SCREENING FOR RESISTANCE TO *Aphis craccivora* IN VEGETABLE COWPEA (*Vigna unguiculata* var. *sesquipedalis* and var. *cylindrica*) AND EVALUATION OF EARLY TYPES

By

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THESIS

Submitted in partial fulfilment of
the requirement for the degree of

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DECLARATION

I hereby declare that this thesis entitled "Screening for resistance to Aphis craccivora in vegetable cowpea (Vigna unguiculata var. sesquipedalis and var. cylindrica) and evaluation of early types" is a bonafide record of research work done by me during the course of research and that the thesis has not been 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,
9 — 6 — 1984.

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CERTIFICATE

Certified that this thesis entitled "Screening for resistance to Aphis craccivora in vegetable cowpea (Vigna unguiculata var. sesquipedalis and var. cylindrica) and evaluation of early types" is a record of research work done independently by Miss K.A. Sulochana, 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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CERTIFICATE

We, the undersigned members of the Advisory Committee of Miss K.A. Sulochana, a candidate for the degree of Master of Science in Horticulture agree that the thesis entitled "Screening for resistance to *Aphis craccivora* in vegetable cowpea (*Vigna unguiculata* var. *sesquipedalis* and var. cylindrica) and evaluation of early types" may be submitted by Miss K.A. Sulochana in partial fulfilment of the requirement for the degree.

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To My Parents

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Introduction

INTRODUCTION

Cowpea is a nutritious leguminous crop low in antinutritional factors. It has a wide range of ecological adaptations and could be more widely grown. In fact, it probably has the greatest potential among all food legumes in the semi arid to sub humid tropical areas. Cowpea (Vigna unguiculata) is classified as vegetable types (Vigna unguiculata sub sp sesquipedalis), pulse types (Vigna unguiculata sub sp radiata) and dual purpose types (Vigna unguiculata sub sp cylindrica) (Simmonds, 1960). The typical vegetable type is characterised by long and stringless pods, fleshy pericarp, thin and long seeds and higher monosaccharides to polysaccharides in the pods.

In Kerala the vegetable cowpea is mainly grown during May-July and September-November months. The main constraint in growing cowpea during the above months has been the incidence of aphids (Aphis craccivora koch.). This polyphagous aphid sucks the sap from the terminal shoots in the early stages of the plant. At later stage aphids infest the pods and arrest their growth and cause discolouration. The aphids also act as vectors for many of the legume viruses which drastically reduce the pod yield. The insecticidal control of aphids is not generally being advised because of the residual toxic hazards.

Identification of aphid resistant line if any would be an appropriate and useful method to control the pest incidence. The released cowpea varieties F 568, C 20, PS 42, NP 1, Barsathi Mutant, Pusa-Do-phasli, Pusa Phalguni and Pusa Barsathi are reported moderately to heavily infested by the aphid (Chari et al. 1976). Chari et al. (1976) could identify the cowpea lines TVU 57, TVU $408P_2$, TVU 410, TVU 1037, TVU 3273 and TVU 4538 to be resistant to aphids. Being very shy bearers the use of above lines as donors for aphid resistance in cowpea was suggested.

The importance of early varieties of cowpea for a multiple cropping system of cultivation so prevalent in Kerala needs no further emphasis. The lines K 1552, K 868 and K 779 were identified by the All India Co-ordinated Vegetable Improvement project as extra early and suited as a component crop in crop rotations and multiple cropping (AICVIP 1981). The suitability of the above lines for the warm humid tropical conditions of Kerala needs to be further studied. The present investigations were undertaken with the following objectives:

1. To identify cowpea line(s) resistant to aphids (*Aphis craccivora*).
2. To catalogue the cowpea germplasm as an aid to pest resistant breeding programme.
3. To identify early high yielding and average stable cowpea lines.

Review of Literature

REVIEW OF LITERATURE

A. Field screening of cowpea lines for resistance to *Aphis craccivora* Koch

"Resistance refers to collective heritable characteristics possessed by a plant which influence the ultimate degree of damage done by an insect. From a practical point of view, resistance is the ability of a certain variety to produce larger yield of good quality than other varieties at the same level of infestation and under similar environmental conditions" (Painter, 1941). Attempts have been made to devise a frame work of terminology within which the inter-relationships between host and insect may be described (Snelling, 1941; Painter, 1958; Beck, 1965 and Maxwell *et al*. 1972). Host resistance was defined by Beck (1965) as "the collective heritable characteristics by which a plant species, race, alone or individual may reduce the probability of successful utilisation of that plant as a host by an insect species, race, biotype or individual".

Plant resistance to aphids.

Considerable work has been done on the resistance in crop varieties to aphids. Painter and Grandfield (1935) reported the resistant alfalfa varieties to the aphid, *Acyrthosiphon pisum*. Harrington (1941), Auclair and Maltais (1950) and Auclair *et al*. (1957) studied the resistance in peas to Acyrthosiphon pisum. Sambandam and Chelliah (1970) screened a number of brinjal cultivars for resistance to Aphis gossypii and developed a resistant brinjal variety "Annamalai". Resistance to Aphis craccivora in broadbean (Saleh et al. 1972), in groundnut (Brar and Sandhu, 1975), in soybean (Demski and Kuhn, 1975) and in cowpea (Fotedar and Kushwaha, 1976; Chari et al. 1976; Singh, 1977 and Gerard, 1978) have also been reported. Kennedy et al. (1978) studied resistance in muskmelon (Cucumis melo) to Aphis gossypii.

Resistance in cowpea to insect pests.

Cuthbert and Chambliss (1972) reported resistance in cowpea, to curculio, Chalcodermus aeneus Bhoeman. The tolerant varieties of cowpea to Empoasca kerii, Pagria signata and Plusia nigrisigna were identified by Ram and Singh (1973). Bindra and Sagar (1976) found resistant cowpea varieties to Etiella zinckenella.

Perrin (1977, 1978) reported relationships of the host plant to attack by the cowpea pod borer, Cydia ptychora (Meyr). Nilakhe and Chalfant (1982) screened 20 cowpea cultivars for resistance to nine different insect pests in field plantings. Cultivar differed significantly in degree of susceptibility to Aphis spp. thrips, the plant bug, Lygus lineolaris the velvet bean caterpillar, Anticarsia gemmatalis Hubner, the southern green stink bug, Nezara viridula and the cowpea curculio, *Chalcodermus aeneus* Boheman and reported that chances of finding a cultivar resistant to several of these insect pests were rare.

Mechanisms of resistance.

Several factors in a plant might reduce the possibility of successful utilisation of the plant by an insect. Painter (1958) divided plant resistance mechanism into three categories - preference/non-preference, antibiosis and tolerance. Plants may be non-preferred for oviposition, shelter or food, primarily because of the lack of essential nutrients or presence of toxic chemicals or due to adverse physical or mechanical factors. Resistant plants may affect the biology of the insect adversely and this phenomenon is termed as antibiosis. Tolerance refers to the ability of a plant to withstand the damage or recover from attack in spite of supporting the population of insects that would normally cause greater injury to a susceptible plant.

Physical factors.

Pubescence is one of the most important physical characters associated with resistance. It is a complex character involving several factors like the distribution of hairs on stem, leaves or petiole, the length of hairs, the density of hair cover, disposition of hairs and the type of hairs (Verma and Afzal, 1940). Sambandam *et al.* (1969) reported that the aphid, *Aphis gossypii* did not settle in the plant *Solanum mamosum* L because the plants were thickly pubscent and the hairs were long. Brar and Sandhu (1975) reported that groundnut varieties with bunch or semi spreading growth habit were susceptible to *Aphis craccivora*. Gibson (1976) reported that presence of glandular hairs provided resistance to *Myzus persicae* and *Macrosiphum euphorbiae* in certain wild potato species. Quiros *et al*. (1977) reported that the increase in hair density in tomato plant restricted feeding activity of potato aphid, *Myzus euphorbiae* under field conditions.

Antibiosis.

The antibiosis mechanism in resistant plants has been investigated by several workers. Kennedy and Booth (1951) reported that the aphids in general prefer to feed and reproduce faster on young or senescent leaves than on mature leaves, especially if they are not well adapted to feed on that host plant. When Painter (1958) reared *Aphis gossypii* on resistant varieties of cotton in the laboratory, he observed reduction in fecundity, early death of adults and general inability to maintain a population on the resistant host plants. Khalifa and Sharaf El-Din (1965) found that the age of the leaves of cotton and bhindi affected the development and fecundity of *Aphis gossypii*. Nymphs on young leaves developed most quickly, and those on mature leaves most slowly. Fecundity was equally high on young and old leaves, but low on matured ones. Young and old leaves provided better nutritious conditions for development and reproduction than mature ones.

Panda and Raju (1972) found that fecundity, nymphal weight, and longevity of the aphids were less on the resistant varieties than on the susceptible ones. Chari et al. (1976) reported that the resistant cowpea varieties supported a lower population of aphids/plant and indicated that this resistance was caused by antibiosis. Fotedar and Kushwaha (1976) found that the duration of nymphal development of Aphis craccivora on cowpea was longer on resistant than on susceptible varieties. Karel and Malinga (1980) reported that the three cowpea cultivars, TVU 408 P_2, TVU 410 and Ife Brown were resistant to pea aphids (Acyrthosiphon gossypii) attack. Antibiosis and non-preference mechanisms were found to be responsible for resistance in these varieties of cowpea to pea aphids.

