	Kumili
PN 42	-	Vellamundi	Kumili
PN 43	43	Kottanadan	Peringamala (TVM)
PN 44	39	Mallikeswara	PRS, Panniyur
PN 45	33	Karuvalli	PRS, Panniyur
PN 46	30	Karimunda	PRS, Panniyur
PN 47	-	Neelamundi churuli (Kalluvally Type II)	-
PN 48	35	Karimunda II	PRS, Panniyur
PN 49	44	Kottanadan	Peringamala
PN 50	204	Panniyur-1	PRS, Panniyur

During the course of investigation, observations on 5 types viz., PN 25 (Periyan), PN 36 (Lodika), PN 44 (Mallikeswara), PN 45 (Karuvalli) and PN 48 (Karimunda II) were abandoned, since these types did not survive.

B. Methods

Observations on the following characters were recorded from all the 45 types available. For morphological descriptions, the terminology used in the present study was as per Narayanaswamy and Rao (1976) and colour descriptions were based on the colour dictionary by Maerz and Paul (1950).

I. Vegetative characters:

1. Colour of vegetative bud

The colour of vegetative bud of each type was compared with the colour chart and this was separately recorded.

2. Shape of vegetative bud

The shape of the vegetative bud was described as short conical curved, short conical straight and long conical slightly curved and the types were grouped accordingly.

3. Length and width of the vegetative bud

This was measured in cm from ten buds selected at random from each plant and length/breadth ratio was calculated. Sketches of the buds were also made to show the variations.

4. Leaf sheath colour

The colour of leaf sheath of different types was recorded.

5. Length of petiole

This was measured in cm from 10 petioles selected at random and the mean worked out.

6. Thickness of petiole

The thickness of petiole was measured in cm. This observation was confined to ten samples per type and the mean was arrived at.

7. Colour of petiole

The colour of petiole was observed for each of the 45 types.

8. Colour of emerging leaves on the upper side

9. Colour of emerging leaves on the lower side

The colour of emerging leaves on the upper and lower sides was observed for all the 45 types.

10. Mature leaf colour on the upper side

11. Mature leaf colour on the lower side

Colour of the mature leaves on the upper and lower sides was separately observed for all the 45 types.

12. Shape of lamina

Shape of lamina of all the 45 types was recorded. Sketches showing the different shapes were also made.

13. Area of lamina

The area of lamina was determined by drawing the leaf boundaries on a graph paper and counting the squares. This observation was confined to ten samples per type and the mean arrived at.

14. Position of the leaf blade

The position of the leaf blade (phyllotaxy) for each of the 45 types was separately observed.

15. Texture of mature leaves

This was determined by folding and breaking the lamina of mature fresh leaf.

16. Leaf tip

17. Leaf base

18. Leaf margin

19. Leaf surface

These characters were observed for all the 45 types.

20. Shape of stem (orthotrophs)

Shape of vertically growing stem was observed for all the types.

21. Length of internode (orthotrophs)

This was measured in cm with the help of a meter scale for ten internodes selected at random for each variety and the mean arrived at.

22. Thickness at node and internode (orthotrophs)

The circumference at the nodal as well as internodal regions was separately measured in cm with the help of a twine and meter scale at the rate of ten observations per type and mean arrived at.

23. Internodal length of laterals (plageotrophs)

This was measured in cm with the help of a meter scale for ten internodes per type selected at random and the mean arrived at.

24. Thickness at node and internode of laterals (plageotrophs)

This was separately measured in cm with the help of a twine and meter scale. Ten observations were recorded per type and the mean arrived at.

25. Angle of laterals

The angle subtended by the lateral with the main stem was measured in degrees and if it was more than 80^{o}, the lateral was designated as drooping and if less than 80^{o}, it was designated as semierect.

II. Floral characters:

26. Length of spike

Length of the spike was measured in cm on the first day of emergence at the rate of ten random spikes per type. This was repeated for 37 days at an interval of 3 days in order to find out the rate of growth.

27. Mean number of spikes per lateral

Ten lateral shoots per type were tagged and number of spikes produced in each lateral was separately counted at the time of harvest and their mean value calculated.

28. Anthesis

Observations on the time of flower opening and anther dehiscence were recorded by observing the time of opening of individual flowers on the spike and the time of dehiscence of anthers in individual flowers at periodic intervals. This observation was confined to ten spikes per type. Spread of flower opening and anther dehiscence was studied by noting the number of flowers opened on each day and also the number of anthers dehisced in each day, right from commencement to completion of the same in a spike. From that, the durations of the female and male phases were worked out for each type.

29. Flowers

The number of hermaphrodite, pistillate and staminate

flowers in a spike was separately counted and recorded. This observation was confined to ten spikes per type and the mean values arrived at. The percentages of hermaphrodite, pistillate and staminate flowers to the total in a spike were also worked out for each type.

30. Stigma

Number of stigmatic lobes for each variety was separately counted. This was taken from ten spikes per type and the mean was worked out.

The receptivity of stigma was observed with the help of hand lens in each variety. Creamy white stigmas with shiny appearance were considered to be receptive, whereas dried and brownish ones were treated as non-receptive. This was ascertained by observing the opened flowers continuously for 7 days.

31. Stamen

Slides of pollen grains of each type were prepared after staining them with acetocarmine. The diameter of pollen grains was measured with a micrometer, the measurement being confined to 100 pollen grain per type. The mean was then worked out.

Fertility of pollen grains was determined by noting the number of well filled, oval, well stained pollen grains

and also the total in a microscopic field. Observations were recorded from 30 microscopic fields per type. Percentage of fertile pollen was determined by using the formula given below.

$$\text{Pollen fertility percentage} = \frac{\text{Number of fertile pollen}}{\text{Total number}} \times 100$$

The procedure of estimation of the quantity of pollen produced per flower was similar to that of Oberle and Goertzen (1952). From each type, spikes with mature anthers which were about to dehisce, were collected. Hundred anthers were separated with a dissection needle and were transferred to cotton plugged glass vials before dehiscence. The anthers were crushed gently and 2.5 ml of water containing 0.25 per cent Calgon was added and the contents thoroughly stirred in order to obtain an even dispersion of the grains in the suspension. A drop of this suspension drawn in a fine pipette was transferred to each of the two counting chambers of a haemocytometer. Each chamber had an area of nine square millimeter ruled into square millimeter areas. Each of the four corner square millimeter areas were ruled into 16 while other five square millimeter areas were ruled into smaller divisions. The counting chambers were 0.1 mm in depth, so that the volume of solution over 0.1 mm^2 was 0.1 mm^3. The number of pollen per flower was calculated as follows:

If N = average number of pollen counted per corner square

X = number of grains per anther

N:X = 0.1:25

0.1X = 25 N

X = 250 N

The pollen grains in each of the four corner squares of each counting chamber were counted with the help of a hand tally counter using the low power objective of the microscope. For each vine, ten such estimates were made and the total number of flowers examined per vine was 250.

III. Fruit characters:

32. Number of berries per spike

Total number of berries per spike, number of well developed berries per spike and number under-developed berries per spike were separately counted for each type at the rate of 10 spikes per type and the means worked out.

33. Berry size

This was estimated by measuring the diameter of a berry in mm by a Vernier. This observation was recorded for 25 berries per spike and the mean arrived at.

34. Berry colour

Colour of young, mature and ripe berries was separately observed and recorded for each variety.

35. Berry weight and volume

Weight in g of 1000 well developed berries was determined soon after harvest and also after proper drying. Ten samples per type were weighed and the means arrived at. The volume in cc of 1000 berries soon after harvest and also after proper driage was also determined by water displacement method. This observation was recorded from 10 samples in each of the variety.

36. Percentage of spike shedding

At the time of emergence, 150 spikes were tagged in each type. The number of spikes that remained till harvest was recorded. From this the percentage of spike shedding was calculated.

IV. Oleoresin content:

The berries were chemically analysed for their oleoresin content, following the method suggested by Nambudri et al. (1970). Two grams of coarsely ground pepper mixed with 20 g sodium sulphate was packed in tall columns and a solvent acetone was allowed to percolate down slowly and collected in previously weighed beakers till the last percolated material became colourless. The extract was then air dried to remove the solvent and weight again determined to obtain oleoresin. From this the percentage of oleoresin was calculated.

Results

RESULTS

Results of observations on important vegetative, floral and fruit characters collected from 45 pepper types are presented below.

Observations on the vegetative characteristics are presented in Table 2. Table 3 furnishes mean length of spikes. Growth rate of spikes of the different pepper types is given in Table 4. Mean number of spikes produced by the laterals is furnished in Table 5. Times of flower opening and anther dehiscence are presented in Tables 6 and 7. Table 8 presents the number of flowers in a spike in which anthers dehiscenced and Table 9 gives the spread of flower opening and anther dehiscence. Mean number of days for spike development, flower opening and anther dehiscence are presented in Table 10. Table 11 presents the sexual composition of the spikes. Size of pollen grains, pollen fertility percentage and pollen production in the different types of pepper are presented in Tables 12, 13 and 14 respectively. Table 15 furnishes the fruit characters of the different types. Extent of spike shedding and percentage of oleoresin in the different types of pepper are given in Tables 16 and 17 respectively.

I. Vegetative characters

Results of observations on the vegetative characters are presented in Table 2.

(TABLE 2)

1. Colour of the vegetative bud

The results presented in the above table, have shown that the 45 types studied fell into four categories based on colour of the vegetative bud. In fortyone out of forty-five types studied, the vegetative bud had Oasis colour, 2 types had Russet gr. colour, and one Chrysollite gr. and another Certosa colour.

2. Shape of vegetative bud

With reference to shape of vegetative bud, 45 types could be grouped into 3 viz., those possessing short conical curved ones (31 types), short conical straight ones (8 types) and long conical slightly curved ones (6 types), with short conical curved ones predominating (vide Plate I).

3. Length, width and length/width ratio of vegetative bud

Length, width and length/width ratio of the vegetative bud varied considerably among the 45 types. When PN 27 had a maximum length of 5.64 cm, PN 46 had the minimum length of 1.64 cm. Other types exhibited values in between the two.

Table 2. Vegetative characters of the different types of pepper

Type No.	Vegetative bud				
	Colour	Shape	Length (cm)	Width (cm)	Length/Width ratio
PN 1	Oasis	S.C.C.	2.56	0.24	10.67
PN 2	Oasis	S.C.C.	2.34	0.30	7.80
PN 3	Oasis	S.C.C.	2.00	0.26	7.69
PN 4	Oasis	L.C.Sc.	2.48	0.30	8.27
PN 5	Oasis	S.C.St.	1.98	0.25	7.92
PN 6	Oasis	S.C.C.	1.90	0.25	7.60
PN 7	Oasis	S.C.C.	1.74	0.30	5.80
PN 8	Oasis	S.C.C.	2.50	0.30	8.33
PN 9	Oasis	S.C.St.	2.34	0.25	9.36
PN 10	Oasis	S.C.St.	2.14	0.25	8.56
PN 11	Russet gr.	S.C.C.	3.23	0.30	10.77
PN 12	Chrysollite gr.	L.C.Sc.	2.68	0.30	8.93
PN 13	Oasis	S.C.C.	2.52	0.30	8.40
PN 14	Oasis	S.C.C.	2.52	0.26	9.69
PN 15	Oasis	S.C.C.	2.66	0.20	13.30
PN 16	Oasis	S.C.C.	2.42	0.28	8.64
PN 17	Oasis	S.C.C.	2.80	0.26	10.77
PN 18	Oasis	S.C.C.	2.86	0.30	9.53
PN 19	Oasis	S.C.C.	2.41	0.36	6.69
PN 20	Oasis	L.C.Sc.	2.36	0.30	7.87
PN 21	Oasis	S.C.C.	3.58	0.34	10.53
PN 22	Oasis	S.C.C.	2.80	0.26	10.77
PN 23	Oasis	S.C.St.	2.60	0.30	8.67
PN 24	Oasis	S.C.C.	2.42	0.30	8.07
PN 26	Oasis	S.C.St.	2.66	0.30	8.87
PN 27	Russet gr.	L.C.St.	5.64	0.35	16.11
PN 28	Certosa	S.C.C.	3.10	0.35	8.86
PN 29	Oasis	S.C.St.	2.48	0.30	8.27
PN 30	Oasis	S.C.C.	3.12	0.30	10.40
PN 31	Oasis	S.C.C.	3.04	0.34	8.94
PN 32	Oasis	S.C.C.	2.44	0.25	9.76
PN 33	Oasis	S.C.C.	3.08	0.35	8.80
PN 34	Oasis	S.C.C.	2.48	0.25	8.32
PN 35	Oasis	S.C.C.	2.74	0.26	10.54
PN 37	Oasis	S.C.St.	2.44	0.35	6.97
PN 38	Oasis	S.C.C.	2.12	0.30	7.07
PN 39	Oasis	L.C.Sc.	3.52	0.30	11.73
PN 40	Oasis	S.C.C.	2.46	0.30	8.20
PN 41	Oasis	S.C.C.	2.38	0.35	6.80
PN 42	Oasis	S.C.C.	2.74	0.34	8.06
PN 43	Oasis	S.C.C.	2.88	0.30	9.60
PN 46	Oasis	S.C.C.	1.64	0.30	5.47
PN 47	Oasis	S.C.C.	2.52	0.30	8.40
PN 49	Oasis	S.C.St.	2.56	0.30	8.53
PN 50	Oasis	L.C.Sc.	3.72	0.30	12.40

S.C.C. = short conical curved. S.C.St = short conical straight
L.C.Sc. = long conical slightly curved

(contd.)

Table 2. continued

Type No.	Sheath colour	Petiole length (cm)	Petiole thickness (cm)	Petiole colour	Colour of emerging leaf on the Upper side	Lower side
PN 1	Russet gr.	1.79	1.18	Shadow green	Oasis	Oasis
PN 2	Russet gr.	2.07	1.20	Shadow green	Oasis	Oasis
PN 3	Russet gr.	1.51	1.20	Absinthe gr.	Certosa	Certosa
PN 4	Russet gr.	1.28	1.32	Absinthe gr.	Certosa	Certosa
PN 5	Russet gr.	1.31	1.08	Absinthe gr.	Oasis	Oasis
PN 6	Russet gr.	1.20	0.90	Shadow green	Certosa	Certosa
PN 7	Russet gr.	1.25	1.00	Shadow green	Oasis	Oasis
PN 8	Russet gr.	1.09	1.20	Shadow green	Oasis	Oasis
PN 9	Russet gr.	0.82	1.36	Shadow green	Oasis	Oasis
PN 10	Russet gr.	1.42	1.06	Shadow green	Oasis	Oasis
PN 11	Sallow	1.66	1.08	Shadow green	Russet gr.	Russet gr.
PN 12	Russet gr.	1.51	1.16	Shadow green	Oasis	Oasis
PN 13	Russet gr.	1.08	1.10	Shadow green	Oasis	Oasis
PN 14	Russet gr.	1.85	1.08	Shadow green	Oasis	Oasis
PN 15	Russet gr.	1.26	1.04	Shadow green	Oasis	Oasis
PN 16	Sallow	1.77	1.10	Shadow green	Oasis	Oasis
PN 17	Sallow	2.31	1.14	Shadow green	Oasis	Oasis
PN 18	Russet gr.	1.38	1.02	Shadow green	Oasis	Oasis
PN 19	Russet gr.	1.11	1.10	Shadow green	Oasis	Oasis
PN 20	Russet gr.	1.35	1.24	Shadow green	Oasis	Oasis
PN 21	Russet gr.	1.29	1.18	Shadow green	Oasis	Oasis
PN 22	Russet gr.	1.19	1.03	Shadow green	Oasis	Oasis
PN 23	Oasis	1.75	1.28	Shadow green	Oasis	Oasis
PN 24	Russet gr.	1.48	1.16	Shadow green	Oasis	Oasis
PN 26	Russet gr.	1.52	1.10	Absinthe gr.	Oasis	Oasis
PN 27	Russet gr.	1.94	1.12	Shadow green	Russet gr.	Russet gr.
PN 28	Russet gr.	1.82	1.06	Shadow green	Oasis	Oasis
PN 29	Russet gr.	1.19	1.10	Green stone	Oasis	Oasis
PN 30	Silver fern	1.61	1.30	Green stone	Oasis	Oasis
PN 31	Russet gr.	1.08	1.17	Green stone	Oasis	Oasis
PN 32	Oasis	1.16	1.17	Green stone	Oasis	Oasis
PN 33	Russet gr.	1.12	1.17	Green stone	Oasis	Oasis
PN 34	Silver fern	1.15	1.15	Green stone	Oasis	Oasis
PN 35	Russet gr.	1.52	1.18	Absinthe gr.	Oasis	Oasis
PN 37	Russet gr.	1.17	0.90	Shadow green	Oasis	Oasis
PN 38	Russet gr.	1.27	0.92	Shadow green	Oasis	Oasis
PN 39	Russet gr.	1.52	1.20	Shadow green	Chrysollite gr.	Chrysollite gr.
PN 40	Russet gr.	1.66	1.18	Shadow green	Oasis	Oasis
PN 41	Russet gr.	1.59	1.08	Shadow green	Oasis	Oasis
PN 42	Mastic	1.05	1.22	Shadow green	Oasis	Oasis
PN 43	Olive sheen	1.51	1.02	Shadow green	Oasis	Oasis
PN 46	Oasis	1.00	0.90	Green stone	Oasis	Oasis
PN 47	Sudan	1.08	1.18	Green stone	Oasis	Oasis
PN 49	Russet gr.	1.36	1.10	Green stone	Certosa	Certosa
PN 50	Russet gr.	1.80	1.72	Green stone	Turtle gr.	Turtle gr.