Biochemical mechanism of resistance.

The nutritive value of the host plants to insects feeding on them appears to play an important role in determining the susceptibility to the insect attack.

Sugars.

Aphids have a special feeding preference for sucrose. Sucrose was found to be necessary phagostimulant for

Acyrthosiphon pisum (Auclair and Cartier, 1963) and Acyrthosiphon gossypii (Auclair 1967a and b) in a holidic diet. When sucrose was totally replaced by glucose and fructose, survival of Acyrthosiphon pisum and Aphis gossypii was significantly reduced. The low survival rate might be due to lack of palatability in sugars with poor nutritive value. Barlow et al. (1977) observed that pea aphid, Acyrthosiphon pisum preferred mostly soluble carbohydrates and total protein. Barlow and Randolph (1978) reported that Acyrthosiphon pisum preferred young pea plants than woody perennials because the phloem sap of young pea plants apparently had lower sugar content and higher total amino acid content than woody perennials.

Amino acids.

Auclair and Maltais (1950) reported that the pea varieties susceptible to Acyrthosiphon pisum generally contained a higher concentration of amino acids than the resistant varieties. Auclair et al. (1957) stated that lower concentration of amino acids in the resistant varieties, reduced the rate of growth of aphids and thus contributed to the resistance. Maltais and Auclair (1962) and Auclair (1963) reported that the susceptible pea varieties to Acyrthosiphon pisum had higher concentration of homoserine, glutamine and aspargine than resistant varieties. Strong and Sankamoto (1963) suggested that atleast nine amino acids were found to be essential for

Myzus persicae among which, methionine was an important feeding stimulant (Mittler, 1967). Turner (1971) stated that the sulphur containing amino acids-cystine and methionine were essential for the growth and survival of *Aphis gossypii*. Srivastava and Auclair (1974, 1975) suggested that certain amino acids either alone or in combination act synergistically with sucrose as phagostimulant to pea aphid *Acyrthosiphon pisum*.

Minerals.

Auclair and Maltais (1950), Maltais (1951) and Auclair *et al.* (1957) reported that the amount of nitrogen in the pea varieties in terms of free and total amino acids, contributed significantly to the resistance or susceptibility of these varieties to pea aphid. Maltais and Auclair (1957) reported that the varieties susceptible to pea aphid *Acyrthosiphon pisum* contained more nitrogen and less sugar than the resistant ones. Rahier (1978) reported that high proportion of Nitrogen and low proportion of potassium in *Brassica rapa* are sub-optimal for the plants but favoured the development of *Myzus persicae*.

Vitamins.

Dadd *et al.* (1967) identified ascorbic acid and nine vitamins as dietary requirements for *Myzus persicae*. Auclair (1965) reported that the absence of 11 vitamins in the diet of *Acyrthosiphon pisum* reduced the growth significantly during the first generation.

Secondary plant substances.

Winsler (1962) observed that mustard oil glucoside sinigrin was present in the plants of family cruciferae and that were preferred hosts to cabbage aphid *Bevicoryne brassicae*. Pons and Moyano (1970) reported that the inhibitor and auxin like substances in *Medicago sativa* affected the degree of susceptibility, resistance or immunity to aphids. Maxwell (1972) reported that the secondary plant substances are the important chemical groups involved in the host selection behaviour to aphids.

pH.

The pH of the diet was found to influence aphid growth, reproduction and survival as well as selection of diets by aphids (Auclair, 1965, 1967a and Cartier, 1968). It has been found that aphids generally prefer slightly alkaline diets.

Influence of weather factors on aphid population.

The role of ecological factors on the field population of aphids have been reviewed by many workers. The higher temperature and radiation increased the aphid *Aphis fabae*, population on field bean in late June and mid July or in early August (May, 1967a). Radke *et al*. (1975a) reported the effect of temperature and light on the development of cowpea aphid *Aphis craccivora*. Radke *et al*. (1975b) reviewed the influence of relative humidity on the development and reproduction of *Aphis craccivora* and reported that it preferred an optimal relative humidity of 65 to 70 per cent for oviposition at 12.8°C and a photoperiod of 12 h induced the production of sexual forms. Saleh *et al.* (1972) revealed that the population density of *Aphis craccivora* reached the maximum on *vicia faba* during March and *vigna sinensis* during August.

Mathew *et al.* (1971) studied the fluctuation of population of *Aphis craccivora* on cowpea and reported that the high and low populations occurred from September to April and from May to August respectively. Pal *et al.* (1978) reported the ideal conditions for the outbreak of *Aphis craccivora* as about 80 per cent R.H., 27.5 to 28.5°C air temperatures and a fewer number of sunshine hours.

B. Evaluation of early cowpea lines for phenotypic stability

The cowpea (*Vigna unguiculata* (L) Walp) grows in almost all parts of India excepting the high hills. It is a multipurpose crop grown for its green pods for use as vegetable, for grains as pulse and for forage. Taxonomically grain types are referred to as sub sp. *cylindrica* and the vegetable types as sub sp. *sesquipedalis*. A good vegetable variety of cowpea should not only be a good yielder but its pod should also be medium long, non-fibrous and succulent or fleshy. Earliness (days to first flower opening) in vegetable types of cowpea is also desirable to fit in a multiples cropping system under irrigated conditions.

Inheritance of maturity has reported to be quantitative by many workers. Mackie (1946) and Brittingham (1950) obtained transgressive segregates for earliness and lateness in F_2 of a cross of early x late, suggesting polygenic nature of inheritance. Dominance of viny habit over the bushy one is reported by Acosta and Patrache (1960). Norton (1961) reported that bushy plants were early maturing and better yielders. Ojomo (1971) observed that early flowering was dominant over late flowering and that duplicate dominant epistasis coupled with the presence of certain modifying genes controlled the incidence of flowering. Virupakshappa et al. (1982) indicated that the genotypes with early duration and determinate growth habit coupled with characters of vegetable types would serve as better female parents in the crossing works of cowpea to get high pod setting.

The important findings relevant to the present study are reviewed under the following aspects. Studies on variability, heritability and genetic advance for quantitative characters and genotype x environment interactions.

Variability studies.

Many workers have studied the extent of variability in various pulse crops through genotypic coefficient of variations and phenotypic coefficient of variations. But the extent of genetic variability is more important than the total variation since greater the genetic diversity, wider will be the scope for selection.

Karthikeyan (1963) appears to be the first to report in some detail the results of genetic studies. He has reported that genotypic variability was found to be the largest for number of fruiting nodes, followed by pods/plant, number of branches and seed yield. Singh and Mehndiratta (1969) showed that pods/plant had the highest genotypic coefficient of variation. Doku (1970) reported that genotypic coefficient of variation was generally higher than phenotypic coefficient of variation. Trehan *et al.* (1970) reported that estimates of genetic variance were high for branches/plant, pods/plant and peduncle length in cowpea. Veeraswamy *et al.* (1973) reported that seeds/pods showed high genotypic coefficient of variation and clusters/plant showed a low genotypic coefficient of variation. Bordia *et al.* (1973) found that high genetic coefficients of variation were observed for pod number. Grain yield/plant was strongly associated with pod number and length and with seeds/pod. Lakshmi and Goud (1977) reported that the genotypic coefficient of variation was higher for plant height, grain yield, pods/plant and 100 grain weight. Durgaprasad and Ramjibhai (1978) reported that days to flower, pods/plant, length of pod, seeds/pod, size of seed and seed yield/plant are predominantly governed by additive gene actions. High heritabilities are observed indicating that considerable progress can be achieved by selection.

Heritability and genetic advance.

The broad sense heritability and genetic advance estimates have been reported by many authors in cowpea. Singh and Mehndiratta (1969) showed that high values of heritability estimates were exhibited by 100 seed weight, days to flower, pod length and days to maturity. Expected genetic advance was found to be appreciable for number of branches, 100 grain weight, pod number, pod length and yield. Trehan et al. (1970) reported that heritability estimates were low and genetic advance higher for peduncle length, pods/plant and yield. Schoo et al. (1971) observed high estimates of heritability and genetic advance for vine length, pods/plant and pod weight. Bordia et al. (1973) reported that heritability was the highest for 100 seed weight followed by days to flower and pod length. High genetic advance was observed for pod number, length and seeds per pod. Lakshmi and Goud (1977) reported that plant height, grain yield, 100 grain weight, length of pod, are associated with higher genetic advance. Sreekumar et al. (1979) reported the lowest heritability for grains/pod, while total duration showed the lowest values of genetic advance.

Genotype x environment interactions.

Genotype x environment interactions are of great significance in evaluating crop varieties over a wide range of environmental conditions and it becomes difficult to evaluate a variety that is relatively stable in performance under different environments (Horner and Frey, 1967; Joshi, 1969). Finlay and Wilkinson (1963) developed a statistical technique in barley and the same was further elaborated by Eberhart and Russel (1966) in maize for testing the stability of varieties over environments. They took into consideration the deviation of each variety from the expected regression line, along with the mean performance and the regression coefficient. Reports on genotype x environment interactions and the stability parameters in cowpea are limited. Joshi (1972) applied the stability analysis as described by Eberhart and Russel to ascertain the stability of green gram varieties for grains yield. Joshi et al. (1972) evaluated the stability parameters for a few bunch genotypes of groundnut (Arachis hypogea L) evolved at the main oil seeds research station, Junagadh.