(contd.)

Table 2. continued

Type No.	Colour of mature leaf on the		Lamina		Leaf	
	Upper side	Lower side	Shape	Area (cm^2)	Base	Margin
PN 1	Garland gr.	Mermaid	Cordate	70.52	Cordate	Even
PN 2	Parrot green	Green stone	Ovate	58.26	Cordate	Even
PN 3	Fern	Tea gr.	Cordate	60.97	Cordate	Even
PN 4	Fern	Green stone	Ovate	80.22	Cordate	Even
PN 5	Fern	Artichoke gr.	Cordate	47.62	Cordate	Even
PN 6	Fern	Mermaid	Ovate	44.68	Cuneate	Even
PN 7	Fern	Mermaid	Ovate	48.67	Round	Wavy
PN 8	Parrot green	Artichoke gr.	Cordate	61.17	Round	Wavy
PN 9	Peridot	Artichoke gr.	Cordate	66.77	Round	Even
PN 10	Parrot green	Green stone	Cordate	79.97	Round	Even
PN 11	Parrot green	Green stone	Cordate	85.38	Round	Even
PN 12	Fern	Green stone	Cordate	100.38	Round	Wavy
PN 13	Fern	Green stone	Cordate	68.11	Round	Even
PN 14	Fern	Artichoke gr.	Cordate	76.22	Round	Even
PN 15	Peridot	Tea gr.	Elliptic	61.87	Round	Even
PN 16	Parrot green	Tea gr.	Cordate	92.24	Round	Even
PN 17	Parrot green	Tea gr.	Cordate	49.66	Round	Even
PN 18	Fern	Tea gr.	Cordate	52.66	Round	Wavy
PN 19	Fern	Artichoke gr.	Cordate	65.93	Round	Wavy
PN 20	Fern	Artichoke gr.	Elliptic	64.45	Cordate	Wavy
PN 21	Parrot green	Green stone	Cordate	50.24	Cordate	Even
PN 22	Parrot green	Green stone	Cordate	66.05	Cordate	Even
PN 23	Peridot	Green stone	Elliptic	63.78	Cuneate	Even
PN 24	Fern	Green stone	Cordate	101.48	Cordate	Even
PN 26	Fern	Green stone	Cordate	39.05	Cordate	Even
PN 27	Grass gr.	Green stone	Cordate	99.85	Cordate	Even
PN 28	Peridot	Green stone	Ovate	70.57	Cordate	Even
PN 29	Fern	Green stone	Cordate	76.48	Cordate	Even
PN 30	Fern	Green stone	Cordate	57.97	Cordate	Even
PN 31	Fern	Tea gr.	Cordate	86.99	Cordate	Even
PN 32	Fern	Green stone	Cordate	62.50	Cordate	Wavy
PN 33	Fern	Artichoke gr.	Cordate	64.63	Cordate	Wavy
PN 34	Parrot green	Green stone	Cordate	75.40	Cordate	Wavy
PN 35	Cerro gr.	Artichoke gr.	Cordate	61.88	Cordate	Wavy
PN 37	Fern	Artichoke gr.	Cordate	64.43	Cordate	Wavy
PN 38	Peridot	Green stone	Cordate	57.00	Cordate	Wavy
PN 39	Piquant gr.	Green stone	Elliptic	93.01	Cordate	Wavy
PN 40	Fern	Artichoke gr.	Elliptic	90.45	Cordate	Wavy
PN 41	Fern	Russet gr.	Cordate	72.41	Cordate	Wavy
PN 42	Peridot	Tea gr.	Cordate	68.28	Cordate	Wavy
PN 43	Parrot green	Tea gr.	Cordate	67.40	Cordate	Wavy
PN 46	Parrot green	Tea gr.	Ovate	45.87	Round	Wavy
PN 47	Peridot	Green stone	Cordate	70.42	Cordate	Wavy
PN 49	Fern	Artichoke gr.	Cordate	66.75	Cordate	Wavy
PN 50	Parrot green	Artichoke gr.	Cordate	83.66	Cordate	Even

Table 2. continued

Type No.	Stem (Orthotrophs)			Stem (Plageotrophs)			
	Internodal length (cm)	Thickness at Node (cm)	Thickness at Internode (cm)	Internodal length (cm)	Thickness at Node (cm)	Thickness at Internode (cm)	Position of laterals with the stem
PN 1	12.58	5.78	4.52	7.90	2.54	1.52	Drooping
PN 2	9.34	5.74	5.06	8.62	2.38	1.16	Semierect
PN 3	7.95	7.70	6.56	6.69	2.40	1.22	Drooping
PN 4	11.60	5.95	4.95	5.68	2.36	1.20	Drooping
PN 5	8.00	4.58	3.75	5.32	2.40	1.18	Drooping
PN 6	9.07	4.48	3.40	4.78	2.12	1.14	Semierect
PN 7	7.31	4.38	3.15	6.58	2.25	1.10	Semierect
PN 8	7.90	6.28	5.32	6.99	2.76	1.30	Semierect
PN 9	5.62	6.45	4.55	6.18	2.48	1.18	Drooping
PN 10	6.45	6.50	5.20	5.97	2.70	1.30	Drooping
PN 11	7.30	6.55	5.35	5.50	2.77	1.40	Semierect
PN 12	7.70	6.05	4.55	9.13	2.73	1.43	Drooping
PN 13	6.58	6.60	5.60	6.24	2.55	1.25	Semierect
PN 14	7.43	5.60	4.70	8.08	2.43	1.30	Semierect
PN 15	7.60	5.30	4.60	5.00	2.40	1.30	Semierect
PN 16	8.08	5.80	4.90	10.73	2.40	1.30	Semierect
PN 17	8.15	5.93	4.90	4.35	2.00	1.00	Semierect
PN 18	8.35	6.00	5.25	6.95	2.25	1.10	Semierect
PN 19	9.55	6.12	5.10	4.20	2.00	1.15	Semierect
PN 20	8.30	6.43	5.20	6.10	2.25	1.15	Semierect
PN 21	6.55	6.20	5.20	5.45	2.20	1.15	Drooping
PN 22	5.30	4.15	3.50	4.00	2.10	1.20	Semierect
PN 23	10.05	3.32	2.26	5.65	2.77	1.47	Semierect
PN 24	6.40	3.46	2.12	5.75	2.25	1.20	Semierect
PN 26	7.70	6.00	4.30	4.18	2.30	1.30	Semierect
PN 27	7.00	5.45	3.45	4.45	2.50	1.30	Drooping
PN 28	5.35	5.80	4.40	4.70	2.60	1.45	Semierect
PN 29	8.15	5.40	4.30	5.14	2.65	1.30	Semierect
PN 30	8.30	5.43	4.30	5.10	2.63	1.45	Semierect
PN 31	10.00	5.70	4.23	3.75	2.50	1.20	Semierect
PN 32	2.70	5.93	4.70	6.40	2.40	1.30	Semierect
PN 33	8.00	6.90	5.40	5.40	2.40	1.30	Semierect
PN 34	6.05	6.10	4.60	3.15	2.35	1.25	Semierect
PN 35	8.16	6.05	4.30	7.05	2.55	1.30	Semierect
PN 37	4.82	4.60	3.00	6.73	2.00	1.10	Semierect
PN 38	7.88	5.43	3.93	9.00	2.25	1.15	Semierect
PN 39	10.20	5.40	4.40	4.80	2.70	1.35	Semierect
PN 40	10.60	7.03	4.50	6.10	2.00	1.15	Semierect
PN 41	8.70	6.03	4.83	5.70	2.30	1.20	Semierect
PN 42	6.50	5.85	4.65	4.45	2.25	1.25	Semierect
PN 43	6.60	5.94	5.14	3.25	2.20	1.20	Semierect
PN 46	7.75	5.20	4.03	3.45	2.35	1.25	Semierect
PN 47	7.80	7.30	6.80	3.90	2.50	1.30	Semierect
PN 49	8.91	5.00	4.20	8.62	2.20	1.20	Semierect
PN 50	8.40	3.16	2.08	8.25	2.65	1.30	Drooping

PLATE I. VEGETATIVE BUD IN PEPPER CULTIVARS

1. Short conical curved
2. Short conical straight
3. Long conical slightly curved

PLATE I VEGETATIVE BUD IN PEPPER CULTIVARS

1 PN-17

2 PN-49

3 PN-27

With reference to width, PN 19 ranked first with a value of 0.36 cm and PN 15 last with a value of 0.20 cm. The length/width ratio was found to vary from 16.11 in PN 27 to 5.47 in PN 46 with other varieties possessing values in between the two extremes.

4. Colour of the leaf sheath

Colour of the leaf sheath was a variable character and the types were grouped into Russet gr., Oasis, Sallow, Silver fern, Mastic, Olive sheen and Sudan. Russet gr. included 34 types. Oasis and Sallow contained 3 types each, Silver fern 2 and the rest three groups - one type each.

5. Length, thickness and colour of petiole

The pepper cultivars were found to vary widely for petiole length which ranged from 0.82 cm in PN 9 to 2.31 cm in PN 17. Other varieties were observed to possess values in between the two extremes. The colour and thickness of the petiole also varied in different cultivars, though not considerably. The diameter of the petiole was found to vary from 0.90 cm in the cultivars PN 6, PN 37 and PN 46 to 1.72 cm in PN 50. Shadow green, Absinthe gr. and Green stone were the colours observed in the petioles. The majority of the cultivars (30 numbers) were of Shadow green colour, 5 cultivars were with Absinthe gr. and ten cultivars had Green stone colour.

6. Colour of emerging leaves on the upper and lower sides

The results indicated that colour on the upper and lower sides in a type of the newly emerged flush in all cases was found to be the same. The colour of emerging leaf was found to vary in the different cultivars. Five major shades could be observed namely Oasis (37 cultivars), Certosa (4 cultivars), Russet gr. (2 cultivars), Chrysolite gr. and Turtle gr. (1 each).

7. Mature leaf colour on the upper and lower sides

The colour of mature leaves on the upper and lower sides varied considerably in one and the same type. The colour on the upper surface of leaf was Fern in 22 cultivars, Parrot green in 12, Peridot in 7 and one each with Garland gr., Grass gr., Cerro gr., and Piquant gr., whereas in the lower side 20 types had Green stone colour, 12 types Artichoke gr., 9 types Tea gr., 3 types Mermaid and one Russet gr.

8. Shape of lamina

Shape of leaf appeared to be a distinct varietal character in pepper and furnished one of the simplest diagnostic characters for use. All the cultivars fell under three major categories (Plate II). When the leaves were narrow and broadest at the middle with tapering ends in the form of an ellipse, they were elliptic (Plate II.3) as in

cultivars PN 15, PN 20, PN 23,PN 39 and PN 40; ovate was the term applied when the elliptic leaves had their maximum breadth nearest to the leaf base (Plate II.1) as in PN 2, PN 4, PN 6, PN 7, PN 28 and PN 46 and when the leaf was heart shaped as in the rest of the cultivars, they were designated as cordate (Plate II-2).

9. Area of lamina

Area of lamina was found to vary widely among the types. It ranged from 39.05 cm^2 in PN 26 to 101.48 cm^2 in PN 24. Rest of the types possessed values in between the two extremes.

10. Position of the leaf blade

Position of the leaf blade remained the same in all the cultivars. The phyllotaxy was 1/2 for all the 45 types studied.

11. Texture of mature leaves

In all the 45 types, mature leaves had coriaceous texture.

12. Leaf tip

All the varieties had acuminate leaf tip.

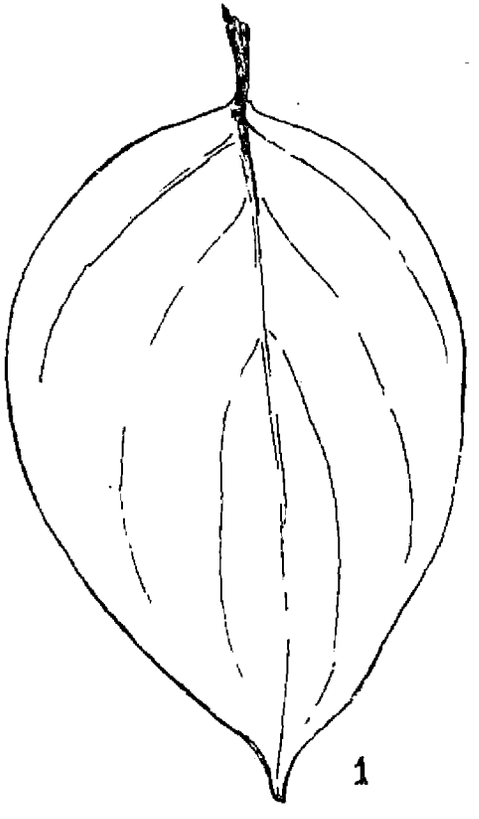
Since there were no varietal differences with reference to position of the leaf blade, texture of mature leaf and

PLATE II. LEAVES OF PEPPER CULTIVARS

1. Ovate
2. Cordate
3. Elliptic

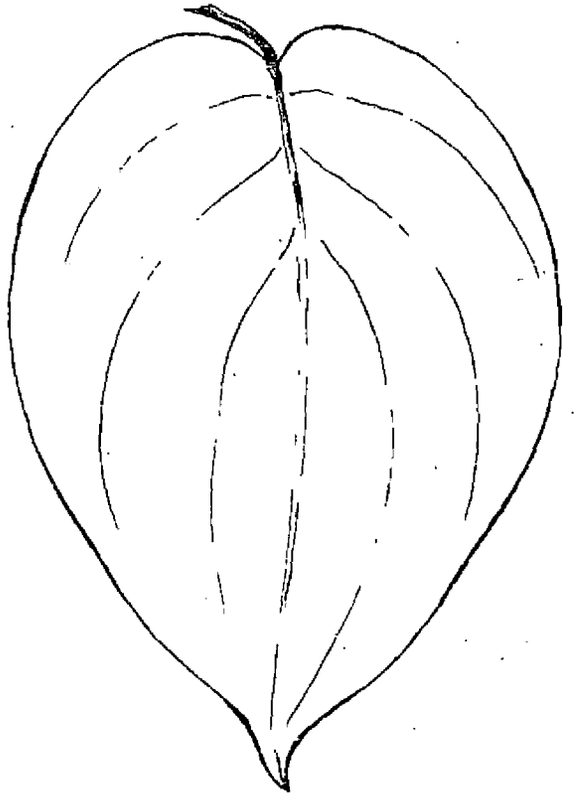
PLATE II

LEAVES OF PEPPER CULTIVARS.