Materials and Methods

MATERIALS AND METHODS

The present studies were conducted during three consecutive crop seasons (June-August, 1982, September-December, 1982 and June-September, 1983) at the Instructional Farm of Kerala Agricultural University, Vellanikkara. This station is located at an altitude of 23 meters above mean sea level and is situated between 10°32' latitude and 76°16' E longitude. Geographically it falls in the warm humid tropical climatic zone.

A. Experimental material

The experimental materials comprised of 83 cowpea lines (Vigna unguiculata (L.) Walp. The source and morphological descriptions of the lines are given in Table 3.1.

B. Experimental design

1. Field screening of cowpea lines for resistance to A. craccivora Koch.

First field evaluation of 83 cowpea lines was conducted during June-August, 1982 raised in single rows with a spacing of 45 cm between rows and 15 cm between plants within a row. Farmyard manure was applied and incorporated at the rate of 15 t/ha by ploughing before formation of ridges. Urea, super phosphate and muriate of potash were applied after the ridge formation to supply N, P_2O_5 and K_2O at the rate of 15:30:15 kg/ha respectively. Fifteen days after sowing a top dressing with urea to supply nitrogen at the rate of 15 kg/ha was also given. The 83 cowpea lines were field tested for resistance to aphids upto 30 days of sowing. Susceptible lines were identified and later plant protection measures were taken to maintain and multiply the lines.

Second field experiment was conducted during September-December, 1982 using 70 cowpea lines. Each line consisted of 25 plants in single row. The susceptible check Kolenchery local was grown all around the plot and in alternate rows. Observations on aphid population were recorded at 15 days interval upto 60 days after sowing. Five plants were selected at random from each line and the aphid population present in leaves, internodes and pods were recorded. Based on aphid population, the lines were classified as immune (0), resistant ($<$100), moderately susceptible ($>$100$<$250), susceptible ($>$250$<$1,000) and highly susceptible ($>$1,000).

Based on results obtained in the second field experiment nine resistant cowpea lines were selected and tested for population build up of aphids through pot culture providing controlled conditions, most suited for the pest. Each line consisting of two plants was raised in the pots and when the plants were 25 days old, adult aphids were released at the rate of 50 aphids/plant on the top leaves of plants. Each line was replicated three times. The population build up of aphids in these plants was recorded 15 days after release and expressed as percentage of area infested.

2. Evaluation of early cowpea lines for phenotypic stability.

The experimental material comprised of the first 15 cowpea lines given in Table 1. They were grown in a randomised block design with two replications in two seasons each under two contrasting environments - high fertile and low fertile. The high fertile environment was created through use of farm yard manure at the rate of 15 t/ha and a fertilizer doze of N, P_2O_5, K_2O at the rate of 20:30:10 kg/ha respectively. The low fertile environment was developed by avoiding application of farm yard manure and giving a reduced fertilizer doze of N, P_2O_5, K_2O at the rate of 10:15:5 kg/ha respectively. Each line was grown in a plot size of 2.5 x 1 m with a spacing of 30 x 10 cm. In each plot, five plants were randomly labelled and observations were recorded.

C. Plant characters studied in the two experiments

1. Nodes to first flower
2. Days to harvest
3. Plant height
4. Branches/plant
5. Pod length
6. Pod weight
7. Seeds/pod
8. Hundred seed weight
9. Pods/plant
10. Pod yield/plant
11. Yield/day - Per day yield was calculated in the first experiment as pod yield/plant divided by days to last harvest

D. Chemical analysis of pods

The monosaccharide to polysaccharide ratio of 15 lines evaluated for earliness were determined as per the method described by the A.O.A.C. (1960).

E. Meteorological observations

1. Maximum temperature.

Mean maximum temperature during the period of experimentation was recorded.

2. Minimum temperature.

Mean minimum temperature during the period of investigation was recorded.

3. Rainfall.

Quantity of rainfall received at monthly interval during the period of investigation was also recorded.

4. Relative humidity.

The average relative humidity at monthly interval during the period of investigation was recorded.

5. Bright sunshine hours.

Bright sunshine hours observed at monthly interval during the period of experimentation.

F. Statistical analysis

1. The extent of variability for all the plant characters observed in the 70 lines evaluated for resistance was estimated by their standard errors.

$$SE = \sqrt{\frac{\Sigma y^2 - \frac{(\Sigma y)^2}{n}}{n\ (n-1)}}$$

2. Analysis of variance.

The data for each of the characters of 15 genotypes were analysed separately for each fertility level as in a randomised block design (Ostle, 1966). The mathematical model of the experimental design is given by:

$$y_{ij} = \mu + t_i + b_j + e_{ij}$$

$$(i = 1, 2 \ldots\ldots\ldots t,\ j = 1, 2 \ldots\ldots\ldots r)$$

where

y_{ij} = Observation of the i^{th} line in j^{th} replications

μ = General mean

t_i = True effect of i^{th} line

b_j = True effect of j^{th} block, and

e_{ij} = Random error

The actual break up of the total variation into different components is as given in Table 3.2.

Table 3.2. General analysis of variance

Source of variation	df	MS	F
Replications	1	R	R/E
Genotypes	14	G	G/E
Error	14	E	

Grand mean, standard error of mean and critical differences were estimated as follows:

$$\text{Grand mean} = \frac{\text{Grand total}}{30}$$

$$\text{Standard error of mean} = \sqrt{\frac{E}{2}}$$

where E = error mean square

Critical difference =

$$\sqrt{\frac{2E}{2}} \times \text{table value of 't' at 14 df}$$

Variability existing in the 15 genotypes for yield and its components were estimated as suggested by

Burton (1952). Genotypic coefficient of variation

$$(gcv) = \frac{\text{Genotypic standard deviation} \times 100}{\text{Grand mean}}$$

Phenotypic coefficient of variation (pcv) =

$$\frac{\text{Phenotypic standard deviation} \times 100}{\text{Grand mean}}$$

Environmental coefficient of variation (ecv) =

$$\frac{\text{Environmental standard deviation} \times 100}{\text{Grand mean}}$$

Estimates of genotypic and phenotypic standard deviations were obtained by solving the following equations from the respective analysis of variance table for different characters.

Estimate of error variance ($\hat{\sigma}e^2$) = E

Estimate of genotypic variance ($\hat{\sigma}g^2$) = $\frac{G - E}{r}$

Estimate of phenotypic variance($\hat{\sigma}p^2$) = $\hat{\sigma}g^2$ + E

where

r = number of replications

E = Error mean square

G = Mean square for genotypes

Heritability in the broad sense was estimated by the formula:

$$h^2 = \frac{\hat{\sigma}g^2}{\hat{\sigma}p^2}$$

The expected genetic advance (GA) was measured by using the formula suggested by Lush (1949) and Johnson *et al.* (1955) at five per cent selection intensity using the constant i as

2.06 given by Allard (1960).

$GA = h^2 i \sigma p$

Genetic gain (Johnson *et al.* 1955) was estimated as

$$GG = \frac{GA \times 100}{mean}$$

3. Pooled analysis of variance.

Analysis of variance of the pooled data for each character was performed as suggested by Panse and Sukhatme (1978) and the detailed analysis of variance is given in Table 3.3.

Table 3.3. Pooled analysis of variance

Source	df	SS
Total	59	$\sum_i \sum_j y_{ij}^2 - CF$
Genotypes	14	$\sum_{i=1}^{15} y_{i.}^2/4 - CF$
Environments	3	$\sum_{j=1}^{4} y_{.j}^2/15 - CF$
G x E	42	
Pooled error	56	

4. Phenotypic stability analysis.

The phenotypic stability analysis were conducted as suggested by Eberhart and Russel (1966). Three parameters were estimated so as to measure phenotypic stability of lines. They are (i) mean, (ii) regression of individual mean performance on environmental index and (iii) deviation from regression. The linear model is of the form:

$$y_{ij} = \mu + b_i I_j + \delta_{ij}$$

where

i = 1, 2........15

j = 1, 2.........4

y_{ij} = mean performance of i^{th} genotype in the j^{th} environment.

μ = mean of all the genotypes over all the environments.

b_i = the regression coefficient of i^{th} genotype on the environmental index which measures the response of the genotype to different environments.

I_j = the environmental index which is defined as the deviation of the mean of all the genotypes at a given location from the overall mean.

δ_{ij} = the deviation from regression of i^{th} genotype at the j^{th} environment.