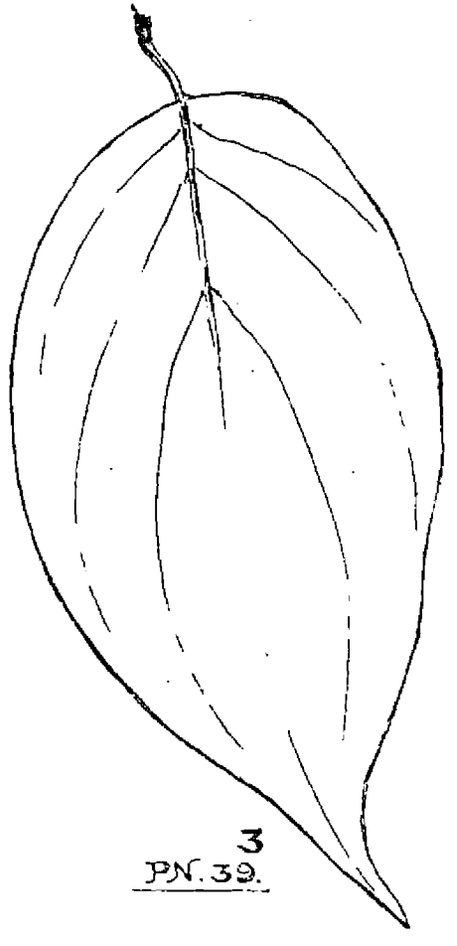
1

PN. 30.



2

PN. 50.



3

PN. 39.

leaf tip, no data pertaining to the same were given in the table, though observations on the same were conducted.

13. Leaf base

The leaf base was cordate in 29 types, round in 14 and cuneate in 2 as per the results presented.

14. Leaf margin

Leaf margin was even in most of the cases (25 types) but slightly wavy in the rest 20 types.

15. Leaf surface

There was no varietal difference for this character and hence no data were furnished in the table. However, observations revealed that leaf surface was glabrous in all the 45 types.

16. Shape of stem (orthotrophs)

There was no varietal difference for shape of stem. Hence no data were presented. However, observations revealed that shape of orthotrophs in all the 45 varieties was terete.

17. Length of internode (orthotrophs)

Varietal differences were observed for internodal length which varied from 2.70 cm in PN 32 to 12.58 cm in PN 1. Other types possessed values in between the two.

18. Thickness at node and internode (orthotrophs)

The types exhibited differences for this character. The thickness at the nodal region ranged from 3.16 cm in PN 50 to 7.70 cm in PN 3 and that at the internodal region it varied from 2.08 cm in PN 50 to 6.80 cm in PN 47 with other types possessing values in between the two extremes.

19. Internodal length, thickness at node and internode of laterals (Plageotrophs)

In the case of plageotrophs, the internodal length and the diameter at the nodal and internodal regions varied considerably among the cultivars. The corresponding ranges were from 3.15 cm in PN 34 to 10.73 cm in PN 16 for internodal length and from 2.00 cm in PN 17, PN 19, PN 37 and PN 40 to 2.77 cm in PN 11 and PN 23 in case of thickness at the nodal region and from 1.00 cm in PN 17 to 1.52 cm in PN 1 in the case of thickness at the internode.

20. Position of laterals with the main stem

The results indicated the existence of two main categories of laterals namely semierect and drooping. The lateral was designated semierect when it subtended an angle of less than 80° with the main stem. It was designated drooping when the angle between the lateral and main stem was more than 80°. In thirtyfive types, semierect laterals

were recognised, while in the remaining ten, the laterals were of the drooping type.

II. Floral characters

21. Length of spike

The mean length of spikes measured in cm for all the 45 types is presented in Table 3.

(TABLE 3)

From the results presented in the above table, it could be seen that the varieties showed wide variation with reference to spike length which ranged from 4.22 cm in PN 46 to 15.52 cm in PN 50, the rest of the types occupying intermediate positions (vide Plate V).

As the growth rate of spikes was same in all the 45 varieties the data were pooled for all and they are presented in Table 4.

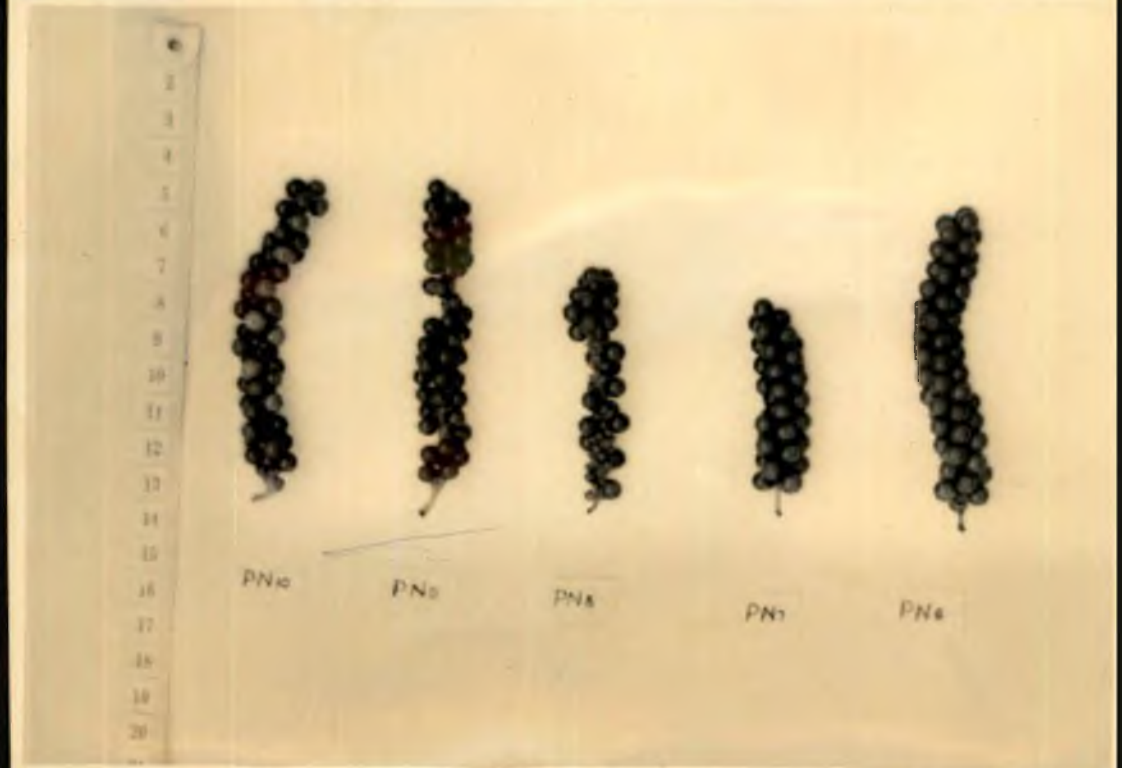
(TABLE 4)

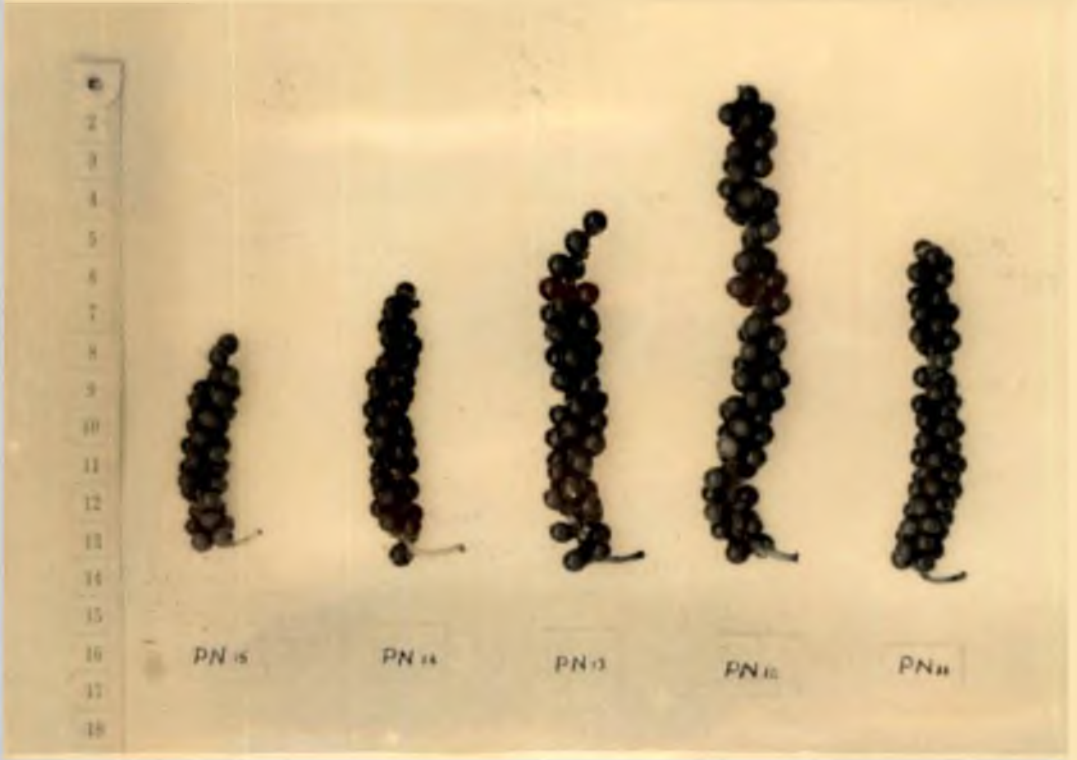
From the results presented in Table 4, it could be seen that growth of spikes in pepper continued for 34 days from emergence. The results have also indicated that the rate of growth was slightly less upto the 7th day after which it shot up till the 25th day followed by a slight reduction in the rate till the 34th day of emergence by

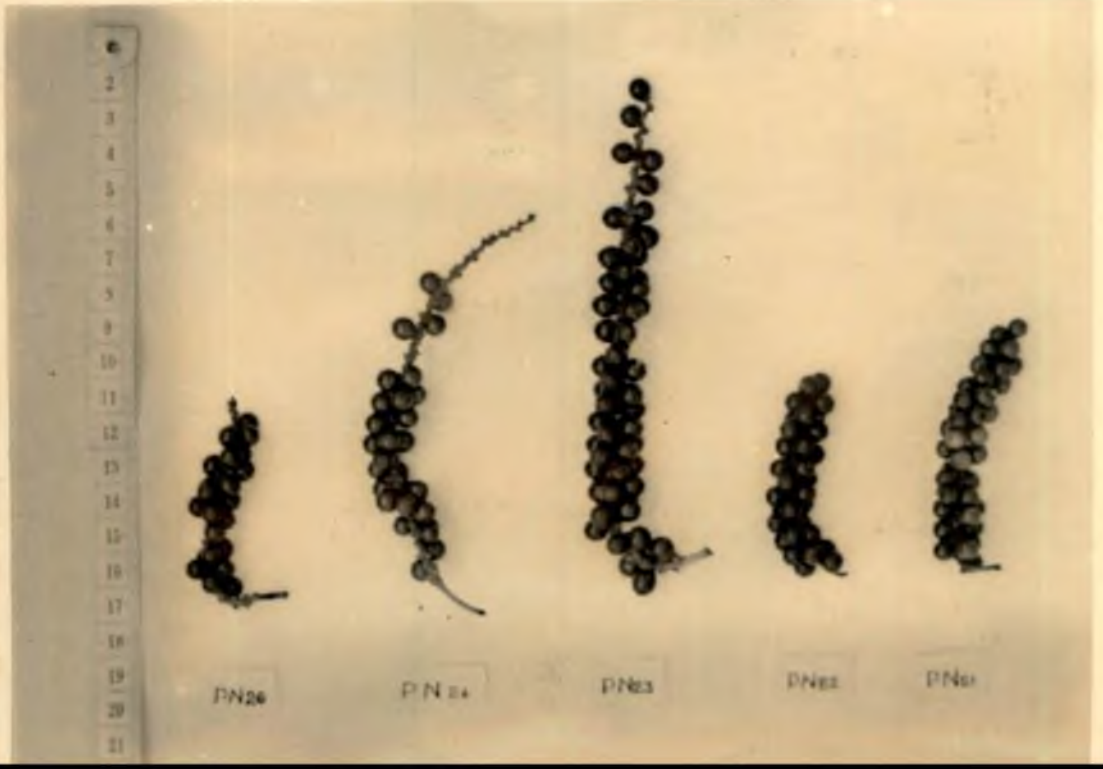
Table 3. Mean length of spikes in cm in the different types of pepper

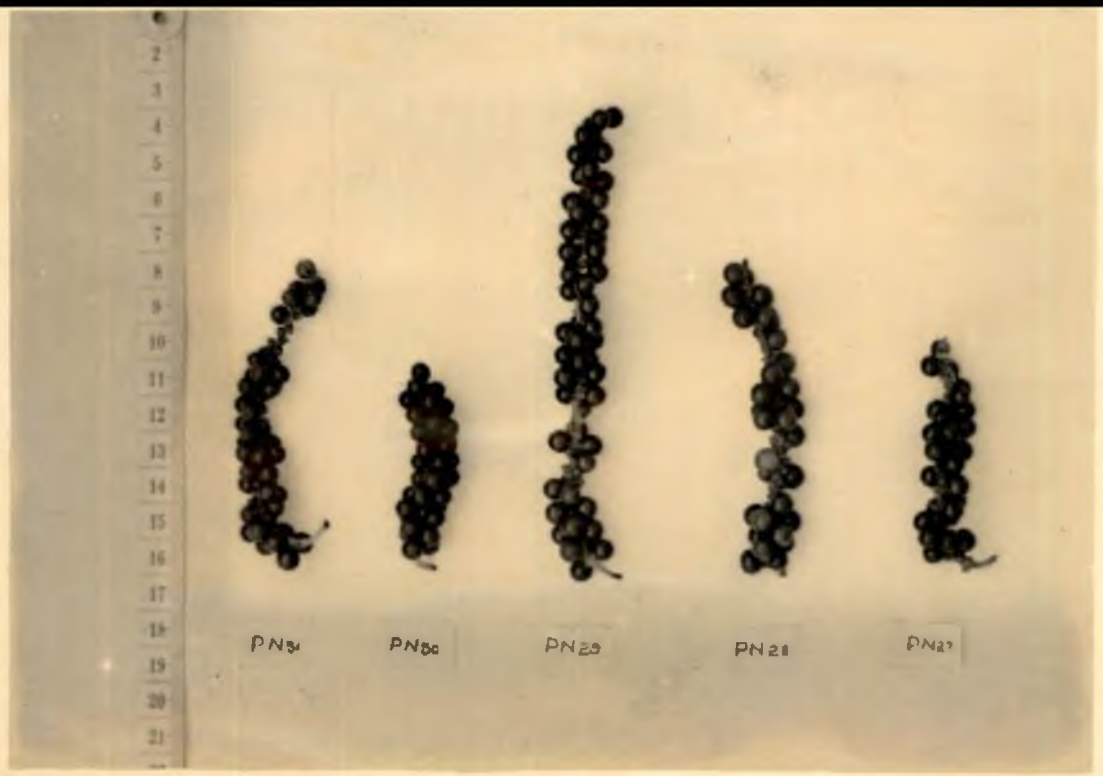
Type No.	Mean length of spike	Type No.	Mean length of spike
PN 1	5.94	PN 24	11.41
PN 2	9.14	PN 26	7.94
PN 3	7.77	PN 27	6.13
PN 4	9.33	PN 28	7.93
PN 5	7.79	PN 29	6.73
PN 6	8.95	PN 30	6.30
PN 7	5.89	PN 31	10.59
PN 8	6.63	PN 32	5.86
PN 9	7.28	PN 33	5.67
PN 10	8.69	PN 34	6.67
PN 11	9.40	PN 35	6.90
PN 12	12.62	PN 37	7.85
PN 13	5.62	PN 38	9.34
PN 14	5.79	PN 39	8.78
PN 15	7.08	PN 40	5.21
PN 16	6.35	PN 41	4.70
PN 17	7.19	PN 42	6.82
PN 18	6.18	PN 43	6.15
PN 19	8.05	PN 46	4.22
PN 20	8.09	PN 47	5.45
PN 21	8.25	PN 49	7.63
PN 22	7.87	PN 50	15.52
PN 23	9.55		

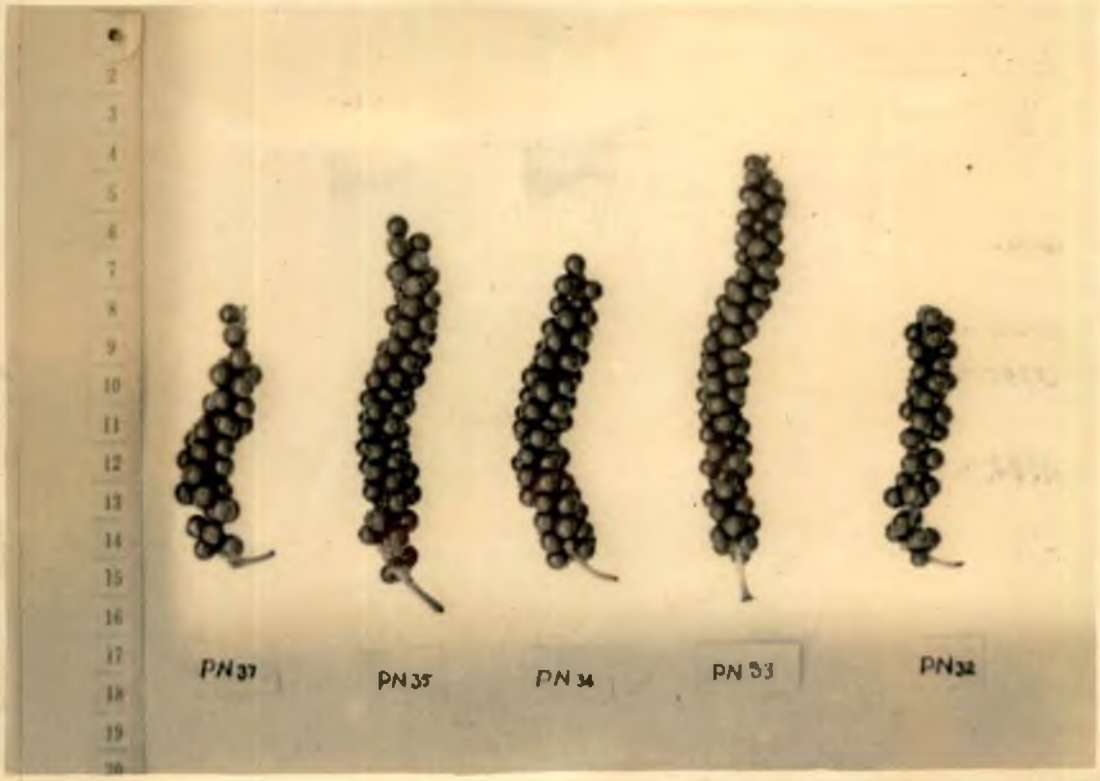
PLATE V. VARIATION IN SPIKE LENGTH IN THE FORTYFIVE PEPPER TYPES

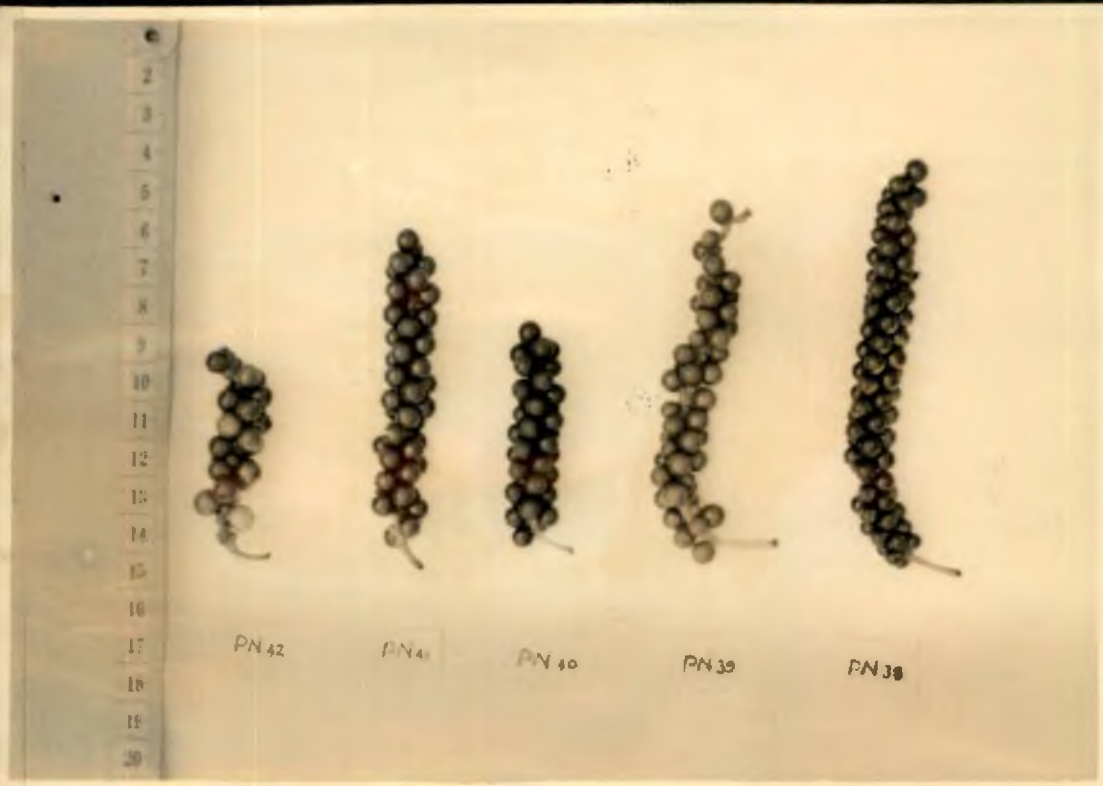

PN10
PN9
PN8
PN7
PN6


PN 15
PN 14
PN 13
PN 12
PN 11


PN26
PN24
PN23
PN22
PN21


PN31
PN30
PN29
PN28
PN27


PN 37
PN 35
PN 34
PN 33
PN 32


PN 42
PN 41
PN 40
PN 39
PN 38

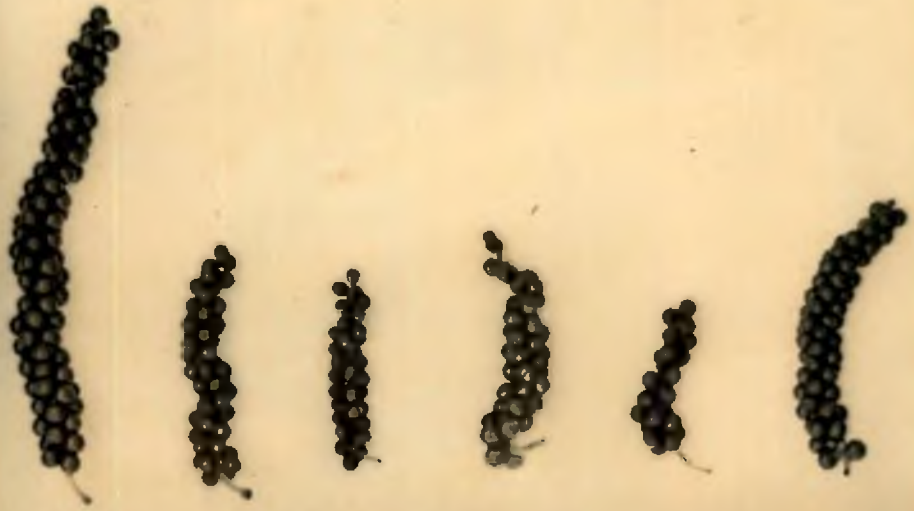

PN 50
PN 49
PN 48
PN 47
PN 46
PN 45

Table 4. Growth rate of spikes (in cm)

Particulars	Days after emergence												
	1	4	7	10	13	16	19	22	25	28	31	34	37
Length of spike (cm)	1.04	2.13	2.87	3.76	4.95	5.92	6.84	7.76	8.63	9.21	9.63	9.84	9.84
Increase in growth (cm)	0	1.09	1.83	2.72	3.91	4.88	5.80	6.72	7.59	8.17	8.59	8.80	8.80
Increase in % over the initial length	0	104.81	175.96	261.54	375.96	469.23	557.69	646.15	729.81	785.58	825.96	846.15	846.15

which time the spike attained its maximum length of 9.84 cm. The average length of spike at emergence was only 1.04 cm.

22. Mean number of spikes per lateral

The mean number of spikes produced by the lateral in the different cultivars of pepper are presented in Table 5.

(TABLE 5)

From the results presented above, it could be seen that the varieties widely varied with reference to mean number of spikes produced by the lateral. It was maximum in PN 5 with a value of 27.2 and minimum in PN 27 with a value of 3.9, the rest of the types occupying intermediate positions between the two extremes.

23. Anthesis

The various stages of the flower bud during anthesis are given in Plate IV.

The times of flower opening and anther dehiscence in different types of pepper are presented in Table 6.

(TABLE 6)

The results presented in the above table have indicated that the time of flower opening in the 45 types of pepper varied from 17.30 to 19.30 hours and that of anther

Table 5. Mean number of spikes produced by the laterals in the different types of pepper

Type No.	Mean number of spikes per lateral	Type No.	Mean number of spikes per lateral
PN 1	7.2	PN 24	6.6
PN 2	6.2	PN 26	4.7
PN 3	9.5	PN 27	3.9
PN 4	9.6	PN 28	7.5
PN 5	27.2	PN 29	4.5
PN 6	15.9	PN 30	8.1
PN 7	9.4	PN 31	10.6
PN 8	4.8	PN 32	6.9
PN 9	6.6	PN 33	8.6
PN 10	6.3	PN 34	6.6
PN 11	7.8	PN 35	7.8
PN 12	7.0	PN 37	8.5
PN 13	7.0	PN 38	7.7
PN 14	13.2	PN 39	11.9
PN 15	5.6	PN 40	8.2
PN 16	7.1	PN 41	10.2
PN 17	4.7	PN 42	8.4
PN 18	9.9	PN 43	5.4
PN 19	10.2	PN 46	6.5
PN 20	9.4	PN 47	8.0
PN 21	19.2	PN 49	6.9
PN 22	6.1	PN 50	5.0
PN 23	8.3		

PLATE IV. ANTHESIS IN PEPPER

a. A mature flower bud

b. A flower with protruded stigma

c. A flower with mature anthers before dehiscence

d. A flower after dehiscence of anthers and pollination

PLATE IV.a

PLATE IV.b

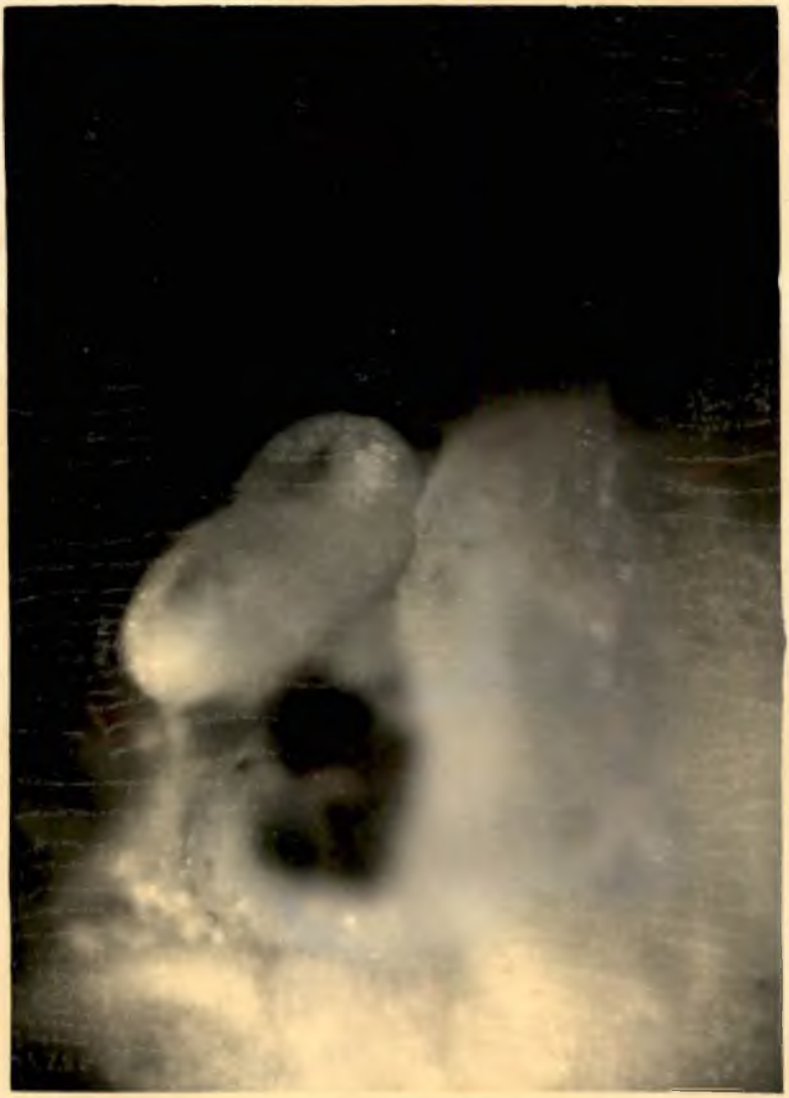


PLATE IV.c

PLATE IV.d

Table 6. Time of flower opening and anther dehiscence in the different types of pepper

Type No.	Time of flower opening (hours)	Time of anther dehiscence (hours)	Type No.	Time of flower opening (hours)	Time of anther dehiscence (hours)
PN 1	18.30-19.00	14.30-15.00	PN 24	17.30-18.00	14.30-15.00
PN 2	18.00-18.30	14.00-14.30	PN 26	18.00-18.30	14.30-15.00
PN 3	19.00-19.30	14.30-15.00	PN 27	18.00-18.30	14.30-15.00
PN 4	18.30-19.00	14.00-14.30	PN 28	17.30-18.00	14.30-15.00
PN 5	18.30-19.00	14.30-15.00	PN 29	18.00-18.30	14.30-15.00
PN 6	18.30-19.00	14.30-15.00	PN 30	18.00-18.30	14.00-14.30
PN 7	17.30-18.00	14.00-14.30	PN 31	18.00-18.30	14.00-14.30
PN 8	18.00-18.30	14.30-15.00	PN 32	18.00-18.30	14.30-15.00
PN 9	18.30-19.00	14.00-14.30	PN 33	18.00-18.30	14.00-14.30
PN 10	18.30-19.00	14.00-14.30	PN 34	18.00-18.30	14.30-15.00
PN 11	18.30-19.00	14.30-15.00	PN 35	18.00-18.30	14.00-14.30
PN 12	18.00-18.30	14.00-14.30	PN 37	18.00-18.30	14.30-15.00
PN 13	19.00-19.30	14.30-15.00	PN 38	18.00-18.30	14.30-15.00
PN 14	19.00-19.30	14.00-14.30	PN 39	17.30-18.00	14.00-14.30
PN 15	18.30-19.00	14.30-15.00	PN 40	17.30-18.00	14.30-15.00
PN 16	18.00-18.30	14.00-14.30	PN 41	18.00-18.30	14.30-15.00
PN 17	18.00-18.30	14.30-15.00	PN 42	18.00-18.30	14.30-15.00
PN 18	18.00-18.30	14.30-15.00	PN 43	18.00-18.30	14.30-15.00
PN 19	18.00-18.30	14.00-14.30	PN 46	17.30-18.00	14.00-14.30
PN 20	18.00-18.30	14.00-14.30	PN 47	17.30-18.00	14.00-14.30
PN 21	18.00-18.30	14.30-15.00	PN 49	18.00-18.30	14.00-14.30
PN 22	18.00-18.30	14.30-15.00	PN 50	18.00-18.30	14.00-14.30
PN 23	18.00-18.30	14.30-15.00			

dehiscence from 14.00 to 15.00 hours. The varieties did not differ much with reference to the times of flower opening and anther dehiscence.

The number of flowers opened at different times was observed in one variety PN 7 and the data have been presented in Table 7.

(TABLE 7)

From the results presented in Table 7 it could be seen that flower opening started between 17.30 and 18.30 hours and continued upto 02.30 hours in the next day. Maximum flowers (39.29%) in a spike opened between 18.30 and 20.30 hours.

The number of flowers in a spike in which anthers dehisced was observed at different times in one variety PN 30 and results have been presented in Table 8.

(TABLE 8)

From the results presented in Table 8, it oould be seen that anther dehiscence commenced between 13.30 and 14.30 hours and continued upto 16.30 hours with a maximum of 59.09 per cent in a spike between 14.30 and 15.30 hours.