The environmental index can be expressed as:

$$I_j = (\sum_i Y_{ij}/15) - (\sum_i \sum_j Y_{ij}/60), \text{ with } \sum_j I_j = 0$$

The first stability parameters (bi) was estimated using the formula:

$$b_i = \sum_j Y_{ij} I_j / \sum_j I_j^2$$

The second stability parameter (s^2d_i) was estimated using the formula:

$$s^2d_i = (\sum_j \delta_{ij}^2/(S-2) - Se^2/r$$

where

Se^2/r is the estimate of pooled error and

$$\sum_j \delta_{ij}^2 = (\sum_j Y_{ij}^2 - Y_i^2/4) - (\sum_j Y_{ij} I_j)^2 / \sum_j I_j^2$$

The average of error mean square over all the environments was taken as the estimate of pooled error variance. The detailed analysis of variance for the estimation of stability parameter is given in Table 3.4.

Table 3.4. Analysis of variance for stability

Source	df	SS	MS
Total	59	$\Sigma_i \Sigma_j Y_{ij}^2$ - CF= T.S.S	
Genotypes	14	$\Sigma_i Y_{i.}^2 j/4$ - CF= G.S.S	MS_1
Environments	3	$\Sigma_j Y_{.j}^2/15$ - CF= E.S.S	
G x Env.	42	T.S.S - G.S.S.-E.S.S	MS_2
Env. + (G x Env.)	45	$\Sigma_i \Sigma_j Y^2_{ij} - \Sigma_i Y^2_{i.}/4$	
Env. (linear)	1	$1/15(\Sigma_j Y_{.j} I_j)^2/\Sigma_j I_j^2$ = S.S.E (linear)	
G x E (linear	14	$\Sigma_i (\Sigma_j Y_{ij} I_j)^2/\Sigma_j I_j^2$ = S.S.E	MS_3
Pooled deviation	30	$\Sigma_i (\Sigma_j \delta_{ij}^2)$	MS_4
Genotype 1	2	$(\Sigma_j Y^2_{ij}) - \frac{(Y_{i.})^2}{4} - \Sigma_j Y_{ij} I_j^2 / \Sigma_j I_j^2$	
Genotype 15	2	$(\Sigma_j Y^2_{15j}) - \frac{(Y^2_{15})}{4} - \Sigma_j Y_{15} I_j^2 / \Sigma_j I_j^2$	
Pooled error	60		MS_5

The significance of the difference among genotype means was tested using the F ratio.

$$F = \frac{MS_1}{MS_4} = \frac{\text{Mean square for varieties}}{\text{Pooled deviation mean square}}$$

The significance of genotype x environment interaction was tested using the F ratio.

$$F = \frac{MS_2}{MS_5} = \frac{\text{Mean square for genotype x environment}}{\text{Pooled error mean square}}$$

The genetic difference among genotypes for their regression on the environmental index were tested using the F ratio.

$$F = \frac{MS_3}{MS_4} = \frac{\text{Mean square for G x E (linear}}{\text{Pooled deviation mean square}}$$

Deviation from regression for each genotype was tested using the F ratio.

$$F = \frac{\sum_j \delta_{ij}^2/2}{MS_5}$$

The significance of the difference between regression coefficients and unit was tested using the appropriate 't' test

$$t = \frac{bi - 1}{\sqrt{MS_4/I^{2}{}_{j}{}^{2}}}$$

Results

RESULTS

Data collected from the experiments were statistically analysed and are presented below:

A. Evaluation of cowpea lines for insect reaction to *Aphis craccivora* koch.

Eighty three cowpea lines consisting of grain, forage and vegetable types (Table 3.1) were evaluated for insect reaction during the rainy season of 1982. Observations were made on number of aphids plant observed 30 days after sowing both on leaves and internodes. All the cowpea lines except 10 TVU lines were infested by the aphid. In susceptible lines the aphid count varied from zero in IIHR sel 1, VS 88 to 1075 in Kolenchery 3 in the leaves and from zero in V 11, V 25, V 15, V 24, V 29, Vn 17, V 10, V 8, V 14 and V 9 to 787 in Mayyanad local in the internodes (Table 4.1).

The TVU series did not get infested upto 30 days after sowing. When observed 45 days after sowing TVU 107 and TVU 62 got infested (Table 4.1). The lines TVU 1889, TVU 408, TVU 2896 and TVU 2962 were completely free from aphid infestation observed on leaves, internodes and pods upto 60 days after sowing. The TVU lines 107, 207, 62, 109, 1892 and 36 got infested either on leaves or on internodes or on pods.

Seventy lines from the first trial were further evaluated during September-December 1982 to test insect

Table 4.1. Evaluation of cowpea germplasm for source of resistance to *Aphis craccivora* during the first crop season

Genotypes	Average number of aphids/plants 30 days after sowing	
	Leaves	Internodes
K 1552	188.00	294.400
Brown seeded	83.00	5.00
Pusa Barsathi	213.75	272.50
Kanakamany	9.00	93.00
Red seeded	134.80	122.80
K 868	16.80	55.60
K 779	165.00	150.40
V 133	95.20	169.60
V 175	8.00	95.60
P 460-1-1	105.00	152.50
P 85-2E-9A	10.00	73.00
IIHR sel 1	0.00	165.00
IIHR 6-1-B	139.80	46.20
Hg 22	225.00	150.00
S 488	230.00	77.50
VS 87	30.20	110.40
VS 88	0.00	129.20
VS 89	3.20	180.00
Yard long bean	25.80	156.80
V 11	15.00	0.00
V 22	175.00	10.00
V 17	106.00	47.00
V 1	87.50	38.75
V 3	18.60	5.00
V 25	12.50	0.00
V 26	15.67	18.30
V 31	33.30	18.00
V 2	292.50	53.75
V 32	113.60	121.60
V 19	152.60	116.25
Vn 23	109.60	51.25
Vn 9	59.60	188.60
V 12	17.00	60.60
Vn 24	208.20	55.00

Contd........

Table 4.1. Contd.....

Genotypes	Average number of aphids/plants 30 days after sowing	
	Leaves	Internodes
V 15	15.00	0.00
Vn 20	0.00	10.00
Vn 16	67.80	63.80
V 16	20.00	15.00
Mayyanad local	132.00	787.00
V 13	20.00	25.00
Vn 7	22.80	112.60
V 20	95.00	77.75
V 24	18.75	0.00
V 30	18.00	10.75
V 27	25.00	10.75
Vn 22	102.00	63.20
V 38	93.40	124.20
V 29	17.50	0.00
Vn 1	216.00	117.60
V 18	75.80	40.00
Vn 17	693.00	0.00
V 21	80.00	46.20
New Era	102.00	86.25
Vn 6	92.40	97.20
Vn 8	17.80	86.00
Vn 11	221.00	83.80
Vn 10	100.00	41.00
Vn 12	10.00	20.00
V 23	122.50	45.00
V 6	5.00	25.00
V 10	132.00	0.00
Kolenchery 3	1075.00	253.80
V 8	20.00	0.00
Vayalathur Red	107.00	56.75
V 5	17.00	25.00
V 14	30.75	0.00
V 4	159.50	3.00
Vayalathur white	200.00	158.00
V 9	12.00	0.00
V 21	8.00	0.00
C 152	230.00	25.00
TVU 207	0.00	0.00
TVU 1889	0.00	0.00
TVU 107	0.00	0.00
TVU 62	0.00	0.00
TVU 408	0.00	0.00
TVU 109	0.00	0.00
TVU 1892	0.00	0.00
TVU 2896	0.00	0.00
TVU 36	0.00	0.00
TVU 2962	0.00	0.00
TVU 410	71.00	61.80

Contd......

Table 4.1. Contd....

Genotypes	Average number of aphids/plants 45 days after sowing	
	Leaves	Internodes
TVU 207	0.0	0.0
TVU 1889	0.0	0.0
TVU 107	63.0	32.0
TVU 62	0.0	84.6
TVU 408	0.0	0.0
TVU 109	0.0	0.0
TVU 1892	0.0	0.0
TVU 2896	0.0	0.0
TVU 36	0.0	0.0
TVU 2962	0.0	0.0

Genotypes	Average number of aphids/plants 60 days after sowing		
	Leaves	Internodes	Pods
TVU 207	0.0	11.4	0.0
TVU 1889	0.0	0.0	0.0
TVU 107	29.8	69.2	0.0
TVU 62	0.0	145.0	71.2
TVU 408	0.0	0.0	0.0
TVU 109	0.0	41.2	0.0
TVU 1892	53.0	71.8	0.0
TVU 2896	0.0	0.0	0.0
TVU 2962	0.0	0.0	0.0

reaction. All the seventy lines except TVU series succumbed to aphids 30 days after sowing. The lines TVU 207, TVU 107, TVU 62, TVU 109, TVU 1892, TVU 36 and TVU 2962 got infested 45 days after sowing. TVU 1889, TVU 408 and TVU 2896 were free from aphid attack. When aphid count was made 60 days after sowing only the lines TVU 408 and TVU 1889 were observed free from aphids except for in the internodes. The remaining TVU lines were susceptible to aphid attack (Table 4.2). The nine TVU lines were artificially infested by releasing fifty aphids each to caged chambers and observations were made on area of aphid infestation (Fig. 1). The line TVU 1889 gave the minimum area of infestation (100 sq. cm), while the lines TVU 62 and TVU 109 had the maximum area of infestation (145 sq. cm) (Table 4.3).