Data collected on the spread of flower opening and anther dehiscence on individual spikes of the different

Table 7. Time of flower opening in pepper

Type	Time (hours)	Number of flowers observed	Number opened	Percentage of the total
PN 7	17.30	56	0	0.00
	18.30		9	16.07
	20.30		22	39.29
	22.30		14	25.00
	00.30		7	12.50
	02.30		4	7.14
	04.30		0	0.00
Total		56	56	100.00

Table 8. Time of anther dehiscence in pepper

Type	Time (hours)	Number of flowers observed	Number dehisced	Percentage of the total
PN 30	13.30	22	0	0.00
	14.30		4	18.18
	15.30		13	59.09
	16.30		5	22.73
	17.30		0	0.00
Total		22	22	100.00

pepper varieties studied are given in Table 9.

(TABLE 9)

The results presented in the above table have revealed that flower opening in a spike lasted for 11 days and anther dehiscence - 9 days. Maximum number of flowers in a spike opened on the 4th day of commencement, while maximum anther dehiscence was on the second and third day after commencement. Both flower opening and anther dehiscence were found to follow a normal distribution pattern (vide Fig.1).

Observations recorded on the mean number of days for spike development, flower opening and anther dehiscence in the different types of pepper are summarised in Table 10.

(TABLE 10)

The results presented in the above table indicated the following. The different types did not vary much for the spikes to complete their development. Type PN 34 completed its spike development in 29.14 days and variety PN 12 in 32.00 days from emergence, the other types possessing values in between the two extremes. With reference to the periods taken for commencement and completion of flower opening and anther dehiscence, the 45 types under study did not show much variation. In type PN 31 the first flower in a spike opened after 18.07 days of emergence, while in PN 42

Table 9. Spread of flower opening and anther dehiscence in pepper

	Number of days from commencement											Total
	1	2	3	4	5	6	7	8	9	10	11	
Mean number of flowers opened	5.05	7.08	7.71	11.67	11.22	5.72	4.43	3.45	2.61	1.14	0.56	60.94
Percentage to the total	8.29	11.62	12.65	19.15	18.41	9.39	7.27	5.66	4.28	2.36	0.92	100.00
Mean number of flowers in which anthers dehisced	6.07	11.61	11.02	7.57	5.34	4.46	2.79	0.97	0.02	0	0	49.85
Percentage to the total	12.18	23.29	22.11	15.19	10.71	8.95	5.60	1.95	0.04	0	0	100.00

Fig.1. SPREAD OF FLR. OPENING AND ANTHER DEHISCENCE IN PEPPER

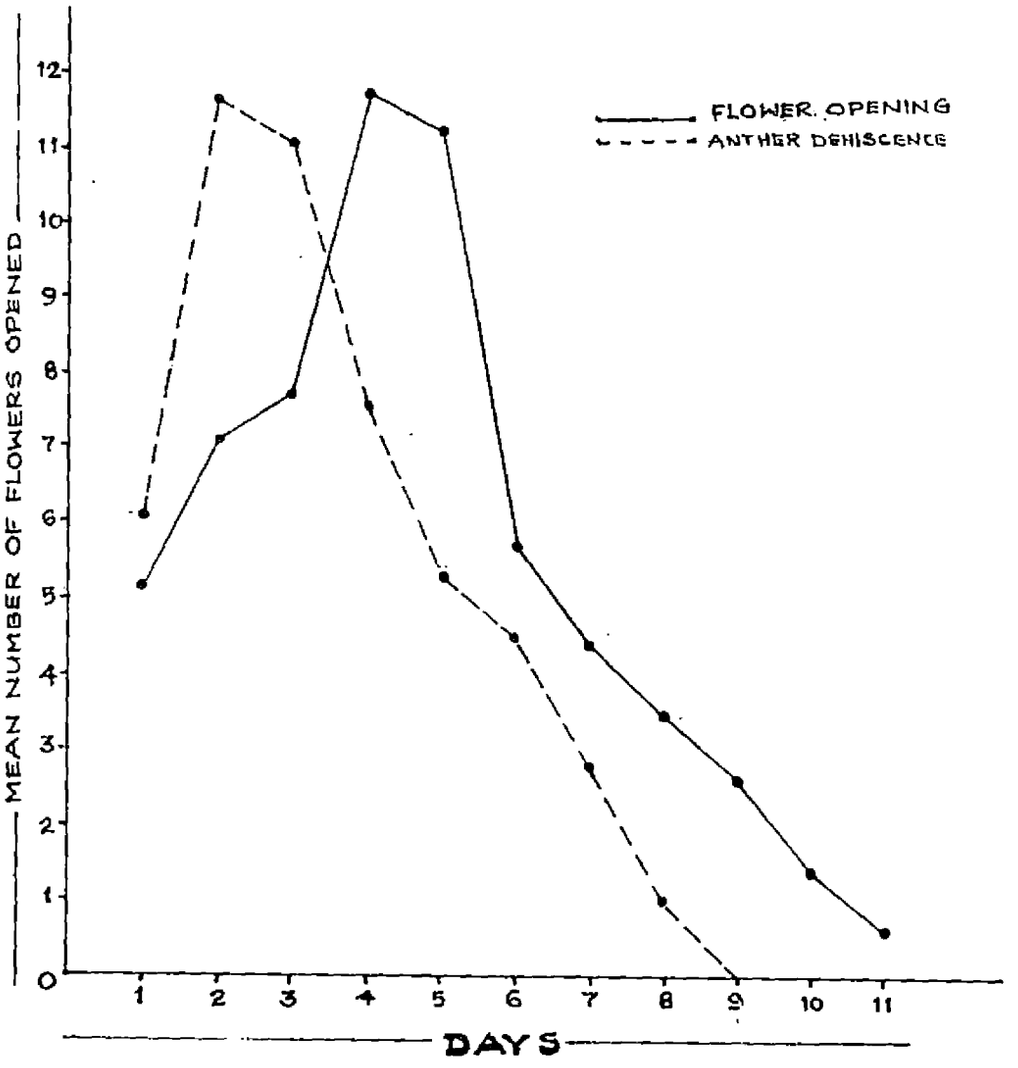


Table 10. Mean number of days for spike development, flower opening and anther dehiscence in different types of pepper

Type No.	Mean number of days from emergence to					Interval between first and last flower opening in a spike	Interval between first and last anther dehiscence in a spike
	Attain maximum length of spikes	First flower opening in spike	Last flower opening in a spike	First anther dehiscence in a spike	Last anther dehiscence in a spike		
1	2	3	4	5	6	7	8
PN 1	29.43	18.83	25.33	23.55	29.45	6.5	5.9
PN 2	30.08	19.46	26.66	24.31	30.11	7.2	5.8
PN 3	29.60	19.01	26.61	23.79	29.69	7.6	5.9
PN 4	30.62	18.92	27.92	23.67	30.67	9.0	7.0
PN 5	30.29	20.42	28.52	25.57	30.32	8.1	4.8
PN 6	29.60	18.43	27.03	22.73	29.63	8.6	6.9
PN 7	29.26	19.18	25.18	24.59	29.29	6.0	4.7
PN 8	30.17	19.06	27.66	23.40	30.20	8.6	6.8
PN 9	31.12	20.97	28.07	25.67	31.17	7.1	5.5
PN 10	30.91	19.33	27.23	24.45	30.95	7.9	6.5
PN 11	31.07	20.94	28.04	25.10	31.10	7.1	6.0
PN 12	32.00	20.89	30.19	25.05	32.05	9.3	7.0
PN 13	29.17	18.42	25.82	23.30	29.20	7.4	5.9
PN 14	29.87	19.75	28.25	24.10	29.90	8.5	5.8
PN 15	30.94	19.48	27.28	24.47	30.97	7.8	5.5
PN 16	31.28	20.30	28.00	25.12	31.32	7.7	6.2
PN 17	29.93	19.71	27.41	23.77	29.97	7.7	6.2
PN 18	29.90	20.04	27.14	24.13	29.93	7.1	5.8
PN 19	30.08	20.02	28.02	24.94	30.14	8.0	5.2
PN 20	29.74	19.06	26.56	23.16	29.76	7.5	6.6

(contd.)

Table 10 continued

1	2	3	4	5	6	7	8
PN 21	29.83	19.15	27.55	23.35	29.85	8.4	6.5
PN 22	29.89	19.42	26.92	23.63	29.93	7.5	6.3
PN 23	29.81	20.70	27.60	24.84	29.84	6.9	5.0
PN 24	30.10	20.81	29.71	24.80	30.13	8.9	5.3
PN 26	31.02	20.99	28.79	25.25	31.05	7.8	5.8
PN 27	29.99	20.01	26.01	25.02	30.02	6.0	5.0
PN 28	30.01	19.92	29.02	24.07	30.07	9.1	6.0
PN 29	30.13	21.09	26.59	25.36	30.16	5.5	4.8
PN 30	29.82	20.16	27.86	24.65	29.85	7.7	5.2
PN 31	30.14	18.07	27.07	23.67	30.17	9.0	6.5
PN 32	30.18	21.11	27.71	25.61	30.21	6.6	4.6
PN 33	30.11	21.04	27.34	25.24	30.14	6.3	4.9
PN 34	29.14	18.45	26.35	23.47	29.17	7.9	5.7
PN 35	29.98	18.73	25.73	23.61	30.01	7.0	6.4
PN 37	29.79	20.54	28.34	24.03	29.83	7.8	5.8
PN 38	29.94	18.90	27.60	23.29	29.99	8.7	6.7
PN 39	30.03	20.52	27.52	24.39	30.09	7.0	5.7
PN 40	30.21	20.48	27.08	24.94	30.24	6.6	5.3
PN 41	30.14	21.07	27.47	24.47	30.17	6.4	5.7
PN 42	29.76	21.43	28.23	24.80	29.80	6.8	5.0
PN 43	29.86	20.94	28.34	24.39	29.89	7.4	5.5
PN 46	29.95	21.04	27.44	25.35	30.05	7.7	4.7
PN 47	29.91	21.33	29.43	25.27	29.97	6.4	4.7
PN 49	30.28	18.62	27.02	23.62	30.32	8.1	6.7
PN 50	31.67	19.34	27.74	24.40	31.70	8.4	7.3

it took 21.43 days, with the other varieties occupying values in between the two. In variety PN 7, the last flower in a spike opened after 25.18 days of emergence, while in variety PN 12, it happened in 30.19 days, with the other varieties occupying intermediate positions. Minimum duration (interval between first and last flower opening in a spike) for flower opening was exhibited by variety PN 29 (5.5 days) and maximum by variety PN 12 (9.3 days).

With reference to anther dehiscence also the different types did not vary considerably. Anther dehiscence started after 22.73 days of emergence of the spike in variety PN 6 and 25.67 days in variety PN 9, the rest of the varieties possessing intermediate values between the two. With reference to completion of anther dehiscence, variety PN 34 took 29.17 days after emergence while variety PN 12 exhibited 32.05 days with other varieties occupying intermediate positions. With reference to duration (interval between first and last anther dehiscence in a spike) of anther dehisoence, the minimum value of 4.6 days was shown by PN 32 and the maximum of 7.3 days by variety PN 50 with the rest of the varieties possessing intermediate values.

24. Flowers

The mean number of hermaphrodite, pistillate and staminate flowers in a spike was separately counted for each

of the 45 varieties and their percentages to the total were separately calculated and the data are presented in Table 11.

(TABLE 11)

The varieties varied considerably with reference to mean number of flowers per spike, with a maximum of 126.70 in variety PN 50 and minimum of 34.20 in variety PN 46. Rest of the varieties possessed values in between the two. The varieties also exhibited wide variation with reference to the mean number of different types of flowers in a spike. Maximum number of hermaphrodite flowers of 125.80 was observed in PN 50 and a minimum number of 0.00 in variety PN 23. With reference to mean number of pistillate and staminate flowers, the variaties exhibited variations from 0 to 68.70 and from 0 to 4.20 respectively.

The varieties also showed differences in their sexual composition. When 31 out of fortyfive types studied had spikes with hermaphrodite and female flowers, eleven had them with hermaphrodite alone, one had female alone, another one in male and hermaphrodite combination and the last one with male, female and hermaphrodite flowers. The percentage of fruitset calculated on the basis of total number of flowers per spike also revealed wide varietal variation. This was minimum (36.88%) in variety PN 5 and maximum (99.61%) in variety PN 12. The rest possessed intermediate values.

Table 11. Sexual composition of the spikes in the different types of pepper

ype No.	Mean number of flowers per spike	Mean number of hermaphrodite flowers	Percentage to the total	Mean number of pistillate flowers	Percentage to the total	Mean number of staminate flowers	Percentage to the total	Percentage of fruitset
1	2	3	4	5	6	7	8	9
PN 1	61.70	61.70	100.00	0.00	0.00	0.00	0.00	95.46
PN 2	66.50	62.30	93.68	0.00	0.00	4.20	6.32	92.33
PN 3	67.70	64.60	95.42	1.60	2.36	1.50	2.22	85.67
PN 4	73.50	70.08	96.33	2.70	3.67	0.00	0.00	95.00
PN 5	72.40	4.60	6.35	67.80	93.65	0.00	0.00	36.88
PN 6	75.30	48.10	63.88	27.20	36.12	0.00	0.00	83.00
PN 7	52.90	51.90	98.11	1.00	1.89	0.00	0.00	92.82
PN 8	72.30	69.10	95.57	3.20	4.43	0.00	0.00	88.66
PN 9	64.00	63.00	98.44	1.00	1.56	0.00	0.00	97.66
PN 10	61.50	43.00	69.92	18.50	30.08	0.00	0.00	99.02
PN 11	74.50	74.50	100.00	0.00	0.00	0.00	0.00	98.79
PN 12	102.40	102.40	100.00	0.00	0.00	0.00	0.00	99.61
PN 13	43.90	42.30	96.36	1.60	3.64	0.00	0.00	98.18
PN 14	60.90	57.00	93.60	3.90	6.40	0.00	0.00	91.95
PN 15	48.50	23.50	48.45	25.00	51.55	0.00	0.00	95.26
PN 16	37.90	37.90	100.00	0.00	0.00	0.00	0.00	98.42
PN 17	60.90	58.70	96.39	2.20	3.61	0.00	0.00	95.73
PN 18	49.70	46.50	93.56	3.20	6.44	0.00	0.00	98.39

(contd.)

Table 11. continued

1	2	3	4	5	6	7	8	9
PN 19	63.90	63.90	100.00	0.00	0.00	0.00	0.00	99.06
PN 20	62.70	58.70	93.62	4.00	6.38	0.00	0.00	95.53
PN 21	64.70	45.70	70.63	19.00	29.37	0.00	0.00	96.45
PN 22	69.10	69.10	100.00	0.00	0.00	0.00	0.00	94.36
PN 23	55.10	0.00	0.00	55.10	100.00	0.00	0.00	98.73
PN 24	84.80	27.10	31.96	57.70	68.04	0.00	0.00	56.25
PN 26	59.30	59.30	100.00	0.00	0.00	0.00	0.00	96.46
PN 27	38.30	38.30	100.00	0.00	0.00	0.00	0.00	99.22
PN 28	71.00	2.30	3.24	68.70	96.76	0.00	0.00	98.45
PN 29	50.10	49.10	98.00	1.00	2.00	0.00	0.00	88.00
PN 30	49.90	47.90	95.99	2.00	4.01	0.00	0.00	97.39
PN 31	73.10	71.10	97.26	2.00	2.74	0.00	0.00	98.08
PN 32	45.50	41.40	90.99	4.10	9.01	0.00	0.00	96.26
PN 33	45.70	40.30	88.18	5.40	11.82	0.00	0.00	90.37
PN 34	62.80	5.20	8.28	57.60	91.72	0.00	0.00	95.06
PN 35	56.80	52.60	92.61	4.20	7.39	0.00	0.00	97.54
PN 37	57.10	44.40	77.76	12.70	22.24	0.00	0.00	96.67
PN 38	91.10	87.80	96.38	3.30	3.62	0.00	0.00	98.63
PN 39	63.60	61.50	96.70	2.10	3.30	0.00	0.00	92.92
PN 40	39.40	39.40	100.00	0.00	0.00	0.00	0.00	97.72
PN 41	35.70	35.70	100.00	0.00	0.00	0.00	0.00	87.11
PN 42	63.20	40.10	63.45	23.10	36.55	0.00	0.00	89.40
PN 43	58.70	52.40	89.27	6.30	10.73	0.00	0.00	96.42
PN 46	34.20	34.20	100.00	0.00	0.00	0.00	0.00	86.26
PN 47	37.00	27.70	74.86	9.30	25.14	0.00	0.00	94.86
PN 49	69.90	66.40	94.99	3.50	5.07	0.00	0.00	96.42
PN 50	126.70	125.80	99.29	0.90	0.71	0.00	0.00	97.71

25. Stigma

Observations on the number of stigmatic lobes did not show any varietal difference. Similarly, receptivity of the stigma was 5-7 days after anthesis for all the varieties. Hence data on the same have not been furnished.

26. Stamen

Size of pollen grains in different varieties was measured and the data are presented in Table 12.

(TABLE 12)

The data revealed that there was varietal differences with regard to pollen size. It was maximum (10.17 μ) in variety PN 34 and PN 22 and minimum (9.16 μ) in variety PN 5, the rest of the varieties possessing intermediate values.

Observations on the percentage of pollen fertility of the different varieties are presented in Table 13.

(TABLE 13)

The results presented in the above table have indicated that the percentage of pollen fertility varied from 84.04 in variety PN 5 to 99.04 in variety PN 32, the rest of the varieties possessing intermediate values in between the two.

Results of pollen production among the varieties are presented in Table 14.

(TABLE 14)

Table 12. Size of pollen grains in the different pepper types (in μ)

Type No.	Pollen size	Type No.	Pollen size
PN 1	10.03	PN 24	9.89
PN 2	9.57	PN 26	9.80
PN 3	9.76	PN 27	9.93
PN 4	9.80	PN 28	9.98
PN 5	9.16	PN 29	10.11
PN 6	9.25	PN 30	10.11
PN 7	9.21	PN 31	9.89
PN 8	10.08	PN 32	10.09
PN 9	9.62	PN 33	10.13
PN 10	9.25	PN 34	10.17
PN 11	9.25	PN 35	10.11
PN 12	10.10	PN 37	9.94
PN 13	9.97	PN 38	9.91
PN 14	9.57	PN 39	10.07
PN 15	9.71	PN 40	10.08
PN 16	9.91	PN 41	9.90
PN 17	9.76	PN 42	10.12
PN 18	10.08	PN 43	10.01
PN 19	10.03	PN 46	9.99
PN 20	9.62	PN 47	10.02
PN 21	9.76	PN 49	9.99
PN 22	10.17	PN 50	10.02
PN 23	9.71		

Table 13. Percentage of pollen fertility in the different types of pepper

Type No.	Percentage of fertile pollen grains	Type No.	Percentage of fertile pollen grains
PN 1	93.75	PN 24	89.08
PN 2	95.48	PN 26	90.69
PN 3	6.60	PN 27	91.29
PN 4	6.25	PN 28	85.39
PN 5	4.04	PN 29	91.67
PN 6	93.82	PN 30	97.92
PN 7	98.10	PN 31	98.53
PN 8	93.20	PN 32	99.04
PN 9	97.24	PN 33	97.46
PN 10	95.21	PN 34	97.48
PN 11	96.79	PN 35	97.83
PN 12	97.99	PN 37	97.57
PN 13	95.60	PN 38	95.92
PN 14	95.33	PN 39	86.64
PN 15	95.12	PN 40	97.03
PN 16	98.21	PN 41	97.19
PN 17	93.49	PN 42	85.62
PN 18	93.07	PN 43	95.41
PN 19	95.40	PN 46	98.66
PN 20	95.37	PN 47	97.22
PN 21	93.60	PN 49	93.48
PN 22	89.97	PN 50	97.69
PN 23	92.63		

Table 14. Pollen production in the different types of pepper

Type No.	Number of pollen grains per flower		Type No.	Number of pollen grain per flower	
	Mean	Range		Mean	Range
PN 1	7013	(6250-10000)	PN 24	6913	(6000-8750)
PN 2	6900	(5500-8750)	PN 26	6325	(4750-7150)
PN 3	6162	(6000-9500)	PN 27	7132	(5500-8750)
PN 4	7150	(6250-10750)	PN 28	4879	(3000-6250)
PN 5	5004	(3750-7250)	PN 29	6359	(5500-8250)
PN 6	6900	(5500-8750)	PN 30	9685	(8250-10750)
PN 7	9015	(7500-12000)	PN 31	9396	(8000-11000)
PN 8	7215	(6000-9500)	PN 32	10023	(8750-12000)
PN 9	8200	(7000-10000)	PN 33	7410	(6250-9500)
PN 10	8019	(6000-10000)	PN 34	10023	(8000-11250)
PN 11	7137	(5500-9500)	PN 35	9998	(8750-11000)
PN 12	9132	(7500-11750)	PN 37	8563	(7750-10750)
PN 13	7231	(5000-9750)	PN 38	7254	(5750-9500)
PN 14	7987	(6250-9500)	PN 39	6397	(5000-8750)
PN 15	8215	(6000-9500)	PN 40	8247	(5500-9500)
PN 16	10015	(7500-12000)	PN 41	5236	(4500-7000)
PN 17	8147	(6000-10750)	PN 42	7123	(5500-8750)
PN 18	6132	(5750-9000)	PN 43	10123	(8250-11500)
PN 19	8256	(7500-11000)	PN 46	10087	(8750-12000)
PN 20	10015	(8000-11250)	PN 47	9689	(8250-10750)
PN 21	5632	(4750-8250)	PN 49	9114	(8000-10000)
PN 22	9635	(7750-11500)	PN 50	10140	(9250-11250)
PN 23	7985	(6750-9250)			

The results indicated wide variation in the production of pollen grains by the different varieties. When variety PN 5 exhibited minimum number of pollen grain per flower (5004), variety PN 50 had the maximum number of pollen grain (10140) per flower. The remaining varieties possessed intermediate values in between the two extremes.

III. Fruit characters

Results of observations on nine important fruit characteristics are presented in Table 15.

(TABLE 15)

The varieties showed wide variation for total number of berries per spike (from 26.70 to 123.79), number of well developed berries (from 10.12 to 106.85) and number under-developed berries (from 5.38 to 52.92). The varieties did not show much variability for diameter of berry. This was maximum in the variety PN 26 (6.72 mm) and minimum in the variety PN 21 (5.02 mm).

There were varietal differences for colour of young, mature and ripe berries. The young berries of 45 varieties were found to fall into nine shades of green colour. Based on colour difference of mature berries, the 45 varieties could be grouped into eight. Eight another varietal groups were also recognised based on the colour of ripe berries.

Table 15. Fruit characters of the different types of pepper

Type No.	Total number of berries per spike	Number of well developed berries	Number of underdeveloped berries	Diameter of berry (mm)	Colour of young berry	Colour of mature berry	Colour of ripe berry	1000 berry weight fresh (g)	1000 berry volume fresh (cc)	1000 berry weight dry (g)	1000 berry volume dry (cc)
1	2	3	4	5	6	7	8	9	10	11	12
PN 1	60.75	54.50	6.25	6.04	Parrot green	Fern	Red banana	80.40	100.21	38.65	44.11
PN 2	61.40	50.36	11.04	5.48	Parrot green	Fern	Red banana	100.71	130.11	42.78	50.05
PN 3	57.99	50.39	7.60	6.02	Parrot green	Fern	Red banana	120.00	140.07	44.80	44.21
PN 4	69.83	27.72	42.11	6.26	Parrot green	Fern	Buccaneer	159.20	170.00	45.00	60.20
PN 5	26.70	10.12	16.58	6.00	Absinthe gr.	Fern	Gypsy	80.60	130.35	38.75	60,60
PN 6	62.49	45.45	17.04	5.82	Fern	Leek gr.	Garnet br.	109.35	115.32	40.90	40.57
PN 7	49.10	43.72	5.38	5.96	Green hopper	Fern	Buccaneer	108.32	100.60	42.50	40.00
PN 8	64.06	22.31	41.75	5.94	Parrot green	Garland gr.	Red banana	99.65	108.74	44.65	45.76
PN 9	62.50	47.77	14.73	5.42	Fern	Garland gr.	Red banana	107.76	108.73	46.20	40.35
PN 10	60.89	29.63	31.26	6.00	Green hopper	Fern	Red banana	109.46	120.65	44.80	50.30
PN 11	73.59	58.02	15.57	5.82	Parrot green	Garland gr.	Red banana	79.40	100.32	40.70	48.40
PN 12	102.00	49.08	52.92	6.08	Pea green	Pea green	Red banana	127.21	134.12	49.50	60.00

Table 15 continued

1	2	3	4	5	6	7	8	9	0	11	12
PN 13	43.10	24.21	18.89	5.98	Grass hopper	Fern	Red banana	94.40	150.00	34.10	37.20
PN 14	55.99	45.99	10.00	6.06	Fern	Mt.vernon green	Red banana	79.80	90.71	30.70	40.50
PN 15	46.20	28.27	17.93	6.00	Pea green	Fern	Garnet br.	100.05	110.34	55.52	60.05
PN 16	37.30	31.44	5.86	6.04	Fern	Parrot green	Red banana	149.53	132.20	50.06	42.23
PN 17	58.29	42.48	15.81	5.98	Green hopper	Garland gr.	Red banana	123.40	127.90	52.33	62.15
PN 18	48.89	33.85	15.04	6.00	Green hopper	Mt.vernon green	Red banana	134.98	122.39	40.80	50.17
PN 19	63.29	56.36	6.93	5.18	Fern	Fern	Red banana	150.30	163.00	60.25	52.13
PN 20	59.89	38.85	21.04	6.00	Parrot green	Garland gr.	Red banana	150.00	145.80	65.78	60.15
PN 21	62.40	41.16	21.24	5.02	Parrot green	Fern	Blood red	114.50	116.10	49.40	40.78
PN 22	65.20	56.80	8.40	6.10	Parrot green	Mt.vernon green	Red banana	127.94	130.13	44.00	46.80
PN 23	54.40	20.43	33.97	5.05	Green hopper	Garland gr.	Red banana	98.40	180.00	45.90	62.34
PN 24	47.70	28.05	19.65	5.72	Parrot green	Pea green	Red banana	132.15	140.40	53.60	57.32
PN 26	57.20	39.26	17.94	6.72	Parrot green	Fern	Red banana	110.40	130.00	44.60	48.68
PN 27	38.00	32.31	5.69	6.00	Fern	Fern	Garnet br.	125.10	80.05	48.50	48.32
PN 28	69.89	30.38	39.31	6.24	Fern	Art gr.	Indian red	125.40	180.98	50.30	76.98
PN 29	44.09	29.85	14.24	6.08	Parrot green	Art gr.	Indian red	105.20	156.15	45.80	44.40
PN 30	48.59	39.15	9.44	6.00	Parrot green	Garland gr.	Holly berry	115.82	108.94	43.72	44.07

Table 15. continued

1	2	3	4	5	6	7	8	9	10	11	12
PN 31	71.69	48.42	23.27	5.94	Parrot green	Mt.vernon green	Red banana	119.70	150.40	49.31	52.13
PN 32	43.79	35.06	8.73	5.82	Parrot green	Mt.vernon green	Indian red	112.40	104.28	39.92	42.72
PN 33	41.29	34.12	7.17	6.06	Green hopper	Fern	Buccaneer	122.28	114.70	44.00	46.15
PN 34	59.69	21.44	38.25	5.32	Forest green	Art gr.	Indian red	119.50	120.23	44.86	46.28
PN 35	55.40	47.34	8.06	5.34	Green hopper	Garland gr.	Indian red	119.70	110.90	48.20	38.90
PN 37	55.19	15.83	39.36	5.70	Parrot green	Peridot	Red banana	110.11	115.00	41.30	44.00
PN 38	89.85	76.21	13.64	6.00	Fern	Garland gr.	Red banana	125.90	120.00	42.20	50.72
PN 39	59.09	44.06	15.03	6.12	Pea green	Fern	Red banana	119.60	125.00	47.40	58.77
PN 40	38.50	32.92	5.58	6.08	Forest green	Fern	Indian red	50.10	164.72	52.60	48.86
PN 41	31.09	25.69	5.40	5.64	Pea green	Pea green	Indian red	109.50	118.77	51.20	65.20
PN 42	56.50	25.34	31.16	6.26	Green hopper	Garland gr.	Red banana	159.40	157.92	50.00	44.92
PN 43	56.59	50.39	6.20	5.96	Art gr.	Garland gr.	Red banana	127.40	108.86	50.10	53.10
PN 46	29.50	24.02	5.48	5.28	Green hopper	Garland gr.	Red banana	109.60	117.20	38.50	39.25
PN 47	35.09	25.18	9.91	6.02	Certosa	Parrot green	Autumn glory	101.40	140.10	56.50	59.33
PN 49	67.39	60.16	7.23	5.94	Pea green	Pea green	Fern	79.40	100.25	30.75	40.40
PN 50	123.79	106.85	16.94	6.02	Fern	Art gr.	Red banana	162.81	152.75	46.41	62.50

The fortyfive varieties showed wide variation in the case of 1000 berry weight, both in the fresh and dry conditions. The thousand berry weight in the fresh condition varied from 50.10 g in PN 40 to 162.81 g in PN 50 and that in the dry condition from 30.70 g in PN 14 to 65.78 g in PN 20. The same was the case with reference to thousand berry volume in the fresh and dry conditions. The volume of 1000 berries in the fresh condition was maximum in PN 28 (180.98 cc) and minimum in PN 27 (80.05 cc) and that in the dry condition was maximum in PN 41 (65.20 cc) and minimum in PN 13 (37.20 cc).

Observations on extent of spike shedding are presented in Table 16.

(TABLE 16)

The results indicated considerable variation among the varieties for percentage of spike shedding. This was maximum (26.00 %) in PN 42 and minimum (4.67%) in PN 47, the rest of the varieties occupying values in between the two extremes.

IV. Oleoresin content

Results of observations on the oleoresin content of the fortyfive varieties are presented in Table 17.

(TABLE 17)

Table 16. Extent of spike shedding in the different types of pepper (in %)

Type No.	Shedding percentage	Type No.	Shedding percentage
PN 1	11.33	PN 24	20.67
PN 2	5.33	PN 26	6.00
PN 3	8.00	PN 27	8.00
PN 4	9.33	PN 28	17.33
PN 5	14.67	PN 29	8.67
PN 6	8.67	PN 30	10.67
PN 7	6.00	PN 31	8.67
PN 8	20.00	PN 32	10.67
PN 9	22.00	PN 33	14.67
PN 10	10.00	PN 34	20.67
PN 11	14.00	PN 35	19.33
PN 12	6.67	PN 37	10.00
PN 13	11.33	PN 38	7.33
PN 14	14.67	PN 39	14.67
PN 15	20.67	PN 40	20.00
PN 16	6.00	PN 41	12.00
PN 17	19.33	PN 42	26.00
PN 18	8.00	PN 43	17.33
PN 19	18.67	PN 46	5.33
PN 20	12.00	PN 47	4.67
PN 21	19.33	PN 49	10.67
PN 22	14.00	PN 50	18.67
PN 23	22.67		

Table 17. Percentage of oleoresin in the different types of pepper

Type No.	Percentage of oleoresin	Type No.	Percentage of oleoresin
PN 1	11.2	PN 24	8.5
PN 2	9.5	PN 26	8.6
PN 3	7.0	PN 27	7.8
PN 4	12.0	PN 28	12.0
PN 5	11.5	PN 29	7.2
PN 6	8.5	PN 30	8.6
PN 7	7.8	PN 31	9.5
PN 8	8.2	PN 32	11.5
PN 9	9.5	PN 33	10.1
PN 10	8.0	PN 34	12.0
PN 11	8.9	PN 35	11.0
PN 12	11.5	PN 37	10.5
PN 13	8.0	PN 38	9.0
PN 14	9.5	PN 39	8.0
PN 15	7.5	PN 40	8.6
PN 16	10.2	PN 41	7.5
PN 17	8.2	PN 42	8.5
PN 18	7.0	PN 43	8.2
PN 19	11.5	PN 46	9.5
PN 20	10.2	PN 47	13.5
PN 21	8.0	PN 49	11.5
PN 22	8.2	PN 50	12.5
PN 23	11.2		

The results have indicated a minimum oleoresin content of 7 per cent in varieties PN 3 and PN 18 and a maximum oleoresin content of 13.5 per cent in PN 47. Rest of the varieties had intermediate values in between the two.