The seventy lines were observed for earliness, vegetative characters, productive characters and their components (Table 4.4). Nodes to first flower ranged from 2 (C-5-7, TVU 109, TVU 1892) to 5.8 in Vb 6. The line K 1552 was the earliest to harvest (52 days). The TVU lines were late to harvest (56 to 62 days) except for TVU 1892 (52 days). The lines Brown seeded, Red seeded, K 868 were dwarfer (less than 55 cm height). The TVU lines were all pole types. Branches/plant ranged from 1.8 to 6.6. The TVU series were highly branched (more than three). The yard long bean had the longest pod (31.2 cm)

Fig. 1. AREA OF APHID INFESTATION IN 9 COWPEA LINES UNDER CONTROLLED CONDITIONS.

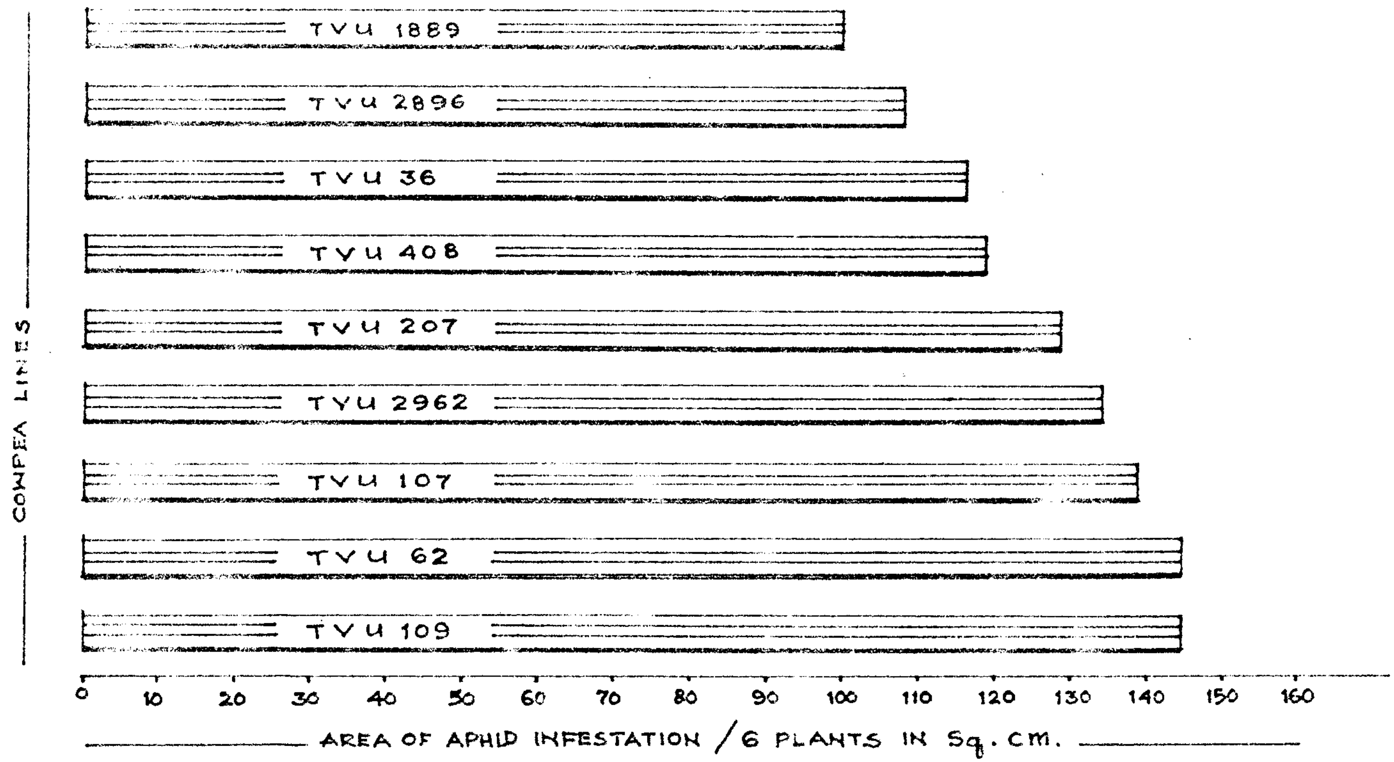


Table 4.3. Area of aphid infestation in nine cowpea lines under controlled conditions

Genotypes	Area in sq. cm
TVU 1889	100.00
TVU 2896	108.50
TVU 36	116.00
TVU 408	119.00
TVU 207	129.00
TVU 2962	134.75
TVU 107	139.00
TVU 62	145.00
TVU 109	145.00

followed by IIHR 6-1-B (27.7 cm). The line TVU 1890 had the shortest pod (10.2 cm). IIHR 6-1-B had the heaviest pod (3.2 g) and P 85-2E-9A the lightest (0.84 g). Seeds/pod ranged from nine in IIHR sel 1 and TVU 2962 to seventeen in IIHR 6-1-B. Hundred seed weight varied from 6.2 g in P 85-2E-9A to 20.1 g in IIHR sel 1. Pods/plant numbered from 10.6 (C 152) to 21.8 in Hg 22. Pod yield varied from 17.6 g in C 152 to 78 g in IIHR 6-1-B.

The yield/day was calculated considering differences in days to final harvest. The variety IIHR 6-1-B had the highest yield/day of 0.82 g. The lowest yield/day was observed in P 85-2E-9A (0.21 g). The TVU lines yield/day ranged from 0.37 g in TVU 2962 to 0.5 g in TVU 207.

Effect of meteorological parameters on aphid population

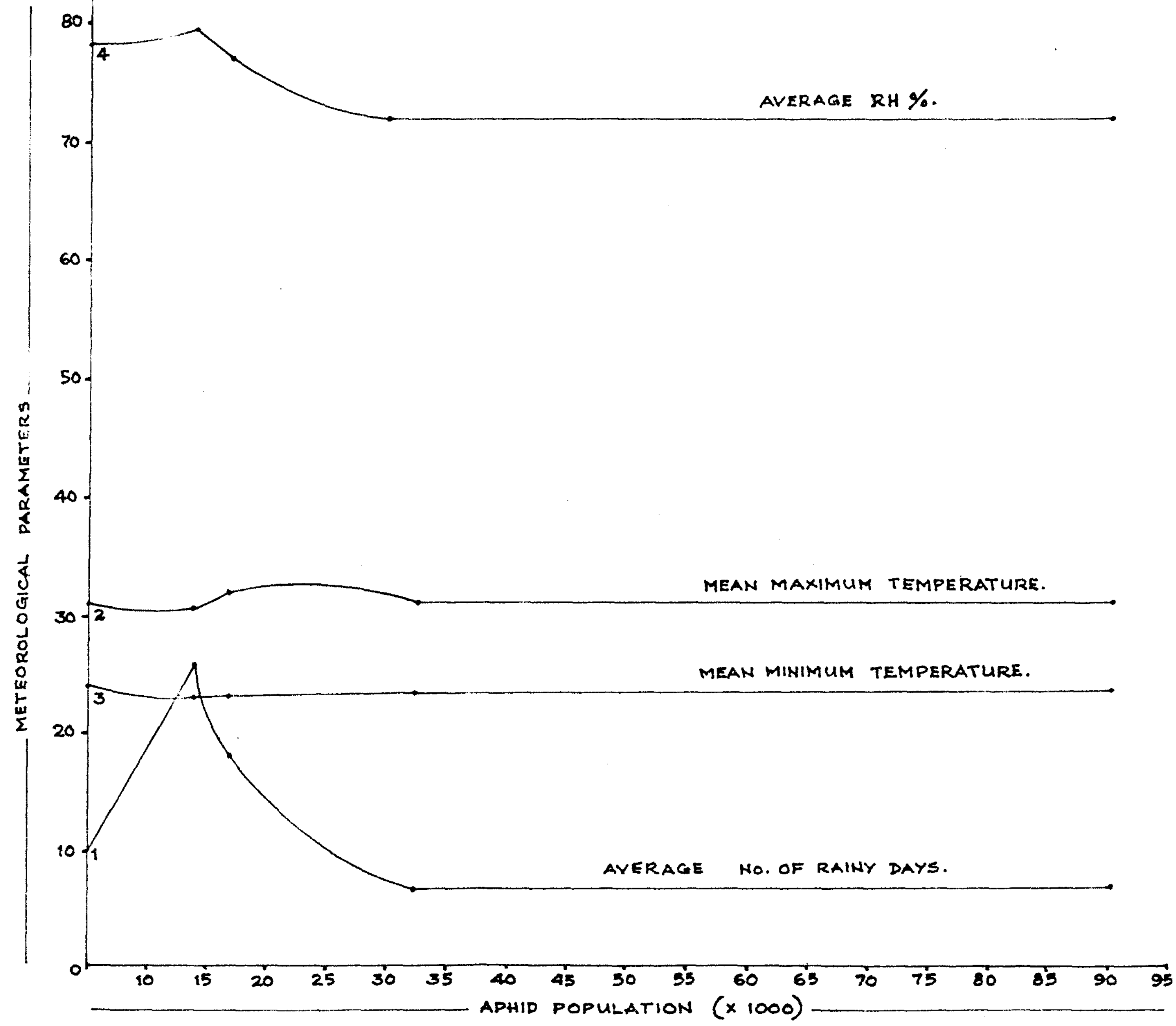
Attempts were made to relate the overall aphid population in the experimental plot as a function of meteorological parameters - average relative humidity, average number of rainy days, mean maximum temperature and mean minimum temperature observed at monthly intervals (Table 4.5 Fig. 2).