Discussion

DISCUSSION

Results of observations on twentyeight quantitative and seventeen qualitative traits collected from 45 types of pepper have been presented in the previous chapter. It now remains to discuss the results as a whole in order to form a key that will help in identifying pepper types.

Pepper as we know, is a perennial woody climber, having a bushy columnar appearance attaining about 4 m height and 1.5 m diameter.

It exhibits dimorphic branching. Orthotropic vegetative climbing stems give the framework of the plant. At each swollen node there is a leaf and an axillary bud which grows out to give the plageotropic fruiting branch and short adventitious roots adhere firmly to the climbing support. Lateral fruiting branches have no roots. The internodal length of the orthotroph varies between 2.7 cm and 12.58 cm with 5.67 cm diameter and that of the plageotroph lies between 3.15 cm and 10.73 cm with 1.25 cm diameter.

The climbing and fruiting branches produce leaves which are alternate, stipulate and simple. Petioles of 0.82 cm to 2.51 cm long are grooved above. Lamina shape is ovate, elliptical or cordate and texture - coriaceous. Leaf base is cuneate, cordate or rounded, tip - long acuminate or

ends in blunt tip. The upper surface of the leaf is shiny but gland dotted beneath with 5-7 veins. Leaf margin is even but rarely wavy, the phillotaxy is 1/2.

There are three sex forms in pepper, namely, male, hermaphrodite and female. Flowers are borne on plageotropic branches opposite to ourrent seasons growth in pendent spikes of 4.22 to 15.52 cm long with a maximum of 127 flowers (vide Plate III). Flowers are minute, borne in the axils of shield like fleshy bracts, perianth absent, stamens small, 1-2 on either side of ovary in hermaphrodite flowers, 1 mm long, anthers small with 2 lobes, ovary globose, one celled, one ovuled, surrounded by 2-5 fleshy stigmas, creamy white when receptive, turning brown later.

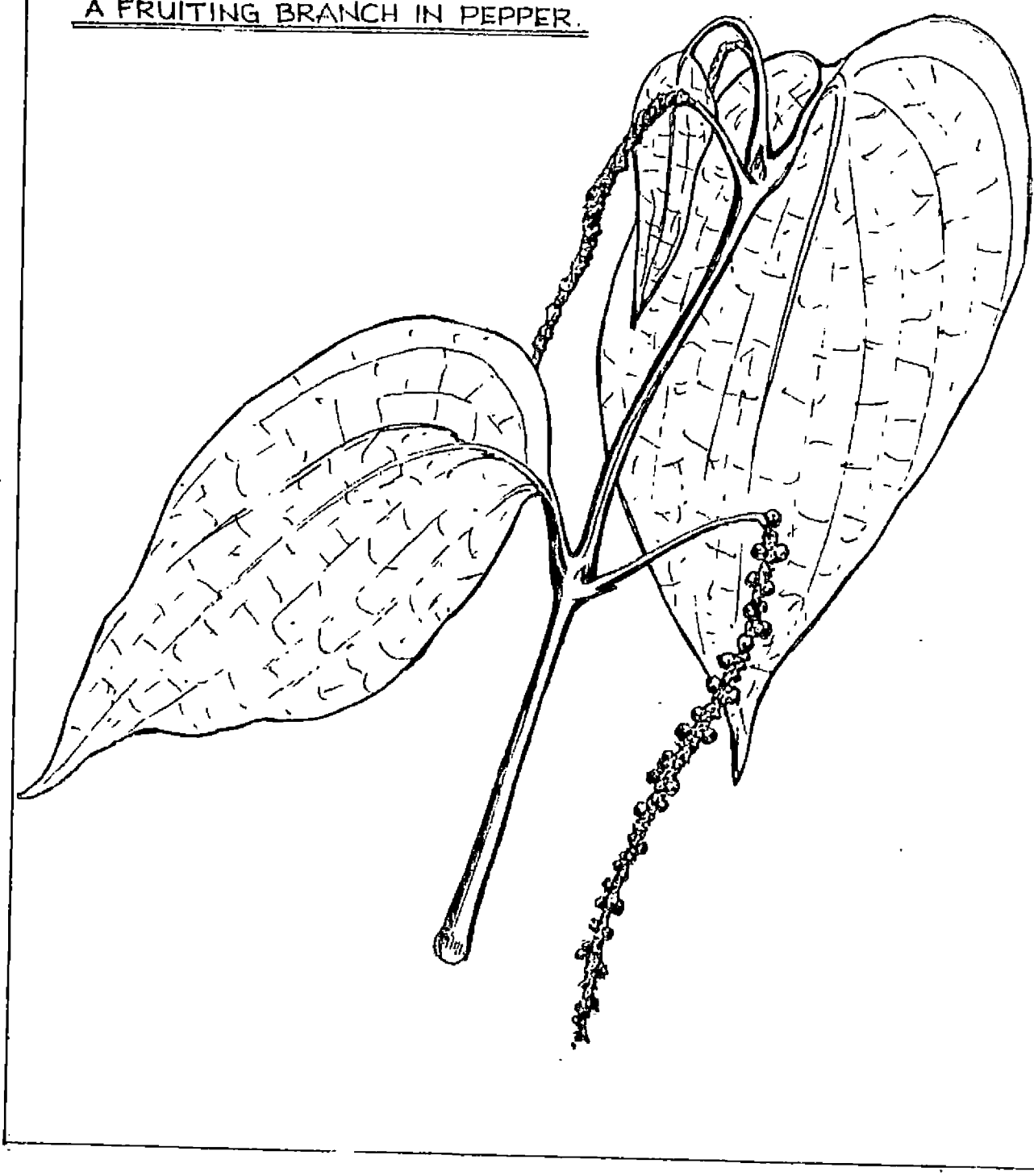
Fruit is botanically a sessile globose drupe, 4-7 mm in diameter with pulpy mesocarp, exocarp turning red when ripe and black on drying. It is, however, commonly called as berry.

The systematic position of black pepper (Piper nigrum L.) has been a point of controversy among the scientists. According to Bentham and Hooker (1979), Piper nigrum belongs to the series Micrembryeae of the subclass Apetalae or Monochlamydeae of the class Dicotyledons in the kingdom Angiosperms. This is cultivated for its fruit which is important as a spice. The genus includes multitudes of forms which are widely

PLATE III. A FRUITING BRANCH IN PEPPER

PLATE III

A FRUITING BRANCH IN PEPPER.



distributed in the pepper growing countries of the tropics. Some of them are under cultivation while many others run wild. Many of them have been collected and presented by scientists in pepper research centres. These types have been given various names based on the name of the locality from where they were collected or some other striking characteristics possessed by them. Identification of these types has always been a problem posed before the scientists, and as such it has been a long felt need to evolve a system based on which these types can be correctly identified and grouped. The work reported herein appears to be the first of its kind which aims at solving the above problem.

One of the approaches in situations like this is to study the variability present in a sample population and arrive at such of those points in which the members of the sample inherently differ. In this respect the procedure followed in the present investigation in observing the variability with reference to 28 quantitative and 17 qualitative traits on fortyfive pepper types representing the wide spectrum of variability present in the pepper germ-plasm available here is fully justifiable. Observations on twenty-eight quantitative characters have revealed wide variability among the varieties with regard to their expression. Thus petiole length among the 45 types varied from 0.82 cm to

2.31 cm, area of lamina from 39.05 cm^2 to 101.48 cm^2, internodal length of orthotrophs from 2.70 cm to 12.58 cm and that of plageotrophs from 3.15 cm to 10.73 cm, spike length from 4.22 cm to 15.52 cm, mean number of spikes from 3.90 to 27.20, mean number of flowers per spike from 34.20 to 126.70, pollen production per flower from 5004 to 10140, mean number of berries per spike from 26.70 to 123.79, thousand berry weight from 50.10 to 162.81 g in the fresh and from 30.70 to 65.78 g in the dry conditions etc. Same is the case with reference to the seventeen qualitative characters. For example colour of vegetative buds among the different types was either Oasis or Russet gr. or Chrysollite gr. or Certosa. Shape of the vegetative bud was either short conical curved or short conical straight or long conical slightly curved. Colour of the leaf sheath was either Russet gr., Oasis, Sallow, Silver fern, Mastic, Olive sheen or Sudan. Same has been the case for petiole colour, which was either Shadow green, Absinthe gr. or Green stone. Five major shades could be observed for the emerging leaves. With reference to colour of mature leaf, there were seven shades observed for colour variation on the upper side and five shades on the lower side. Three different lamina shapes could be observed namely, cordate, elliptic and ovate. The leaf base was either cordate, round or cuneate and leaf margin - wavy or even. Similarly for young berries, nine different

shades could be recognised and in the case of colour of mature as well as ripe berries, there were eight groups. These facts have clearly indicated that the material subjected for study in the present case was highly varying.

The objective of the present investigation has been the formulation of a key for identification of varieties. Such a key has to be based on those traits which are inherent to the type and which are least subjected to environmental fluctuations. As such, no fruitful purpose will be served if an attempt is made to formulate a key based on all the twentyeight quantitative and seventeen qualitative characters on which observations have been recorded in the present case. Thus, from among the fortyfive traits studied we have to pin point a few traits which are inherent to the types and a key has to be prepared.

Most of the pepper workers in the past were unanimous in their opinion that the main difference between the various varieties of pepper was in the sexual composition of the flowers in the spikes (Sayeed, 1968). According to him most of the cultivated pepper varieties were bisexual in nature. A few pure female forms were also seen among those under cultivation. Pure male forms were seen only among the wild types. Results of the present investigations are in support of the above view. When thirtyone out of fortyfive types

studied had hermaphrodite and female flowers in the spike, eleven had only hermaphrodite flowers, one - only female flowers, another one male as well as hermaphrodite flowers and still another one male, female and hermaphrodite ones. No type was observed with either male flowers alone or male and female flowers together in a spike. The results of the present investigation along with those published earlier have indicated that sexual composition of the spike must be considered as an important trait in varietal classification.

Systematists (Hooker, 1886; Purseglove, 1977; and Purseglove et al., 1981) are unanimous in their opinion that for the species Piper nigrum, internodal length of plageotrophs, length of petiole, spike length, leaf shape, leaf base, leaf margin, colour of the lamina on the upper and lower surfaces etc. form the diagnostic characteristics. As such, those traits are to be given greater emphasis in formulating any scheme for identification of the varieties. Thus the key that is being described below has been based on four quantitative and five qualitative traits.

A closer examination of the variability present in the material for the four quantitative traits chosen for the formulation of the key namely, sexual composition of the flowers in the spikes, internodal length of plageotrophs, petiole length and spike length, has furnished interesting

information. The type having the highest value for length of plageotrophs namely PN 16 is 8th for petiole length and 31st for spike length. Similarly the type PN 34 which takes the last rank for the magnitude of length of plageotrophs is 36th for petiole length and 29th for spike length. The same holds good with reference to the expression of all the four quantitative traits among the fortyfive types. This fact clearly indicates that these are traits which are inherent to the types, and any attempt in distinguishing the types based on them will only be reliable. Thus selection of four quantitative traits for formulation of the key from among the twentyeight traits is justifiable. This explanation holds good for the consideration of five qualitative traits viz., leaf shape, leaf base, leaf margin and leaf colour on the upper and lower sides from among the seventeen studied.

The distribution pattern of the fortyfive varieties for the expression of three of the four quantitative traits chosen for the formulation of a key indicates a sudden increase or decrease of values at the extreme ends (vide Fig.2, 3 and 4). As such it was thought that more than the general mean, it would be more realistic to consider median for dividing the 45 types into two groups based on the expression of the traits. Thus the fortyfive types were divided

Fig-2. LINE DIAGRAM SHOWING THE VARIABILITY IN INTERNODAL LENGTH OF PLAGIOTROPHS.

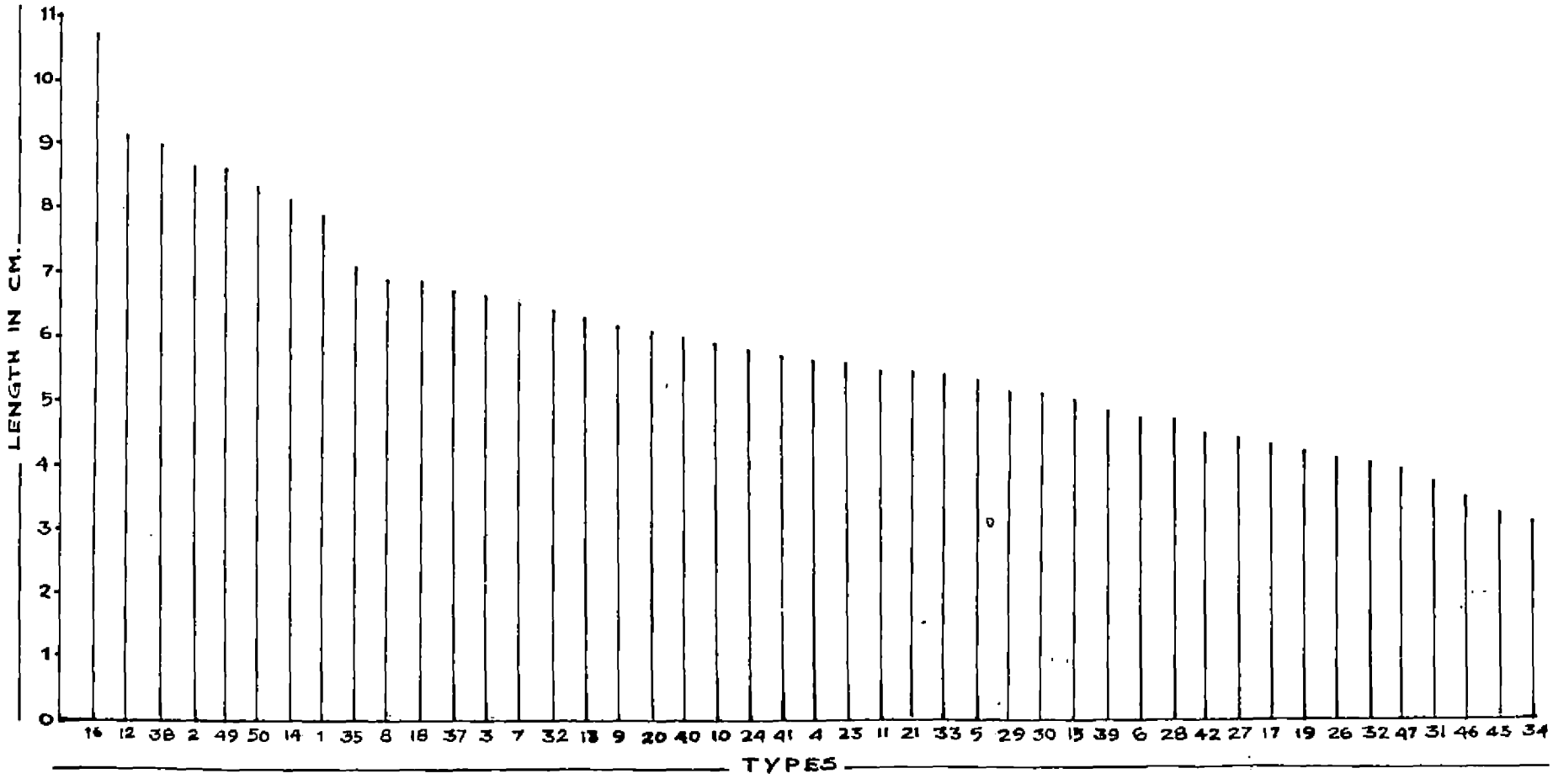


Fig-3. LINE DIAGRAM SHOWING THE VARIABILITY IN PETIOLE LENGTH.