Aphid population showed a diminishing trend with increase in the number of rainy days and consequent increase in average relative humidity. The maximum mean temperature and minimum mean temperature were observed not influencing the aphid population. The aphid population varied from 14243.37/plants during June to 90651.20/plants during November.

Table 4.5. Weather factors and aphid population during the period of experimentation

Month	Average number of rainy days	Mean maximum temperature °C	Mean minimum temperature °C	Average relative humidity	Aphid population
June	26	30.60	23.10	79.80	14243.37
September	10	30.98	24.00	78.80	0.00
October	18	32.04	23.15	77.00	17183.60
6th November	7	31.40	23.93	71.88	32955.20
22nd November	7	31.40	23.93	71.88	90651.20

Fig-2. RELATION BETWEEN WEATHER FACTORS AND APHID POPULATION DURING THE PERIOD OF EXPERIMENTATION



Evaluation of early cowpea lines for Phenotypic stability

Fifteen selected early varieties of vegetable cowpea were grown in two seasons under low and high fertility conditions. The fifteen varieties were found to be significantly different for vegetable yield and its components during the four independent trials (Table 4.6). The differences were statistically significant at 0.01% level of probability. Mean performance of 15 vegetable types of cowpea observed during two seasons under two fertility levels are given in Table 4.7. Mean, range, genotypic coefficient of variation, phenotypic coefficient of variation, environmental coefficient of variation, heritability, genetic advance and genetic advance as percentage of mean for vegetable yield and its components were given in Table 4.8. High heritability (0.98) associated with high genotypic coefficient of variation (57) resulting in high genetic advance was observed for plant height. The characters pods/plant and pod yield/plant had lower values of genotypic coefficient of variation and heritability values. Consequently these characters had lower values of genetic advance as percentage of mean. The fifteen genotypes had significant variability for days to harvest. It ranged from 51 to 66 days. The varieties differed significantly for plant height ranging from 39 cm to 295 cm. As for branches/plant significant variability was observed. Pod length ranged from 13.20 cm

Table 4.6. General analysis of variance for vegetable yield and its components

Source of variation	df		Mean squares									
			Nodes to first flower	Days to harvest	Plant height	Branches/plant	Pod length	Pod weight	Seeds/pod	Hundred seed weight	Pods/plant	Pod yield/plant
Replications	1	E_1	0.390	7.49	179.68	0.09	0.17	0.01	0.03	0.01	0.16	312.34
		E_2	0.002	2.46	13.41	0.53	0.01	0.01	0.97	0.11	0.13	2.03
		E_3	1.090	0.43	202.49	0.01	0.72	0.64	0.81	1.73	30.00	603.39
		E_4	0.640	10.55	7.64	0.13	0.22	0.05	3.20	0.79	48.64	412.48
Genotypes	14	E_1	2.39**	31.58**	9603.79**	0.98**	42.12**	0.01**	3.51**	31.91**	25.01*	241.49*
		E_2	1.73**	37.41**	5249.14**	1.12**	43.97**	0.68	7.41**	22.24**	18.62**	91.85**
		E_3	2.18**	44.69**	8878.43**	1.73**	47.27**	0.37	5.99**	28.75**	47.31**	433.34**
		E_4	1.88**	31.41**	7495.68**	1.41**	45.78**	0.56**	4.39**	26.13**	25.23*	118.88**
Error	14	E_1	0.23	5.27	80.52	0.05	0.28	0.180	0.69	0.26	9.59	80.38
		E_2	0.05	1.49	31.81	0.08	0.18	0.003	0.29	1.33	2.34	10.89
		E_3	0.14	0.12	71.89	0.07	0.11	0.230	0.46	0.23	8.94	108.81
		E_4	0.08	5.95	79.23	0.04	0.50	0.020	0.88	0.43	9.83	29.77

* P = 0.05
** P = 0.01

E_1 = Low yielding environment in the first crop season
E_2 = Low yielding environment in the second crop season
E_3 = High yielding environment in the first crop season
E_4 = High yielding environment in the second crop season

to 31.36 cm overall the trials. Pod weight ranged from 1.32 g to 3.69 g. Seeds/pod ranged from 8.6 to 16.3. The varieties differed significantly in hundred seed weight (ranged from 7.68 to 21.20). As for pods/plant the varieties ranged from 8.10 to 29.30,pod yield/plant ranged from 26.40 g to 89.66 g. High heritability values (0.9) were observed for nodes to first flower, plant height, pod length and hundred seed weight. Lower values of heritability were observed for pods/plant and pod yield/plant. Genetic advance as percentage of mean was the highest for plant height and the lowest for seeds/pod. Pod yield/plant had only lower values of genetic advance as percentage of mean ranging from 25.16 to 35.59.

The two cropping seasons and two different fertility levels with each season consecuted four different environments to evaluate the performance of fifteen cowpea lines. The environments were significantly different to creat significant differences for characters, days to harvest, plant height, branches/plant, pod length, pod weight, pods/plant and pod yield/plant. The environments were not significantly different to creat significant differences for nodes to first flower, seeds/pod and hundred seed weight (Table 4.9). The genotype x environment interaction was significant for days to harvest, plant height, branches/plant, pod length, seeds/pod, hundred seed weight and pod yield/plant. The interaction was not significant for nodes to first flower, pod weight and pods/plant. The

Table 4.9. Pooled analysis of variance for vegetable yield and its components

Source	df	Mean squares									
		Nodes to first flower	Days to harvest	Plant height	Branches/ plant	Pod length	Pod weight	Seeds/ pod	Hundred seed weight	Pods/ plant	Pod yield/ plant
Genotypes	14	7.94**	122.75**	35936.59**	4.87**	176.64**	2.20**	15.78**	106.95**	163.05**	558.20**
Environments	3	0.24	39.80	1137.43	1.38	2.51*	1.29**	3.43**	3.69	239.89**	3127.79**
G x E interaction	42	0.11	7.45**	357.28**	0.12**	0.84**	0.12	1.83**	1.55**	4.77	101.27*
Pooled error	56	0.12	3.21	65.73	0.06	0.28	0.11	0.58	0.56	7.68	57.46

* P = 0.05

** P = 0.01

detailed general analysis of variance of phenotypic stability for vegetable yield and its components (Table 4.10), revealed that variance due to linear effect of environment was significant for nodes to first flower, days to harvest, pod length, hundred seed weight and pod yield/plant. It also revealed that the major portion of variances due to environment + genotype x environment were contributed by variance due to linear effect of environment. The genotype x environment linear was significant for hundred seed weight and pod yield/plant. The varieties K 1552, Brown seeded, Red seeded, K 868 and K 779 had their first flower on the third node. K 1552 had a mean value of 2.80 nodes to first flower, bi - 0.02 and S^2di - 0.15. IIHR 6-1-B had a mean value of 4.73 nodes to first flower with bi - 0.12 and S^2di - 0.06. K 1552 was the earliest with 52.13 days to harvest, bi - 0.49 and S^2di - 1.43. The yard long bean took more days to harvest (63.75 days), bi - 0.17 and S^2di - 10.67. The yard long bean had the longest pod (30.47 cm) followed by IIHR 6-1-B (25.86 cm). IIHR sel 1 had the boldest seed (Hundred seed weight - 19.28 g) followed by VS 88 (18.17 g). The phenotypic stability of the fifteen varieties for pod yield/plant revealed that IIHR 6-1-B is the most average stable variety with the highest mean (62.35 g/plant) bi value tending to one (0.96). Its deviation from regression was however significant.

Table 4.10. General analysis of variance of phenotypic stability for vetable yield and its components

Source	df	Mean squares				
		Nodes to first flower	Days to harvest	Pod length	Hundred seed weight (g)	Pod yield/plant (g)
Genotypes	14	3.93**	61.36**	88.98**	53.48**	284.80**
Environments	3	0.20	29.72**	1.17**	2.76**	1576.26**
(Genotype x Environment)	42	0.10	3.72**	0.44**	0.78**	50.44
Environment + (Genotype x Environment)	45	0.11	4.78	0.49	0.85	152.16
Environment (linear)	1	0.59*	59.44**	3.54**	5.53**	4728.78*
Genotype x Environment (linear)	14	0.15	4.06	0.49	1.48**	155.15**
Pooled deviation	30	0.11	3.32	0.38	0.39	45.42
Genotypes						
K 1552	2	0.22*	0.24	0.60	0.89*	47.44
Brown seeded	2	0.004	0.74	0.59*	0.01	15.56
Kanakamany	2	0.0005	5.46*	0.01	0.07	40.85
Red seeded	2	0.07	0.83	0.41	0.11	34.86
K 868	2	0.02	0.27	0.33	0.02	16.46
K 779	2	0.14	0.13	0.85**	0.01	5.61
V 133	2	0.03	0.37	-0.07	0.05	20.65
V 175	2	0.03	1.01	0.12	0.15	90.01
P 85-2E-9A	2	0.01	0.13	0.09	0.05	16.15
IIHR sel 1	2	0.03	1.03	0.25	1.75**	3.14
IIHR 6-1-B	2	0.004	4.91	1.59*	0.85	178.02*
VS 87	2	0.03	0.94	0.12	0.20	1.01
VS 88	2	0.06	9.47**	0.26	0.24	1.32
VS 89	2	0.83**	11.90**	1.90**	1.41*	192.45**
Yard long bean	2	0.15	12.34**	-1.22	0.07	16.17
Pooled error	60	0.13	3.34	0.27	0.57	75.80

* P = 0.05

** P = 0.01

The varieties K 1552, VS 89 and K 868 were high yielders (59.62 g, 54.45 g and 52.62 g respectively) and had regression value more than one (2.19, 1.51 and 1.55 respectively). IIHR sel 1 was the lowest yielder (34.56 g)(Table 4.11 and Fig. 3). The fifteen varieties were further evaluated for glucose, starch and glucose/starch ratio. K 1552 had the highest glucose content (4.5%) followed by yard long bean (4.00%). Starch content is high in K 779 (17.58%) followed by K 1552 (16.36%). Glucose starch ratio was the highest for the Yard long bean followed by K 1552, IIHR 6-1-B and VS 87 (Table 4.12).