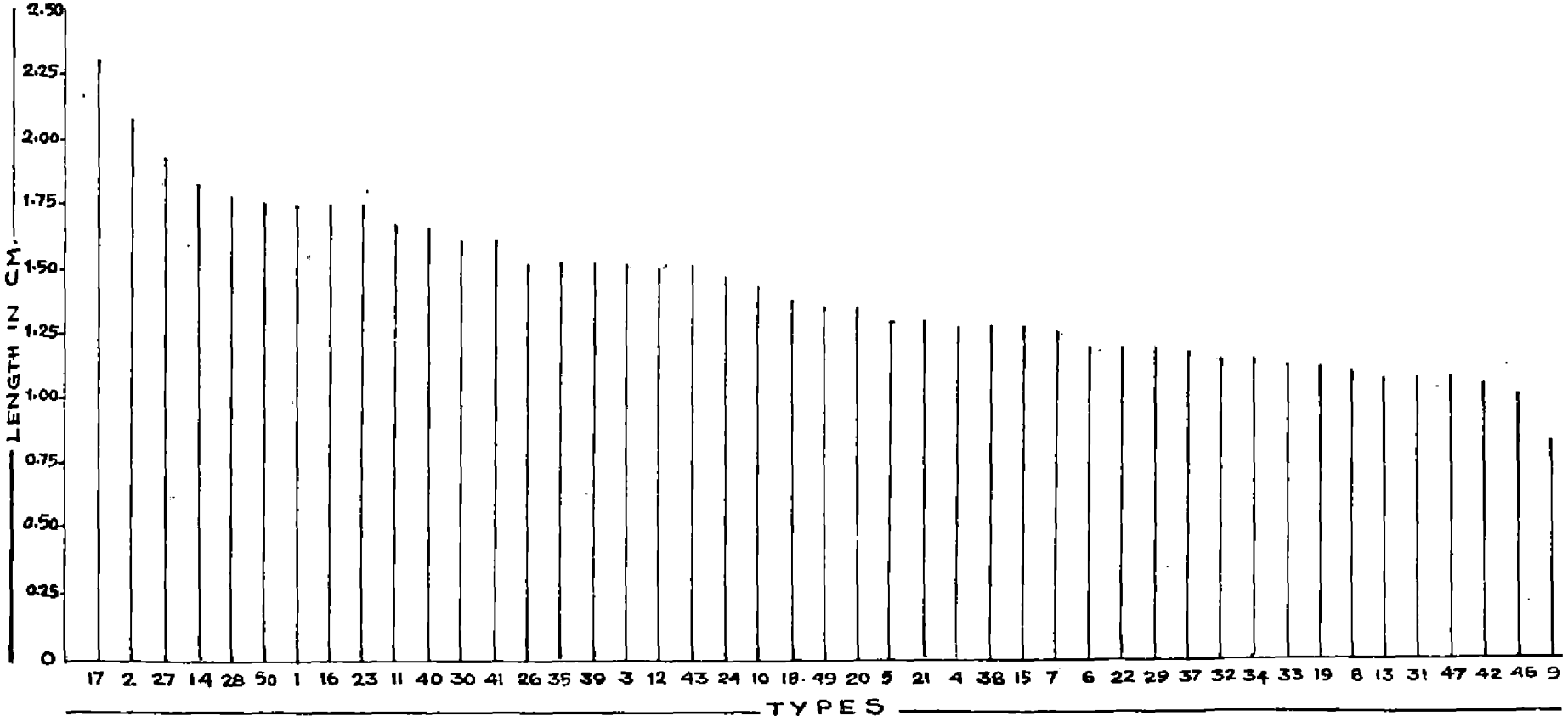
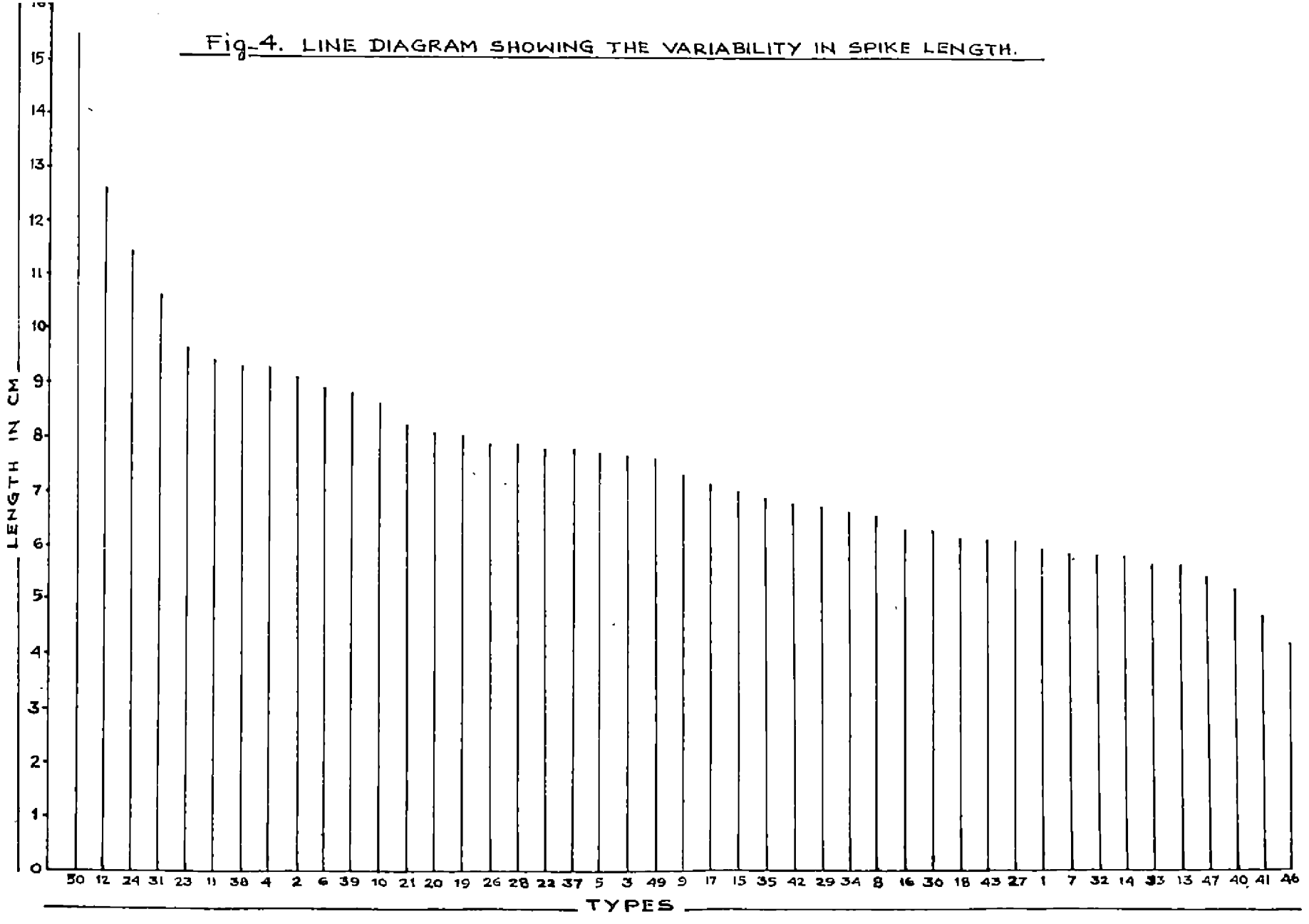


Fig-4. LINE DIAGRAM SHOWING THE VARIABILITY IN SPIKE LENGTH.



into two groups viz., those above median constituting one group and those representing the median and below forming another group for the three quantitative traits. Thus initially the 45 types were divided into five groups based on the sexual composition of flowers in the spikes. Each of the five groups was again subdivided based on internodal length of plageotrophs, petiole length and spike length. Thus altogether $5 \times 2^3 = 40$ groups were realised in the key. Each of the 40 groups thus formed was further subdivided based on the expression of leaf shape (cordate, ovate and elliptical), leaf base (cordate, round and cuneate), leaf margin (even and wavy), and colour on the upper side of the lamina (Peridot, Parrot green, Grass gr., Fern, Piquant gr., Cerro gr. and Garland gr.) and colour on the lower side of lamina (Tea gr., Green stone, Artichoke gr., Mermaid and Russet gr.). The details of the key thus proposed based on the diagnostic features of Piper nigrum is given below:

KEY FOR IDENTIFICATION

A Spikes with only female flowers

B Internodal length of laterals (plageotrophs) above median

C Petiole length above median

D Spike length above median

DD Spike length median and below

CC Petiole length median and below

D Spike length above median

DD Spike length median and below

BB Internodal length of laterals median and below

C Petiole length above median

D Spike length above median

	Leaf			Lamina colour on the		Type No.
	Shape	Base	Margin	Upper side	Lower side	
1. Elliptic	Cuneate	Even		Peridot Green	stone	PN 23

DD Spike length median and below

CC Petiole length median and below

D Spike length above median

DD Spike length median and below

AA Spikes with only hermaphrodite flowers

B Internodal length of laterals above median

C Petiole length above median

D Spike length above median

	Leaf			Lamina colour on the		Type No.
	Shape	Base	Margin	Upper side	Lower side	
2.	Cordate	Round	Even	Fern	Green stone	PN 12
DD	Spike length median and below					
3.	Cordate	Round	Even	Parrot green	Tea gr.	PN 16
4.	Cordate	Cordate	Even	Garland gr.	Mermaid	PN 1
5.	Elliptic	Cordate	Even	Fern	Artichoke gr.	PN 40
6.	Cordate	Cordate	Even	Fern	Russet gr.	PN 41
CC	Petiole length median and below					
D	Spike length above median					
DD	Spike length median and below					
BB	Internodal length of laterals median and below					
C	Petiole length above median					
D	Spike length above median					
7.	Cordate	Round	Even	Parrot green	Green stone	PN 11
8.	Cordate	Cordate	Even	Fern	Green stone	PN 26
DD	Spike length median and below					
9.	Cordate	Cordate	Even	Grass gr.	Green stone	PN 27
CC	Petiole length median and below					
D	Spike length above median					
10.	Cordate	Round	Wavy	Fern	Artichoke gr.	PN 19
11.	Cordate	Cordate	Even	Parrot green	Green stone	PN 22
DD	Spike length median and below					

	Leaf			Lamina colour on the		Type No.
	Shape	Base	Margin	Upper side	Lower side	
12.	Ovate	Round	Even	Parrot green	Tea gr.	PN 46
AAA Spikes with female and bisexual flowers						
B Internodal length of laterals above median						
C Petiole length above median						
D Spike length above median						
13.	Cordate	Round	Even	Parrot green	Green stone	PN 10
14.	Cordate	Cordate	Even	Fern	Green stone	PN 24
15.	Cordate	Cordate	Even	Parrot green	Artichoke gr.	PN 50
DD Spike length median and below						
16.	Cordate	Round	Even	Fern	Artichoke gr.	PN 14
17	Cordate	Round	Wavy	Fern	Tea gr.	PN 18
18	Cordate	Cordate	Wavy	Cerro gr.	Artichoke gr.	PN 35
CC Petiole length median and below						
D Spike length above median						
19	Cordate	Cordate	Wavy	Fern	Artichoke gr.	PN 20
20	Cordate	Cordate	Wavy	Fern	Artichoke gr.	PN 37
21	Cordate	Cordate	Wavy	Peridot	Green stone	PN 38
22	Cordate	Cordate	Wavy	Fern	Artichoke gr.	PN 49
DD Spike length median and below						

		Leaf			Lamina colour on the		Type No.
		Shape	Base	Margin	Upper side	Lower side	
	23	Ovate	Round	Wavy	Fern	Mermaid	PN 7
	24	Cordate	Cordate	Wavy	Parrot green	Artichoke gr.	PN 8
	25	Cordate	Round	Even	Peridot	Artichoke gr.	PN 9
	26	Cordate	Round	Wavy	Fern	Green stone	PN 13
	27	Cordate	Cordate	Wavy	Fern	Green stone	PN 32
BB	Internodal length of laterals median and below						
	C Petiole length above median						
	D Spike length above median						
	28	Ovate	Cordate	Even	Peridot	Green stone	PN 28
	29	Elliptic	Cordate	Wavy	Piquant gr.	Green stone	PN 39
	DD Spike length median and below						
	30	Cordate	Cordate	Even	Parrot green	Tea gr.	PN 17
	31	Cordate	Cordate	Even	Fern	Green stone	PN 30
	32	Cordate	Cordate	Even	Parrot green	Tea gr.	PN 43
	CC Petiole length median and below						
	D Spike length above median						
	33	Ovate	Cordate	Even	Fern	Green stone	PN 4
	34	Cordate	Cordate	Even	Fern	Artichoke gr.	PN 5
	35	Ovate	Cuneate	Even	Fern	Mermaid	PN 6
	36	Cordate	Cordate	Even	Parrot green	Green stone	PN 21
	37	Cordate	Cordate	Even	Fern	Tea gr.	PN 31

	Leaf			Lamina colour on the		Type No.
	Shape	Base	Margin	Upper side	Lower side	
DD Spike length median and below						
38	Elliptic	Round	Even	Peridot	Tea gr.	PN 15
39	Cordate	Cordate	Even	Fern	Green stone	PN 29
40	Cordate	Round	Wavy	Fern	Artichoke gr.	PN 33
41	Cordate	Cordate	Wavy	Parrot green	Green stone	PN 34
42	Cordate	Cordate	Even	Peridot	Tea gr.	PN 42
43	Cordate	Cordate	Even	Peridot	Green stone	PN 47
AAAA Spikes with male and hermaphrodite flowers						
B Internodal length of laterals above median						
C Petiole length above median						
D Spike length above median						
44	Cordate	Cordate	Even	Peridot	Tea gr.	PN 2
CC Petiole length median and below						
D Spike length above median						
DD Spike length median and below						
BB Internodal length of laterals median and below						
C Petiole length above median						
D Spike length above median						
DD Spike length median and below						
CC Petiole length median and below						
D Spike length above median						
DD Spike length median and below						

	Leaf			Lamina colour on the		Type No.
	Shape	Base	Margin	Upper side	Lower side	
AAAAA	Spikes with female, male and hermaphrodite flowers					
B	Internodal length of lateral above median					
C	Petiole length above median					
D	Spike length above median					
	45. Cordate	Cordate	Even	Fern	Tea gr.	PN 3
DD	Spike length median and below					
D	Spike length above median					
DD	Spike length median and below					
BB	Internodal length of laterals median and below					
C	Petiole length above median					
D	Spike length above median					
DD	Spike length median and below					
CC	Petiole length median and below					
D	Spike length above median					
DD	Spike length median and below					

The scheme proposed above seems to be satisfactory, because the fortyfive types considered as separate entities initially have been proved to be so in most of the cases. However, in two cases it has been proved to be otherwise. Three types, viz., PN 20, PN 37 and PN 49 were found to fall into the same group and two others viz., PN 17 and PN 43 into another group. It might be

possible that after collection the above types might have been given different local names, and as such might have been entered in the germ plasm collection as different entries. However, this needs further confirmation.

Summary

SUMMARY

The present studies were undertaken in the Department of Agricultural Botany, College of Horticulture, Vellanikkara, during the period of 16 months from May 1981 to August 1982.

From the germ plasm maintained in the Pepper Research Scheme, College of Horticulture, Vellanikkara 45 types of diversified origin representing the wide spectrum of variability were selected. Observations on twenty-eight quantitative and seventeen qualitative characters were recorded from all the fortyfive varieties. The results indicated that the types were highly varying with reference to the traits studied.

Based on nine diagnostic features of Piper nigrum, namely sexual composition of flowers in a spike, internodal length of plageotrophs, petiole length, spike length, leaf shape, leaf base, leaf margin and colour of lamina on the upper and lower sides, a key was formulated for identification of pepper types. Based on the key, the fortyfive types selected initially were found to fall into fortytwo groups. Forty groups were represented by one type each, one group--by three types and another group by two types.

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FORMULATION OF A KEY FOR IDENTIFICATION OF THE DIFFERENT TYPES OF PEPPER, *Piper nigrum* L.

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the
requirement for the Degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agricultural Botany
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Vellanikkara - Trichur
KERALA — INDIA

1982

ABSTRACT

The studies reported herein were carried out in the Department of Agricultural Botany, College of Horticulture, Vellanikkara, during the year 1980-82 with a view to formulating a key for identification of different varieties of pepper.

From the germ plasm collection maintained in the Pepper Research Scheme of the College, 45 types of uniform age were earmarked. Observations on twentyeight quantitative and seventeen qualitative characters were recorded from all the fortyfive types and the variability among the types was assessed. The study revealed that the material was highly variable with reference to many of the characters.

From among the characters studied, sexual composition of flowers in a spike, length of internode of plageotrophs, petiole length, spike length, leaf characters (shape, base and margin) and colour of the lamina of the mature leaf in the upper and lower sides which have been recognised as diagnostic features of Piper nigrum were separately considered and a scheme was proposed for identification of the different types of pepper.