Fig-3. SCATTER DIAGRAM INDICATING MEAN PERFORMANCE (μ) AND REGRESSION COEFFICIENT (bi) FOR YIELD.

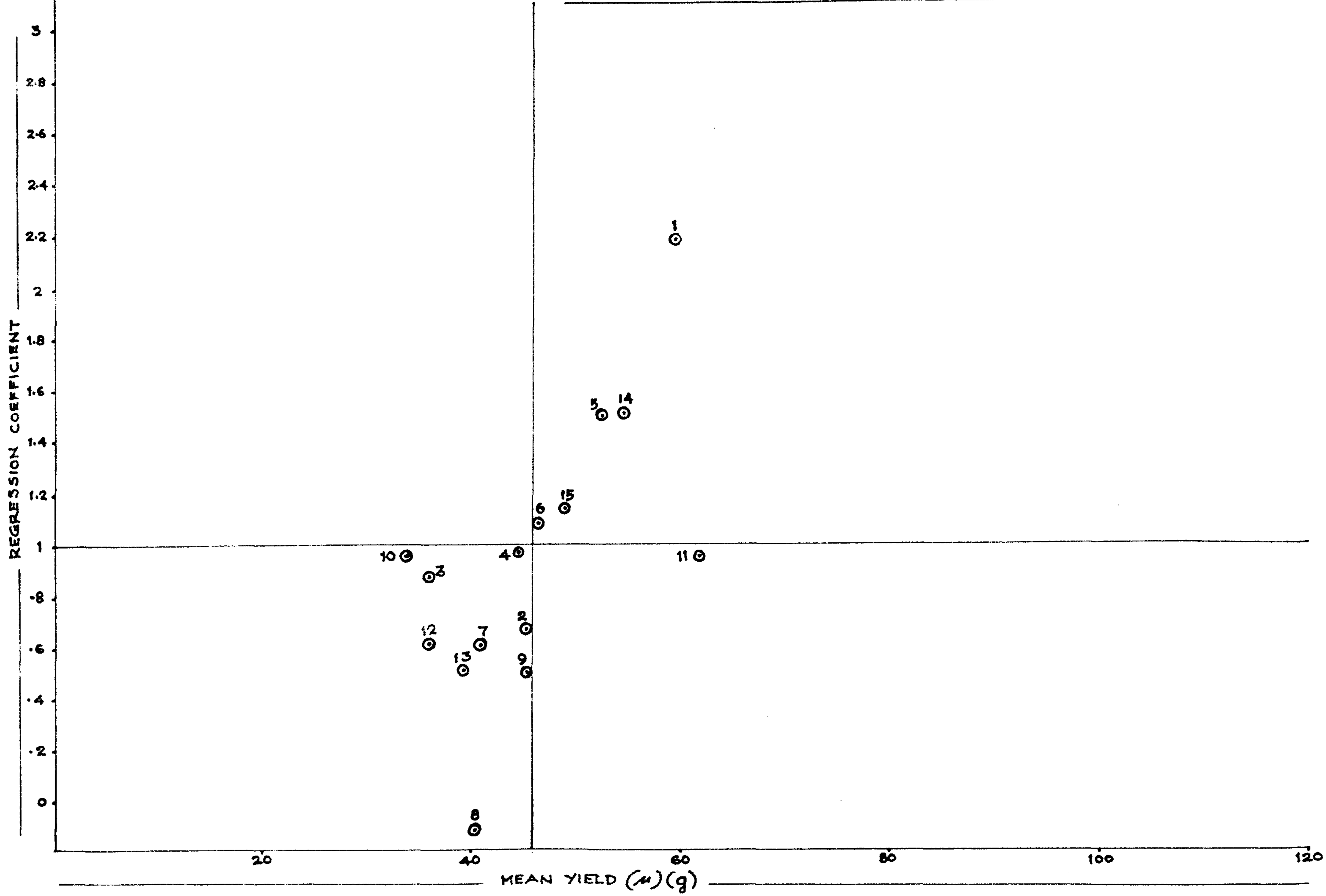


Table 4.12. Glucose and starch contents of fifteen vegetable varieties of cowpea

Varieties	Glucose %	Starch %	Glucose/starch
K 1552	4.54	16.36	0.29
Brown seeded	2.56	10.04	0.25
Kanakamany	2.23	12.12	0.18
Red seeded	2.01	10.90	0.18
K 868	2.85	10.30	0.28
K 779	4.26	17.58	0.24
V 133	3.40	13.46	0.25
V 175	2.84	11.97	0.24
P 85-2E-9A	2.23	12.52	0.18
IIHR sel 1	2.44	14.15	0.17
IIHR 6-1-B	2.46	8.49	0.29
VS 87	2.96	10.26	0.29
VS 88	2.30	14.00	0.16
VS 89	2.21	9.93	0.22
Yard long bean	4.00	9.35	0.43

Discussion

DESCUSSION

The cowpea Vigna unguiculata (L) walp is an important tropical crop grown for pods, pod seeds and forage. The vegetable type of cowpea Vigna unguiculata var sesquipedalis specifically grown for pods is an important component of Indian dietary. One of the major problems of the crop has been the incidence of aphids, Aphis craccivora on foliage, internodes and pods. Heavy losses occurred when inflorescence and pods were affected. Besides being a pest this aphid is an important vector of plant viruses attacking cowpea (Nene, 1972). Chari et al. (1975) evaluated 104 multiple disease resistant germplasm line and observed that six lines TVU 57, TVU 408 P_2, TVU 410, TVU 1037, TVU 3273 and TVU 4538 were uniformly free of aphid infestation. Karel and Malinga (1980) evaluated eleven cowpea varieties and observed that three cultivars TVU 408 P_2, TVU 410, Ife Brown were found resistant to pea aphids attack Acyrthosiphon gossypii. Eighty three cowpea lines evaluated during the rainy season 1982 included ten TVU lines free from aphid infestation observed till thirty days after sowing. The variety K 1552, Brown seeded, Pusa Barsathi, Kanakamany, Red seeded, K 868, K 779, V 133, V 175, P 460-1-1, P 85-2E-9A, IIHR sel 1, IIHR 6-1-B, Hg 22, Yard long bean, Mayyanad local, New Era, Kolenchery 3, Vayalathur Red, C 152 and fifty three other lines succumbed to aphid infestation within thirty days of sowing. The line Kolenchery 3 was the most susceptible line and could be used for evaluation studies as a susceptible check. The ten TVU lines were further evaluated observing aphid infestation for thirty days, fourty five days and sixty days after sowing. The line TVU 1889 was the most promising line as far as aphid resistance is concerned. No aphid infestation was observed in both the season except for one colony of aphids observed in the internodes sixty days after sowing. The line TVU 2896 also showed resistance to aphid except for two to three colonies in the internodes sixty days after sowing. The line TVU 408 was also free from aphid infestation in both the seasons and is observed promising. The resistance reaction observed under field conditions was further examined by caging plants and releasing counted number of aphids. The area of infestation was measured and the lowest area of infestation was observed for TVU 1889 followed by TVU 2896. The line TVU 410 observed to be resistant to aphids by Chari et al. (1976) and Karel and Malinga (1980) succumbed to infestation in the present study. This could be due to presence of more virulent strain of aphids.

A production breeding programme associated with pest resistance could be effective if the pest resistant line could be improved per se for horticultural characteristics or the resistance factor transferred to popular varieties otherwise susceptible to aphids.

Whatever course of strategy a breeder adopts information on variability in the population for desirable horticultural characteristics would be an essential requirement a priory to any effective breeding programme. Considerable variability was observed in the eleven TVU lines for nodes to first flower, days to harvest, height, branches/plant, pod length, pod weight, seeds/pod, hundred seed weight, pods/plant and pod yield/plant. The line TVU 1889 took 62 days to first harvest, its pod length was 18 cm, pod weight 2.4 g and yielded 38.1 g/plant. The yield/day was calculated considering earliness and total yield under cultivation without resorting to any plant protection measures. The yield/day in TVU 1889 was 0.40 g. The line TVU 408 took 58 days to harvest and yielded 35.40 g/plant. The per day yield was 0.39 g. The lines TVU 1889, TVU 408 and TVU 2896 needed improvement for earliness and pod yield/plant. With appropriate plant protection measures the varieties like K 1552 yielded 68 quintals/ha while TVU 1889 could yield only 29.30 quintals.

Transfer of resistant genes to established varieties of cowpea could be a worthy attempt.

Aphid population as influenced by changes in meteorological parameters is an important information in the evaluation of cowpea lines for resistance to the insects. The review of literature indicated no information on this aspect. The insect population build up started diminishing with increase in the rainfall days and consequent increase in relative humidity. The mean maximum temperature and mean minimum temperature were observed not affecting the aphid population build up.

Evaluation of early cowpea lines for phenotypic stability

Earliness (days to first flower opening) in vegetable types of cowpea makes the crop fit in a multiple cropping system under irrigated conditions. Fifteen cowpea lines which are early and whose pods could be of vegetable types were grown in two seasons each under two fertility conditions. The study could also reveal information on variability, heritability and expected genetic advance of earliness, vegetative characters, yield and their components. The above information is vital to initiate any effective breeding programme (Allard, 1960), Karthikeyan (1963), Singh and Mehndiratta (1969), Doku (1970), Trehan (1970), Veeraswamy _et al_. (1973), Bordia _et al_. (1973) and Lakshmi and Goud (1977) also reported on variability in the different cowpea germplasm collection. Information on heritability and expected genetic advance would be of use in a selection method of crop improvement. Singh and Mehndiratta (1969), Trehan _et al_. (1970), Schoo _et al_. (1971), Bordia _et al_. (1973), Lakshmi and

Goud (1977) and Sreekumar *et al.* (1979) conducted studies to gather information on heritability and genetic advance for a set of independent characters. High heritability (0.98) associated with high genotypic coefficient of variation (69) resulting in high genetic advance was observed for plant height, pods/plant and pod yield/plant had lower values of genetic advance as percentage of mean resulting from lower values of genotypic coefficient of variation and heritability. The fifteen genotypes had significant variability for days to harvest. It ranged from 51 to 66 days. The fifteen cowpea varieties differed significantly for plant height, branches/plant, pod weight, seeds/pod, hundred seed weight, pods/plant and pod yield/plant. The lower values of genetic advance as percentage of mean for pods/plant and pod yield/plant indicated that these characters could be improved only through selection after hybridization among genetically diverse lines which could give transgressive segregants. The characters, nodes to first flower, plant height, pod length and hundred seed weight could be improved through appropriate selection method.

Reports on genotype x environment interaction and stability parameters in cowpea are limited. The line IIHR 6-1-B was observed to be the most average stable variety with highest mean (62.35 g) and bi value tending to one (0.96). Its deviation from regression was however significant. Eberhart and Russel (1966) defined an average stable variety has been one with high mean, regression tending to one and deviation from regression tending to zero. The line IIHR 6-1-B could be recommended for all round cultivation under varying fertility levels. The varieties K 1552, VS 89 and K 868 were high yielders (59.62 g, 54.45 g and 52.62 g respectively) and regression value more than one (2.19, 1.51 and 1.55 respectively). These varieties could be recommended for high fertility locations and for cultivation among progressive farmers with access to inputs.

A vegetable cowpea should bear snaped pods and should have high glucose content. The line K 1552 had the highest glucose content (4.54%) followed by Yard long bean (4.00 g). The glucose starch ratio was highest for Yard long bean (0.43) followed by K 1552, IIHR 6-1-B and VS 87 (0.29).

Evaluation of eighty three cowpea lines for aphid resistance indicated that TVU 1889, TVU 408 and TVU 2896 were free from aphid attack. These lines need improvement for horticultural characteristics. With the availability of the above sources of resistance transfer of resistant gene to popular vegetable types could also be thought of.

There is enough scope to develop high yielding and early lines with aphid resistance, pods/plant and pod yield/plant through selection after hybridization. The line IIHR 6-1-B is the most average stable variety. It took 59 to 61 days to first harvest. Pod length varied from 24 to 27 cm. Pod weight 3.06 to 3.69 g. Seeds/pod 10.7 to 16.3. Hundred seed weight 13.8 to 15.42 g, pods/plant 10.7 to 15.6 and pod yield/plant 52.05 to 83.75 g. The lines K 1552, VS 89 and K 868 were high yielders and are suited for high fertility areas.

Summary

SUMMARY

Cowpea Vigna unguiculata (L) walp is an important legume grown both in tropics and sub tropics. The aphids Aphis craccivora is a major pest of the crop. Attempts were made to isolate resistant line(s) to aphids. There are considerable variability in the vegetable types of cowpea for earliness which is important for the crop to be fitted in a multiple cropping system. The present investigations aimed to identify average stable varieties with earliness and high pod yield.

1. Eighty three cowpea lines were evaluated for field resistance to Aphis craccivora. All the lines except 10 TVU lines were infested by the aphid before 30 days after sowing. The lines TVU 1889, TVU 408, TVU 2896 and TVU 2962 were completely free from aphid infestation observed on leaves, internodes and pods upto 60 days of sowing.

The nine TVU lines were further tested in caged chambers under controlled conditions. The line TVU 1889 recorded the minimum area of infestation while the line TVU 62 and TVU 109 recorded the maximum area of infestation.

2. Considerable variability was observed in the cowpea germplasm for nodes to first flower, days to harvest, plant height, branches/plant, pod length, pod weight, seeds/pod, hundred seed weight, pods/plant and pod yield/plant. The lines K 1552 and TVU 1892 was earliest to

harvest (52 days).

3. The aphid resistant line TVU 1889 took 62 days to harvest, its pod length was 18 cm, pod weight 2.4 g and yielded 38.10 g/plant. The yield/day in the line was 0.4 g.

4. The study on relation between aphid population and weather parameters indicated that the aphid population got reduced considerably with increase in the number of rainy days and increase in average relative humidity.

5. The phenotypic stability of selected 15 vegetable types of cowpea was studied. The crops were grown in two seasons under two fertility levels. The 15 lines exhibited significant differences for nodes to first flower, days to harvest, plant height, branches/plant, pod length, pod weight, seeds/pod, hundred seed weight, pods/plant and pod yield/plant. The genotype x environment interaction was significant for days to harvest, plant height, branches/plant, pod length, seeds/pod, hundred seed weight and pod yield/plant indicating the non linearity of the combined effects of genotype x environments.

6. The varieties K 1552, Brown seeded, Red seeded, K 868 and K 779 were bushy types with their first flower on 3rd node. The variety K 1552 was the earliest (52.13 days) followed by K 868 (52.43 days). The Yard long bean was the latest (63.75 days). The

yard long bean had the longest pod (30.47 cm) followed by IIHR 6-1-B (25.86 cm). IIHR sel 1 had the highest seed weight (19.28 g) followed by VS 88 (18.17 g).

7. The line IIHR 6-1-B is the most average stable variety with highest mean (62.35 g) and bi value tending to one (0.96). The varieties K 1552, VS 89 and K 868 were high yielders but had bi value more than one and are suited for high yielding environments.

8. The chemical analysis of pods for mono saccharides to polysaccharides ratio indicated that the Yard long bean had the highest ratio followed by K 1552, IIHR 6-1-B and VS 87.

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SCREENING FOR RESISTANCE TO *Aphis craccivora* IN VEGETABLE COWPEA (*Vigna unguiculata* var. *sesquipedalis* and var. *cylindrica*) AND EVALUATION OF EARLY TYPES

By

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ABSTRACT OF A THESIS

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ABSTRACT

Cowpea *Vigna unguiculata* (L) walp is an important legume grown both in tropics and sub tropics. Eighty-three cowpea lines were evaluated for field resistance to *Aphis craccivora*. All the lines except 10 TVU lines were infested by the aphid before 30 days after sowing. The lines TVU 1889, TVU 408, TVU 2896 and TVU 2962 were completely free from aphid infestation observed on leaves internodes and pods upto 60 days of sowing during the first crop season. The resistance reaction observed during second crop season and under controlled aphid infestation revealed that TVU 1889 was the most promising as far as aphid resistance is concerned. There are considerable variability in the cowpea for different characters and the lines K 1552 and TVU 1892 were the earliest to harvest (52 days). Among the weather parameters average number of rainy days and relative humidity had negative relationship with aphid population.

Fifteen selected varieties of vegetable cowpea were grown in two seasons under two fertility levels. There were considerable variability in the vegetable types of cowpea for earliness which is important for the crop to be fitted in a multiple cropping system. The variety K 1552 was the earliest (52.13 days) followed by K 868 (52.43 days). The line IIHR 6-1-B is the most

average stable variety with the highest mean (62.35 g) and bi value tending to one (0.96). The varieties K 1552, VS 89 and K 868 were high yielders but had bi value more than one and are suited for high yielding environments. The chemical analysis of pods for monosaccharides to polysaccharides ratio indicated that the yard long bean had the highest ratio followed by K 1552, IIHR 6-1-B and VS 87.